


# NorthMet Project

# Air Data Package

**Version 5**

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## Acronyms

| Acronym | Stands For |
|---|---|
| AERA | Air Emission Risk Analysis |
| AQRV | Air Quality Related Value |
| BWCAW | Boundary Waters Canoe Area Wilderness |
| California OEHHA | California Office of Environmental Health Hazard Assessment |
| DEIS | Draft Environmental Impact Statement |
| GHG | Greenhouse Gas |
| IAP | Impact Assessment Planning |
| LTVSMC | LTV Steel Mining Company |
| MPCA | Minnesota Pollution Control Agency |
| NAAQS | National Ambient Air Quality Standards |
| PSD | Prevention of Significant Deterioration |
| RASS | Risk Assessment Screening Spreadsheet |
| SDEIS | Supplemental Draft Environmental Impact Statement |
| SAG | Semi-autogenous grinding |
| SIL | Significant Impact Level |
| USEPA | U.S. Environmental Protection Agency |
| USFS | U.S. Forest Service |
| VNP | Voyageurs National Park |

## 1.0 Introduction

This document describes the air data for the Poly Met Mining Inc. (PolyMet) NorthMet Project (Project) that was used in the preparation of the Supplemental Draft Environmental Impact Statement (SDEIS) and where applicable, updated data that was developed to aid in the preparation of the Final Environmental Impact Statement for the Project (FEIS). It summarizes reports, memos, and spreadsheets that have been submitted and approved on air emission calculations, air dispersion modeling (Class I and Class II), Air Emission Risk Analysis (AERA), greenhouse gasses, mercury deposition, emission control technologies, and mineral fibers. All approved reports and their associated work plans are included as attachments to this document. Large Table 1 lists the documents that form the basis for this Air Data Package. Any discrepancy between this document and an approved report will be resolved in favor of the approved report.

The methods, assumptions, and scope for the air analyses were established in work plans, protocols, and scoping documents that were approved by the Air Working Group. The Air Working Group started as the Air Impact Assessment Planning (IAP) group, which included representatives of the Minnesota Department of Natural Resources (MDNR), the Minnesota Pollution Control Agency (MPCA), the U.S. Forest Service (USFS), the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency (USEPA), the Bois Forte Band of Chippewa, the Grand Portage Band of Chippewa, and the Fond du Lac Band of Lake Superior Chippewa. When the work assigned to the Air IAP group was completed, many of the participants continued to participate in the scoping and review of potential air quality impact evaluations as the Air Working Group.

The Project will include a Mine Site, located near the city of Babbitt, Minnesota, and a Plant Site at the re-developed former LTV Steel Mining Company (LTVSMC) taconite plant and tailings basin (Large Figure 2 in Reference (1)) near the city of Hoyt Lakes. The Plant Site is located approximately six miles west of the Mine Site. Air analyses presented in this report are based on the features and operations of the Project as documented in the Project Description submitted for the SDEIS(Reference (1)), along with minor Project changes that have been made for the FEIS, which are explained in Attachment A. These Project changes will affect emissions at the Plant Site, but not at the Mine Site. The Plant Site Emissions inventory has been updated, as described in Section 5.0. The Project changes for the FEIS (Attachment A) will also result in a minor change to the Project carbon footprint, as described in Section 10.4.

Several management plans use the air data from this report, including the Air Management Plan – Mine (Reference (2)); the Air Management Plan – Plant (Reference (3)); and the Wetland Management Plan (Reference (4)).

## 1.1 Outline

The outline of this document is:

Section 2.0 Overview of regulatory basis for air emission studies

Section 3.0 Summary of meteorological data and background data

Section 4.0 Discussion of air emission control technology reviews

Section 5.0 Description of air emission inventory calculations

Section 6.0 Summary of Class I Area impacts evaluation studies, including air dispersion modeling, and semi-quantitative evaluations of potential cumulative visibility impacts and potential ecosystem acidification

Section 7.0 Summary of Class II Area air dispersion modeling

Section 8.0 Summary of Air Emission Risk Analysis (AERA) modeling to evaluate the potential exposure and associated risks from air toxics concentrations at and beyond the facility boundaries

Section 9.0 Summary of modeling to assess the effects of Project mercury emissions on nearby lakes, when added to other past, present, and reasonably foreseeable future actions

Section 10.0 Summary of studies evaluating the direct and indirect greenhouse gas emissions from the Project, and assessing the interaction between climate change and the Project

This document is intended to evolve through the environmental review, permitting, operating and closure phases of the project. A Revision History is included at the end of the document.

## 2.0 Regulatory Basis

PolyMet has analyzed potential air emissions in preparation for permitting and to inform the environmental review process required for the joint state and federal Environmental Impact Statement under the National Environmental Policy Act (United States Code 1976, title 42, sections 4321 to 4361) and the Minnesota Environmental Policy Act (Minnesota Rules, chapter 116D). The overall scope of the air evaluations for the SDEIS, as determined by the Air Working Group, is documented in the Air Impact Assessment Planning Summary Memo (Attachment B). The scope for additional information submitted for the FEIS was specified by the co-lead agencies (i.e., MDNR, USFS and the U. S. Army Corps of Engineers) with input from MPCA as the local air permitting authority.

Minor updates have been incorporated into the Project at the Plant Site since the SDEIS was published. An updated Emission Inventory (including modeling parameters) for the Plant Site (Post SDEIS version 3.0; December 16, 2014) showed that these changes result in very small changes to air emission sources (i.e., shifting of source locations within a building), and very small changes to air emission estimates (i.e., overall decrease). A comparison of the updated Emissions Inventory against the criteria used to define significant effects for the Project[1] shows that none of the minor project updates are likely to have a significant effect on the air quality assessments described below. Further air modeling (Class I, Class II, Air Emissions Risk Analysis (AERA), Mercury Risk Estimation Method (MREM)) for the Project will occur as necessary during the permitting process, which will ensure that air quality impact criteria are met, and that revised risk estimates continue to be below acceptable levels.

PolyMet is proposing to obtain a single Title V air permit for the Plant Site and Mine Site. The Project will be a major Title V source, but not a major source under Prevention of Significant Deterioration (PSD) air permitting because the permit application will propose emission limitations with the objective of being a synthetic minor source for PSD purposes. The permit application will also provide details on the applicability of state and federal requirements including New Source Performance Standards (40 CFR Part 60), Part 61 and Part 63 National Emission Standards for Hazardous Air Pollutants, and Minnesota Standards for Performance for Stationary Sources (Minnesota Rules, chapter 7011).

[1] The criteria used to define significant effects for this Project include demonstrating that new emissions, in conjunction with existing conditions, do not cause or contribute to a violation of any applicable National Ambient Air Quality Standards (NAAQS), Minnesota Ambient Air Quality Standards (MAAQS), and Prevention of Significant Deterioration (PSD) increment; demonstrating no adverse effects on visibility and other Air Quality Related Values (AQRV) in Class I areas; demonstrating that estimated potential incremental human health risks are acceptable given guideline values and the conservatism in the analysis; and demonstrating that estimated Project-only and cumulative mercury deposition will have no reasonably foreseeable potential effects on existing background mercury concentrations in fish and any existing background risks to recreational and subsistence fishers consuming those fish.

To inform the environmental review process, PolyMet conducted a number of air emission studies that may be used to support the air permitting process, including:

- reviews of emission control technologies were conducted to estimate the air emissions from the Project with emission controls in place
- air emission risk assessments were conducted to evaluate risks due to hazardous air pollutants
- modeling was used to demonstrate compliance with National and Minnesota Ambient Air Quality Standards

Furthermore, while PolyMet proposes to permit the Project as a synthetic minor source, which is not subject to PSD review, to provide information for environmental review, PolyMet agreed to complete dispersion modeling on additional parameters, referred to as PSD increments, in a manner that is generally consistent with what would be required for a major source permit. PSD increments are used to regulate growth in a manner consistent with land usage goals. They are typically evaluated as an increase in ambient air concentration of pollutants since a baseline date. The federal PSD program generally divides areas into two classes based on local land use: Class I and Class II areas. Wilderness and national park areas of a certain size are automatically designated as Class I areas; other areas can also be designated Class I areas based on the need for special protection. All other areas are designated as Class II areas. Class I and Class II areas have different increments values, with Class I increments being more stringent. In Class I Areas, additional criteria apply to protect the special attributes of the designated areas. These criteria are known as Air Quality Related Values (AQRVs) and include parameters such as visibility impairment and acid deposition. The modeling completed for the Project included both Class I and Class II modeling.

The environmental review process also includes analyses of cumulative impacts. The co-lead agencies requested that PolyMet conduct cumulative impact studies on the following topics:

- visibility impacts in Federal Class I areas
- ecosystem acidification
- mercury deposition and bioaccumulation in fish (it was agreed by the Air Work Group that it was appropriate to conduct a quantitative evaluation using air dispersion modeling in lieu of the semi-quantitative approach discussed in the original scoping decision document).
- cumulative effects from toxic air pollutants (i.e., cumulative AERA)

## 3.0 Baseline Data

### 3.1 Meteorological Data

Meteorological inputs for the Class I modeling were produced using a CALMET data set developed from three years (2002-2004) of MM5 prognostic mesoscale meteorological data, surface weather data, precipitation data, and upper air data as detailed in Section 2 of the Class I Air Dispersion Modeling Protocol (Appendix B of Attachment C).

Meteorological data inputs for Class II and AERA modeling were developed from the 2006 – 2010 Hibbing, Minnesota airport surface data set, and the 2006-2010 International Falls, Minnesota upper air data set (Attachment D and Attachment E).

### 3.2 Background Data

Background values used in the evaluation of impacts in Class I Areas are presented in Table 4 of Appendix B of Attachment C.

Background data for the Class II modeling, were submitted with the Mine Site and Plant Site Class II Air Quality Dispersion Modeling Reports (Figures 4 through 7 of Attachment F and Tables 3A and 3B in Attachment G)

Background risks for the cumulative AERA were calculated by the MPCA based on 2008-2010 monitoring data from Virginia and Cloquet, Minnesota and 2008-2011 monitoring data from Ely, Minnesota.

## 4.0 Air Emission Control Technology

The Project incorporates numerous engineered controls to manage air emissions, as described in Reference (2) and Reference (3). PolyMet reviewed a range of air emission control technologies to select options that meet or exceed regulatory requirements. The effectiveness of various emission control technologies was also evaluated in order to estimate Project air emissions with emission controls in place.

Technology to control air emissions of fine particles, including mineral fibers, is assessed in the following reports:

- Emission Control Technology Review for NorthMet Project Processing Plant: Revised Addendum 01 Version 3, February 2012 (Attachment H)

- Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore: Addendum 02 Fine Particle Air Emission Control Technology Update Version 2, December 2011 (Attachment I)

While these reports are referred to as addendums (to the original emission control technology review completed for the Draft Environmental Impact Statement (DEIS), they completely cover all technology review updates included in the agreed upon scope for the SDEIS.

As described in Attachment A, additional emission sources and pollution control equipment is proposed for the Beneficiation Plant in the FEIS project description associated with the incorporation of a semi-autogenous grinding (SAG) mill in the Project flowsheet. The additional pollution control equipment would be of the same type and have the same performance specifications as that described for the majority of sources in Attachment H (i.e., cartridge filter dust collectors). Therefore, additional evaluation of pollution control equipment is not necessary for the FEIS.

Technology to control air mercury emissions is assessed in the following report:

- Mercury Emission Control Technology Review for NorthMet Project Processing Plant, February 2012 (Attachment J)

## 5.0 Air Emission Calculations

Modeled emission rates for the Project were used as the basis for the Class I and Class II modeling, the AERA, and the mercury cumulative impacts analysis. Air emission calculations used for the air quality impact assessments completed for the SDEIS were submitted in the emissions inventory spreadsheets submitted to the Air Work Group. Updates were provide as needed to reflect the modeling conducted for the Class I Air Dispersion Modeling Report (Attachment C), the Mine Site Class II Air Dispersion Modeling Report (Attachment F) and the Plant Site Class II Air Dispersion Modeling Reports (Attachment G).

Summaries of the emission inventories prepared for the SDEIS, and used for the impact assessments discussed in this document are included as Attachment K. Minor changes to the Project for the FEIS (Attachment A) will affect air emissions only at the Plant Site, so an updated Plant Site emission inventory was submitted to the MPCA and the co-lead agencies on November 6, 2014, and version 2, which incorporated comments received on version 1, was submitted on December 2, 2014. Version 3 was submitted on December 16, 2014, to address the final comments received. Attachment L includes a summary of the updated Plant Site emissions inventory, and a comparison between the Plant Site SDEIS emissions levels and the Plant Site FEIS emissions levels. The FEIS emission levels are lower for particulate matter (e.g., 23.5 tpy lower for $PM_{10}$) due to a reduction in the total volume of dust collector exhaust gas in the Beneficiation Plant, and lower for $NO_2$ (reduced by 0.7 tpy) and other natural gas combustion pollutants because of a small reduction in the total Beneficiation Plant heating demand.

The air emission inventory for nearby sources at the Mine Site are documented in the Class II Air Dispersion Modeling Protocol for the Mine Site (Attachment D). The nearby source emission inventory for Plant Site was updated for the FEIS. The updated inventory is included as Attachment M. The updates include the proposed removal of Mesabi Mining sources from the Mesabi Nugget inventory and the switch from coal to natural gas as the primary fuel at the Laskin Energy Park. Both of these changes would result in lower modeled emissions for these nearby facilities.

## 6.0 Class I Area Impacts Evaluation

The evaluation of Class I area impacts completed in support of the SDEIS included air dispersion modeling, semi-quantitative assessment of cumulative visibility impacts, and semi-quantitative assessment of cumulative ecosystem acidification.

For the FEIS, minor changes are proposed to the configuration of the Project evaluated for the SDEIS, as explained in Attachment A. These changes result in a net reduction in point source emissions of the pollutants of concern for the Class I Areas (i.e., $PM_{10}$, $PM_{2.5}$, $SO_2$ and $NO_x$). Proposed minor changes to the locations of stacks and vents are not expected to affect modeled impacts, especially at the Class I areas which are at least 20 miles from the Project site. In other words the changes in stack location are very small relative to the distance to the nearest Class I receptors.

Additional proposed changes, such as the Coal Ash Landfill relocation and the extension of the Flotation Tailings Basin Containment System are potential sources of construction equipment tail pipe emissions at the Plant Site, but these activities can be completed without increasing activity levels on Tailing Basin Roads, increasing material handling rates, or increasing tailpipe emissions.

Because of the results of this evaluation, the modeling completed for the SDEIS (as described below) continues to be representative of potential maximum Project air quality impacts in the Class I Areas for the Project; therefore, additional Class I modeling or other impact assessment is not needed for the FEIS.

### 6.1 Class I Area Air Dispersion Modeling

PolyMet conducted Class I Area air dispersion modeling to demonstrate that the Project will not significantly deteriorate air quality in the following wilderness and national park areas:

- Boundary Waters Canoe Area Wilderness (BWCAW)
- Rainbow Lake Wilderness
- Voyageurs National Park (VNP)
- Isle Royale National Park

Locations of these Class I areas are shown on Figure 1 of Appendix B of Attachment C. The Class I modeling assessed whether the Project will significantly deteriorate air quality from baseline levels (increment modeling), and analyzed potential visibility and acid deposition and impacts (AQRVs). The Class I modeling analyzed emissions of $NO_X$, $SO_2$, and $PM_{10}$ from point sources, Mine Site heavy mining equipment and Flotation Tailings Basin and Hydrometallurgical Residue Facility construction equipment (used during operations). For Class I modeling, the

Mine Site and Plant Site were combined because the distance between the sites is small compared to the distance between the Project and the Class I areas. Class I modeling included both analyses of the potential effects of Project air emissions and cumulative impact analyses of the net effect of the Project and other emission sources, where modeled impacts for the Project alone were above screening levels.

Full details on the Class I modeling are provided in the following report:

- Class I Air Dispersion Modeling Report Version 2, May 2012 (Attachment C)

### 6.1.1 Modeling Approach

The modeling procedures used to evaluate the Project's potential impact on nearby Class I areas followed the protocol approved by the Air Working Group (Appendix B of Attachment C).

Modeling was conducted to quantify PSD increment consumption and impacts related to the appropriate AQRVs for each area. The AQRVs assessed included acid deposition and visibility impairment. Table 6-1 lists the specific analyses conducted for the Class I Areas:

**Table 6-1 Class I Impact Evaluations**

| Parameter | Analysis Conducted (Yes/No) | | | | Impact Criteria |
|---|---|---|---|---|---|
| | BWCAW | Isle Royale | Rainbow Lake | VNP | |
| Class I Increment ($SO_2$, $NO_2$, $PM_{10}$) | Yes | Yes | Yes | Yes | USEPA Class I Increment Values and SILs |
| Visibility | Yes | Yes | No | Yes | FLM Guidelines |
| Aquatic Sulfur and Nitrogen Deposition | Yes | Yes | Yes | Yes | Wilderness Areas: Green Line, National Parks: DAT |
| Terrestrial Sulfur and Nitrogen Deposition | Yes | Yes | Yes | Yes | |
| $SO_2$ impacts on flora and Fauna | Yes | Yes | Yes | Yes | Green Line |

#### 6.1.1.1 Project Emissions

The Project worst-case air emissions that are the basis for the Class I modeling are presented in Section 2.1 of Attachment C. Modeled sources included all point sources, the large mining vehicles, the Flotation Tailings Basin and Hydrometallurgical Residue Facility construction equipment, the locomotives used to haul ore from the Mine Site to the Plant Site, and the switcher locomotive. Fugitive sources were not included, as is standard practice, due to the fact

that these emissions do not travel long distances. Mine Site and Plant Site emission sources are fully catalogued in the emissions inventory spreadsheets submitted to the MPCA along with the Class I Air Dispersion Modeling Report (Attachment C).

In order to provide maximum operating flexibility, the Class I assessment of air quality impacts used the maximum hourly emission rate for all point sources at the Mine Site, even though they may not operate at their maximum rate at the same time.

The Plant Site will operate in two different modes:

1. Concentrate Only Mode - Beneficiation Plant produces separate copper and nickel concentrates that are shipped off-site as products.

2. Hydrometallurgical Mode -– Beneficiation Plant operates the same as in Concentrate Only Mode. Copper concentrate is shipped off-site as product, but nickel concentrate is fed to the Hydrometallurgical Plant, where high pressure and temperature autoclave leaching followed by solution purification steps are used to extract and isolate gold and platinum group metals and base metals (nickel and cobalt).

In order to provide maximum operating flexibility, the Class I assessment of air quality impacts used a composite of the maximum emission scenarios. This assessment included the following:

- Crushing Plant without dust collector exhaust recycling where allowed under anticipated permit conditions

- flotation process uses maximum emission case for organics and sulfur compounds

- flotation concentrate handling using Concentrate Only Mode with 100% flotation concentrate shipped offsite

- Hydrometallurgical Plant operating in the Hydrometallurgical Mode with all the nickel concentrate fed to the Autoclave

- process consumables handling and storage using the Hydrometallurgical Mode

- combustion equipment –space heater emission calculations based on design capacity; emissions from autoclave startup boiler and oxygen plant heater based on rated capacity for Hydrometallurgical Mode

- Flotation Tailings Basin and Hydrometallurgical Residue Facility – Flotation Tailings Basin beach area not significantly dependent on mode of operation, Hydrometallurgical Residue Facility sized for 100% Hydrometallurgical Mode

Large Table 2 shows Plant Site operating scenarios and worst-case emissions.

Mobile source emissions from the Mine Site and Plant Site were evaluated for four different operating scenarios, as detailed in Section 2.1 of Attachment C.

### 6.1.2 PSD Increment Modeling Results

PSD increment analysis (Section 6 of Attachment C) demonstrates that air quality will not be deteriorated as a result of the Project. The increase in criteria pollutant ambient air concentrations are all below the Significant Impact Levels (SILs) except for 24-hr $PM_{10}$ in BWCAW. Because modeled concentrations are greater than the SIL, a cumulative increment analysis was conducted, as required. At the request of MPCA, receptors were also placed in VNP, although project-only results were below the SIL. The cumulative impacts analysis was conducted in accordance with Appendix B of Attachment C.

Results of the cumulative increment modeling indicate that the Project, along with other projects, has not consumed the available increment for $PM_{10}$ in the BWCAW (Section 6.3 of Attachment C). This conclusion is also supported by the fact that monitored concentrations have decreased in this area, indicating that an increase in the increment concentration is available for future growth.

### 6.1.3 Visibility Modeling Results

Visibility impacts analysis (Section 5 of Attachment C) demonstrates that when compared to pristine conditions as prescribed in current guidance, no adverse visibility impacts are indicated.

### 6.1.4 Acid Deposition Modeling Results

Acid deposition analysis (Section 4 of Attachment C) compared potential effects of Project $SO_2$ and $NO_X$ emissions to thresholds established by the USFS and the National Park Service. Results demonstrate no adverse impact on flora and fauna is expected. Deposition values were below the "Green Line Values" set by the USFS and National Park Service. Therefore, no adverse impact on terrestrial and aquatic ecosystems is expected.

## 6.2 Semi-quantitative Cumulative Visibility Impacts Evaluation

As part of the environmental review process, the co-lead agencies requested that PolyMet conduct cumulative impact studies on several topics. The Air Working Group determined that semi-quantitative methods, rather than modeling, are the appropriate approach to evaluate the topic of cumulative visibility impacts in Federal Class I areas.

Full details on the semi-quantitative cumulative visibility impacts evaluation are provided in the following report:

- Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota Version 3, January 2012 (Attachment N)

### 6.2.1 Evaluation Approach

The visibility cumulative impact analyses evaluated the net effect of the potential maximum emissions from the Project and other proposed projects, plus the potential emissions increases and decreases due to reasonably foreseeable actions and potential regulatory requirements. The visibility cumulative impacts analysis included particulate emissions along with $SO_2$ and $NO_X$ emissions, because fine particles are an important contributor to visibility impairment and fine particles can be made up of sulfate and nitrate aerosols. The methods used for the increment and visibility cumulative impacts analysis are described in Sections 1, 2, and 3 of Attachment N. The analysis boundaries, namely the timeframe, the other actions to be assessed, and the zone of impact are presented in Section 2 of Attachment N. The projects included in the cumulative analysis are shown on Figure 1 of Attachment N, and their individual emissions are summarized in Table 1 of Attachment N.

### 6.2.2 Cumulative Visibility Evaluation Results

Results of the cumulative visibility analysis indicate that the net effect from the proposed projects, the expected reductions at existing facilities, and the foreseeable regulatory requirements will be to reduce emissions of $SO_2$ and $NO_X$ in Minnesota. Within the context of anticipated regulatory changes and expected emission reductions, the current trend in visibility improvement is not likely to be changed by the proposed projects in northeast Minnesota. Although direct emissions of $PM_{10}$ will increase, a large percentage is fugitive emissions that will deposit nearby the source. Subsequently, foreseeable emission reductions in Minnesota should continue to improve the visibility in VNP and the BWCAW, although it is uncertain as to the degree of visibility improvement that will be obtained from the emission reductions in Minnesota alone. Additional improvement in the air quality of VNP and the BWCAW is expected due to national, statewide, and regional reductions of $SO_2$, $NO_X$, and $PM_{10/2.5}$ emissions. Therefore, gradual visibility improvement in VNP and the BWCAW is expected in the future (Section 6 of Attachment N)

## 6.3 Semi-quantitative Cumulative Ecosystem Acidification Impacts Evaluation

As part of the environmental review process, the co-lead agencies requested that PolyMet conduct cumulative impact studies on several topics. The Air Working Group determined that semi-quantitative methods, rather than modeling, are the appropriate approach to evaluate the topic of ecosystem acidification.

Full details on the semi-quantitative ecosystem acidification cumulative impacts evaluation is provided in the following report:

- Assessment of Potential Ecosystem Acidification Cumulative Impacts in Northeast Minnesota Version 2, November 2011 (Attachment O)

### 6.3.1 Evaluation Approach

The ecosystem acidification cumulative impact analysis evaluated the net effect of the potential maximum emissions from the Project and other proposed projects, plus the potential emissions increases and decreases due to reasonably foreseeable actions and potential regulatory requirements. The ecosystem acidification cumulative impacts analysis focused on $SO_2$ and $NO_X$ because they are the two primary air pollutants that can lead to ecosystem acidification (acid precursors). The methods used for the ecosystem acidification cumulative impacts analysis are described in Sections 1 and 2 of Attachment O. The analysis boundaries, namely the timeframe, the other actions to be assessed, and the zone of impact are presented in Section 2 of Attachment O. The projects included in the cumulative analysis are shown on Figure 1-1 of Attachment O, and their individual emissions are summarized in Table 1-1 of Attachment O.

### 6.3.2 Cumulative Ecosystem Acidification Evaluation Results

Results of the ecosystem acidification cumulative impacts assessment indicate that the cumulative potential emissions from the proposed projects do not have the potential to cause or significantly contribute to ecosystem acidification in northeast Minnesota (Technical Summary of Attachment O).

## 7.0 Class II Area Air Dispersion Modeling

PolyMet conducted Class II Area air dispersion modeling to demonstrate that the Project will not exceed national ambient air quality standards (NAAQS) or significantly deteriorate air quality in Class II areas (all areas outside of National Parks and Wilderness Areas). For Class II modeling, the Mine Site and Plant Site were modeled separately. Full details on the Class II modeling are provided in:

- Mine Site Class II Air Quality Dispersion Modeling Report Version 2, August 2012 (Attachment F)
- Mine Site Class II Air Quality Dispersion Modeling Protocol, January 2012 (Attachment D)
- Mine Site Class II Air Quality Dispersion Modeling Report Version 2, November 2012 (Attachment G)
- Mine Site Class II Air Quality Dispersion Modeling Protocol, May 2012 (Attachment E)

## 7.1 Modeling Approach

The Class II modeling procedures followed the protocols approved for the Mine Site and the Plant Site (Attachment D and Attachment E, respectively).

The ambient air boundaries for the Plant Site and Mine Site (shown on Large Figure 2 of Attachment P) were based on land expected to be controlled by PolyMet at the commencement of operations. The ambient air boundaries establish the receptor grid boundaries. A different receptor grid boundary was used at the Plant Site to assess combined impacts from NorthMet, Mesabi Nugget Phase I and II[2] and the Cliffs Erie Pellet Yard. This combined impacts boundary was based on the operating boundary for the former LTVSMC operation at the site. Figures showing the Mine Site and Plant Site receptor grids for the Class II modeling are included in Attachment D and Attachment E, respectively.

### 7.1.1 Mine Site Emissions

At the Mine Site all fugitive and point sources were included in both the NAAQS and increment modeling. The emergency generator at the Waste Water Treatment Facility was not included in

[2] A current project description has not been submitted to the regulatory agencies for the Mesabi Nugget Phase II project (Mesabi Mining) and MPCA has recommended that this project be removed from the Project cumulative modeling. Based on this recommendation, the cumulative modeling reported in this document is conservative in that it includes Mesabi Mining. Any additional modeling completed in the future will be updated for the current status of this project at the time of the modeling. Attachment M identifies which Mesabi Nugget sources are part of Mesabi Mining.

the $SO_2$ and $NO_2$ modeling because it will operate infrequently for testing and during power failures, consistent with USEPA policy. It was included at limited operating frequency in the $PM_{2.5}$ and $PM_{10}$ modeling. Mine Site emission sources used in the Class II NAAQS and PSD increment modeling are fully catalogued in the emissions calculation spreadsheets submitted to the MPCA along with the Mine Site Class II Air Dispersion Modeling Report (Attachment F).

Haul truck traffic associated with mining operations is the largest source of fugitive dust emissions at the Mine Site. Therefore, the years with the maximum haul truck vehicle miles travelled can be assumed to be the years with the highest emissions. Haul truck traffic patterns are determined by the mining activities, as specified in the Mine Plan (Reference (5)). The Mine Plan includes two operating modes: 1) temporary stockpile phase (Mine Years 1-11); 2) in-pit disposal phase with temporary stockpile reclaim (Mine Years 12-20). Two representative worst-case years were modeled for the Mine Site emissions: the worst-case year during the temporary stockpile phase (Mine Year 8) and the worst-case year during the in-pit disposal phase (Mine Year 13).

In addition to Project sources, nearby facilities were included in cumulative impacts assessments for NAAQS and PSD increment. The $SO_2$ and $NO_2$ modeling results were below the SIL for the Mine Site sources, so further analysis was not needed for these pollutants. The Mine Site cumulative $PM_{10}$ and $PM_{2.5}$ NAAQS modeling included the following sources: Plant Site, Mine Site, Mesabi Nugget Phase I and II, Northshore Peter Mitchell Mine, and Cliffs Erie Pellet Yard. Mine Site cumulative increment modeling included: the Plant Site, Mesabi Nugget Phase I and II, and the LTVSMC shutdown of plant and mine.

### 7.1.2 Plant Site Emissions

At the Plant Site a single scenario with a conservative worst case including all emission units was used for all pollutants and averaging times except for Flotation Tailings Basin wind erosion where two scenarios were considered for $PM_{2.5}$ and $PM_{10}$ modeling. The Plant Site NAAQS modeling included all fugitive and point sources. Increment modeling at the Plant Site did not include Flotation Tailings Basin wind erosion, Flotation Tailings Basin light truck traffic and other unpaved roads, because these activities were present at the baseline date for $PM_{10}$. Sources that only operate during emergency conditions, or for infrequent testing, were not included in the NAAQS or increment modeling for $SO_2$ and $NO_2$ (i.e., the emergency generators and fire pumps) consistent with USEPA guidance. Plant Site emission sources used in the Class II NAAQS modeling are fully catalogued in the emissions inventory spreadsheets submitted to the Air Work Group along with the Plant Site Class II Air Dispersion Modeling Report (Attachment G.

In addition to NorthMet sources, nearby facilities were included in cumulative impacts assessments for NAAQS and PSD increment. For the Plant Site modeling, the Mine Site, Mesabi Nugget Phase I and II, Northshore Peter Mitchell Mine, and the Cliffs Erie Pellet Yard were included in the $PM_{2.5}$ and $PM_{10}$ NAAQS modeling. $NO_2$ and $SO_2$ 1-hr NAAQS modeling also

included Laskin Energy Center[3], Arcelor Mittal, Virginia Public Utilities, and US Steel Minntac. Increment modeling included the Mine Site, Mesabi Nugget Phase I and II and the former (LTVSMC) operations (increment expanding source).

For the FEIS, minor changes are proposed to the configuration of the Project evaluated for the SDEIS, as explained in Attachment A. These changes only affect the Plant Site. They result in a net reduction in point source emissions of the pollutants of concern for the Class II modeling (i.e., $PM_{10}$, $PM_{2.5}$, $SO_2$ and $NO_x$). Proposed minor changes to the locations of stacks and vents, due to the incorporation of a SAG mill into the process flow sheet, are not expected to affect modeled impacts at the Project ambient air boundary or at the cumulative impacts boundary. The changes in stack location are very small relative to the distance to the modeled Class II receptors. All stack locations will remain within the footprint of the Beneficiation Plant buildings, and their locations move a maximum of about 100 feet. The Concentrator Building, where most stack location changes occur, is about 2,000 feet from the Plant Site ambient air boundary and much further from the cumulative impacts boundary. A comparison of the stack locations in the SDEIS and the FEIS, is included in Attachment A.

Other proposed changes, such as the Coal Ash Landfill relocation and the extension of the Flotation Tailings Basin Containment System are potential additional sources of fugitive dust emissions at the Plant Site, but these activities can be completed without increasing activity levels on Tailing Basin Roads or increasing material handling rates. Because of these factors, the Class II modeling completed for the SDEIS is representative of potential maximum Project air quality impacts for the Project, and therefore additional Class II modeling is not needed for the FEIS. Details are provided in Attachment A.

### 7.1.3 Additional Emission Sources Considered

Product will be shipped off site using trains and trucks. The Air Working Group requested that information on emissions associated with product shipment be calculated to provide background for discussion and a final decision on whether or not these activities should be included in modeling or other assessments. After reviewing and considering these additional emission sources, the co-lead agencies agreed that emissions from product shipment need not be included in Class II air dispersion or AERA modeling (Attachment B). The information provided to the co-lead agencies is summarized in the following section.

#### 7.1.3.1 Trucks Used to Haul Products

Over the road commercial trucks owned by outside companies may be used to haul some products produced at the Plant Site. PolyMet intends to ship flotation concentrates produced

[3] In the time since the modeling reported in this document was completed, Laskin Energy Center has switched from coal to natural gas as the primary fuel, which resulted in emission reductions. Therefore, the cumulative modeling is conservative and any additional modeling completed in the future will reflect this emission reduction (see Attachment M).

when the facility operates in the Concentrate Only Mode exclusively by rail, so these products are not discussed further in this section.

Platinum Group Metal Concentrate and Nickel/Cobalt Hydroxide produced under the Hydrometallurgical Mode could potentially be shipped offsite by truck. Attachment Q provides information on typical and potential maximum truck traffic rates due to product shipping, and the associated emissions. The emission calculations should be considered conservative because they are based on maximum truck traffic, not typical rates. For example, the potential maximum daily truck values assume that a winter storm or similar event has backed up shipping for three days.

The preferred route for trucks leaving NorthMet is expected to be to the west past the Area 1 Shops, past the Mesabi Nugget Plant Site and then onto Minnesota Highway 135. Alternatively, trucks may travel to the south onto county Highway 666. On either route, trucks will not pass by residences or other potentially sensitive receptors before entering a public highway.

Another factor in assessing the potential for impacts from truck traffic is whether or not trucks would idle for extended periods of time at or near a Project site. PolyMet expects that trucks will be loaded indoors with engines shutdown. The frequency of truck arrivals and the expected loading time will result in minimum queuing of trucks. Therefore, PolyMet does not anticipate significant onsite idling time for trucks hauling products. In addition, PolyMet is considering the implementation of an idling reduction policy. This policy would consider the size, fuel type, and function of each type of vehicle, as well as weather conditions and anticipated duration of vehicle stoppage. Such a policy would reduce environmental impacts, improve worker health and safety, and reduce fuel usage and engine wear.

## 7.2 Class II Modeling Results

### 7.2.1 Mine Site

$PM_{2.5}$ and $PM_{10}$ NAAQS modeling indicate no violations of applicable standards (Table 3 of Section 4 of AQDMR-01 in Attachment F).

$PM_{10}$ PSD increment modeling results show that modeled concentration increases are below the prescribed increment (Table 4 of Section 4 of AQDMR-01 in Attachment F).

### 7.2.2 Plant Site

NAAQS modeling indicates no violations of applicable standards for $PM_{2.5}$ and $PM_{10}$ (Table 3 of Section 4 of AQDMR-01 in Attachment G). Cumulative one hour $SO_2$ and $NO_2$ modeling results exceed applicable standards, but Project emissions do not cause or contribute to those exceedances (Tables 3a and 3b of Section 4 of AQDMR-01 in Attachment G). $SO_2$ and $NO_2$ modeling based on emissions alone modeled at the Project boundary does not show exceedance of the NAAQS.

PSD increment modeling results show that modeled concentration increases are below the prescribed increment (Table 4 of AQDMR-01 in Attachment G).

## 8.0 Air Emission Risk Analysis (AERA)

This section describes the Mine Site AERA and the Plant Site AERA, which evaluated the potential exposure and associated risks from air toxics concentrations at and beyond the facility boundaries. Full details on the AERA are presented in:

- Supplemental Air Emission Risk Analysis – Mine Site Version 3, February 2013 (Attachment R)
- Work Plan for a Supplemental Air Emission Risk Analysis for the NorthMet Mine Site, July 2011, amended August 2012 (Attachment S)
- Supplemental Air Emission Risk Analysis – Plant Site Version 3, March 2013 (Attachment P)
- Work Plan for a Supplemental Air Emission Risk Analysis for the NorthMet Plant Site, August 2011 (Attachment T)

### 8.1 Analysis Approach

The AERA analysis procedures followed the work plans approved for the Mine Site and the Plant Site (Attachment S and Attachment T, respectively). The work plans specified the chemicals for evaluation in emissions from the Mine Site and the Plant Site, and prescribed that a cumulative inhalation risk assessment be conducted to account for potential cumulative effects from the proposed Mesabi Nugget Phase I and II and the Laskin Energy Center power plant (located several kilometers southwest of the Plant Site). Figures showing the Mine Site and Plant Site receptor grids for the AERA modeling are included in Attachment R and Attachment P, respectively.

Air toxics modeling at the Mine Site included point and fugitive sources and the large mining vehicles and locomotives, as detailed in the calculation spreadsheets submitted with Class I and Class II modeling reports (Attachment C and Attachment F, respectively). Air concentrations were modeled for Mine Year 8 and Mine Year 13 emissions, as these are projected to be the worst case years for the stockpile and in-pit disposal operational phases, respectively.

Potential health risks were assessed for two routes of exposure; direct via inhalation and indirect (ingestion exposure) via food consumption. Multi-pathway exposure, which evaluates concurrent exposure to contaminants by both inhalation and food consumption, was also assessed. The exposure scenarios and receptors evaluated for the Mine Site and Plant Site AERAs are summarized in Table 5-1 of Attachment R and Table 5-1 of Attachment P, respectively.

## 8.2 Air Emission Risk Analysis (AERA) Results

### 8.2.1 Mine Site

When the estimated risks are compared to guideline values, and accounting for conservatism in the risk analysis methodology, adverse impacts to human health are not expected to be associated with the potential air emissions from the proposed Mine Site operations (Section 1.3 of Attachment R).

### 8.2.2 Plant Site

When the estimated risks are compared to guideline values, and accounting for conservatism in the risk analysis methodology, adverse impacts to human health are not expected to be associated with the potential air emissions from the proposed Plant Site operations (Section 1.3 of Attachment P).

For the FEIS, minor changes are proposed to the configuration of the Project evaluated for the SDEIS, as explained in Attachment A. These changes only affect the Plant Site. They result in a net reduction in point source emissions for some AERA pollutants (e.g., metals and $NO_x$), no change for others and no emission increases. Proposed minor changes to locations of stacks and vents, due to the incorporation of a SAG mill into the process flow sheet, are not expected to affect modeled impacts at the Project ambient air boundary or at the cumulative impacts boundary. The changes in stack location are very small relative to the distance to the modeled Class II receptors. All stack locations will remain within the footprint of the Beneficiation Plant buildings, and their locations move a maximum of about 100 feet. The Concentrator Building, where most stack location changes occur, is about 2,000 feet from the Plant Site ambient air boundary and much further from the LTVSMC boundary (nearest point were resident or farmer receptors would be present). A comparison of the stack locations in the SDEIS and the FEIS, is included in Attachment A.

Additional proposed changes, such as the Coal Ash Landfill relocation and the extension of the Flotation Tailings Basin Containment System are potential sources of fugitive dust and construction equipment tail pipe emissions, but these activities can be completed without increasing activity levels on Tailing Basin Roads, increasing material handling rates, or increasing tailpipe emissions. Because of these factors, the AERA modeling completed for the SDEIS is representative of potential maximum Project air quality impacts for the Project, , and therefore additional AERA modeling is not needed for the FEIS. Detailed information on these changes is provided in Attachment A.

Changes in toxicity values since the December 2012 version of the MPCA Risk Assessment Screening Spreadsheet (RASS) were compiled by MPCA staff and emailed to Barr Engineering staff on October 15, 2014. Pertinent changes to the risk driver chemicals evaluated in the March 2013 AERA are shown in Table 8-1.

**Table 8-1 Changes in Toxicity Values for Chemicals Evaluated in the March 2013 Supplemental AERA**

| Chemical Name | Exposure Duration and Effect | Value in RASS Version 20120302 and Source | Value in Current RASS (version 20130304) and Source |
|---|---|---|---|
| Nickel and compounds (including nickel refinery dust CAS# 1146 ; and nickel subsulfide CAS# 12035-72-2) | Chronic, non-cancer effects | 0.05 µg/m3, Cal EPA | 0.014 µg/m3, Cal EPA |

The only change in toxicity value pertinent to the 2013 Supplemental AERA was to the chronic noncancer inhalation value for nickel compounds by the California Office of Environmental Health Hazard Assessment (California OEHHA):

- previous chronic noncancer inhalation value (applied to all receptors): 0.05 µg/$m^3$
- current chronic noncancer inhalation value from California OEHHA: 0.014 µg/$m^3$

The current chronic noncancer toxicity value for nickel compounds of 0.014 µg/$m^3$ was derived by California OEHHA using the more rigorous benchmark dose methodology and a dosimetric adjustment factor that accounts for the smaller lungs of infants and children.

The current chronic toxicity value of 0.014 µg/$m^3$ is applicable to the Resident and Farmer receptors at the former LTVSMC ambient air boundary as children/infants have the potential to be present. Revised estimates of potential human health risks for nickel compounds for these two receptors are provided in Table 8-2. The revised potential risk estimates are based on the maximum modeled air concentration for nickel compounds reported in the March 2013 Supplemental AERA.

Because the Off-site Worker is an adult and cannot be an infant or child, the current noncancer chronic inhalation toxicity value of 0.014 µg/$m^3$ for nickel compounds is not applicable to the Off-site Worker. Therefore, continued use of the 0.05 µg/$m^3$ value for receptors where infants and children will not be present is conservative, and the risk results in the March 2013 Supplemental AERA for the Off-site Worker receptor for nickel compounds are not affected by the current toxicity value.

#### 8.2.2.1.1 Project Only

As previously discussed, changes to emission sources are not reasonably expected to result in any significant changes to modeled air concentrations. However, because of the change in the chronic inhalation toxicity, revised risk estimates for nickel compounds are provided in Table 8-2.

**Table 8-2 Estimated Potential Inhalation Risks for the Resident and Farmer Receptors using the Current Toxicity Value for Nickel Compounds Compared to Previous Risk Estimates in the Supplemental Air Emissions Risk Analysis – Plant Site (March 2013)**

| Receptor | Evaluation Time | Maximum Modeled Air Concentration For Nickel Compounds (annual) (µg/m$^3$) | Chronic Noncancer Inhalation Toxicity Value (µg/m$^3$) | Chronic Noncancer Inhalation Risk Estimate (Hazard Quotient – Ni only) | Chronic Noncancer Inhalation Risk Estimate (Hazard Index – all compounds evaluated) | Percent Change In the Hazard Quotient | Percent Change In the Hazard Index |
|---|---|---|---|---|---|---|---|
| Resident | March 2013 | 6.18E-03 | 0.05 | 0.1 | 0.2 | | |
| | October 2014 | 6.18E-03 | 0.014 | 0.4 | 0.5 | 300 | 150 |
| | | | | | | | |
| Farmer | March 2013 | 6.18E-03 | 0.05 | 0.1 | 0.2 | | |
| | October 2014 | 6.18E-03 | 0.014 | 0.4 | 0.5 | 300 | 150 |

As identified in Table 8-2, the current nickel compounds toxicity value of 0.014 µg/m$^3$ has some effect on the previously estimated potential risks for the Resident and Farmer Receptors, but potential risks for nickel compounds and summed risks (Hazard Index) are well below the guideline value of 1, and continue to show that potential health risks are insignificant.

### 8.2.3 Cumulative

The potential additional risk from the Project is small and considered to be conservatively overestimated for this screening analysis. Detailed information regarding the cumulative risk at each of the receptors of interest is provided in Attachment P. Although there are no guideline values for cumulative risk, the estimated cumulative risk is compared below to the incremental risk guideline values for a single facility or project per MPCA risk guidance. Please note that the incremental risk guidelines were not developed for use in this manner and the comparisons below only provide a very broad context for the extent of cumulative risk.

- The Project is estimated to account for about 57% of the estimated potential cumulative acute risk. The estimated cumulative acute inhalation risk is 1 and does not exceed the incremental risk guideline value of 1.

- The Project accounts for about 7% of the estimated potential cumulative chronic noncancer risk. The estimated cumulative chronic non cancer risk is 1 and does not exceed the incremental risk guideline value of 1.

- The Project accounts for only 9% of estimated potential cumulative cancer risk. The estimated cumulative cancer risk is 4E-05, which is higher than the incremental risk guideline value is 1E-05. Background risk (3E-05) that is derived from monitored air concentrations already exceeds the incremental risk guideline value.

Because the cumulative inhalation risks presented in the March 2013 AERA (Section 11 of Attachment P) were evaluated outside the LTVSMC boundary, infants and children could be present and the current noncancer chronic toxicity value of 0.014 µg/$m^3$ is appropriate for use in revising potential risk estimates. Using the current noncancer inhalation value for nickel of 0.014 µg/$m^3$ results in a small increase in the potential inhalation risk from the Project (revised Hazard Index of 0.3), with the Project now estimated to contribute approximately 21% of the potential inhalation chronic noncancer cumulative risk. This change in the potential noncancer chronic inhalation risk does not affect the cumulative risk estimates in the March 2013 Supplemental AERA (Section 11 of Attachment P) as the Hazard Index remains below the guideline value of 1.

## 9.0 Mercury Cumulative Impacts Analysis: Local Mercury Deposition and Bioaccumulation in Fish

Modeling was conducted to assess the effects of Project mercury emissions on nearby lakes, when added to other past, present, and reasonably foreseeable future actions. Full details of the mercury cumulative impacts analysis are provided in the July 2012 report titled Local Mercury Deposition and Bioaccumulation in Fish v3 (Attachment U), as modified by the March 2013 addendum (Attachment V).

The Project changes described in Attachment A do not affect the cumulative mercury deposition and bioaccumulation in fish evaluation because the primary potential source of mercury emissions, the Autoclave Stack, is not affected by any of these changes.

### 9.1 Modeling Approach

The Cumulative Impact Analysis on local mercury deposition evaluated the net effect of the potential maximum emissions from the Project and other proposed projects and projects that recently commenced operation (i.e., projects with mercury emissions not reflected in background fish tissue mercury concentrations). The modeling approach and assumptions are detailed in the Cumulative Mercury Deposition Analysis Work Plan v2 (Appendix C of Attachment U) and summarized in Section 3 of Attachment U. In this case, the only other relevant project in the area with appreciable mercury emissions is the recently constructed Mesabi Nugget Phase I. The locations of the waterbodies included in the analysis are shown on Figure 2 of Attachment U. Two scenarios for Project mercury speciation were evaluated as described in Table 2 of Attachment U.

### 9.2 Mercury Deposition Cumulative Impacts Analysis Results

Based on the approved MPCA screening-level model, the mercury emissions from these two projects (the Project and Mesabi Nugget Phase I) could, at most, increase mercury concentrations in the fish in the nearest lakes from between 0.3% to 1.8% over current levels for both scenarios evaluated. (The current levels of mercury in the fish in selected nearby lakes already exceed the levels that trigger a fish-consumption advisory.) These results do not account for emission reductions due to mercury emissions from coal-fired power plants and taconite plants in the area, which are targeted to be reduced by 75% by 2025 under the MPCA's current Statewide Mercury Total Maximum Daily Load implementation strategy (Section 1 of Attachment U).

## 10.0 Greenhouse Gas and Climate Change Evaluation

PolyMet evaluated direct and indirect greenhouse gas (GHG) emissions from the Project, assessed the interaction between climate change and the Project, compared the GHG emissions of two metallurgical processing alternatives, and documented measures included in the Project to reduce GHG emissions. The Greenhouse Gas and Climate Change Evaluation report is included as Attachment W. Two addendums have been prepared, updating the Greenhouse Gas and Climate Change Evaluation report:

- Addendum 1 to Appendix A of the Greenhouse Gas and Climate Change Evaluation v5 (Attachment X) updates the estimated project GHG emissions based on changes to the Project that were proposed for the SDEIS after completion of the Greenhouse Gas and Climate Change Evaluation report.

- Addendum 2 to Appendix A of the Greenhouse Gas and Climate Change Evaluation v5 (Attachment Y) further updates the Project carbon footprint based proposed changes to the Project for the FEIS, as described in Attachment A.

### 10.1 Regulatory Basis

The regulatory basis for the greenhouse gas and climate change evaluation is presented in Section 2.1.1 of Attachment W. In addition to promulgated regulations, the White House Council on Environmental Quality issued draft guidance in February 2010 for addressing climate change and GHGs under the National Environmental Policy Act. This guidance was considered during the scoping process for the greenhouse gas and climate change evaluation.

There has been one significant change in the regulatory framework for greenhouse gases since the report included as Attachment W was prepared. A U.S. Supreme Court decision (Utility Air Regulatory Group (UARG) v. Environmental Protection Agency (EPA) (No. 12-1146) has prohibited EPA from requiring PSD permits for projects solely based on GHG emissions. USEPA has not finished developing guidance for the revised permitting situation, but the result of this decision is expected to be that the Project will no longer be required to have a PSD synthetic minor limit for greenhouse gases; limiting all other PSD pollutants below the major source level will be sufficient.

### 10.2 Evaluation Approach

The overall approach and methods for the greenhouse gas and climate change evaluation are described in the report scoping document (Attachment Z). Additional discussion of scope of analysis is documented in a comment and response spreadsheet and emails, also included in Attachment Z. The expected direct and indirect GHG emissions from the Project were calculated using The Climate Registry General Reporting Protocol and the MPCA General Guidance for Carbon Footprint Development in Environmental Review (Section 3.1.1 of Attachment W). Detailed descriptions of emission sources at the Mine Site and Plant Site areas are provided in

Appendix A of Attachment W, and updated in the March 2013 and December 2014 addendums (Attachment X and Attachment Y).

### 10.3 Project and Climate Change

A qualitative discussion of the interaction between climate change and the Project over the approximately 20-year operating lifetime of the Project is presented in Section 2.2 of Attachment W. The assessment includes discussion of wetlands, water resources, air quality, cover types, and threatened and endangered species.

### 10.4 Carbon Footprint of Project

The maximum total potential direct and indirect GHG emissions from the Project as proposed for the FEIS are summarized in Table 2 of Attachment Y.

### 10.5 Alternatives Analysis

Two main alternatives are available for processing the NorthMet ore: 1) hydrometallurgical processing – as proposed for the Project and 2) pyrometallurgical processing – commonly referred to as smelting. It is estimated that the hydrometallurgical process demands 50% less energy than a copper smelting process (Section 3.2 of Attachment W). Less energy demand is one indicator of potentially lower GHG emissions and possibly a lower carbon intensity.

### 10.6 GHG Reductions

As part of the Project, PolyMet is taking measures to reduce GHG emissions and decrease the carbon intensity of production by improving both energy and production efficiency. These energy and production efficiency measures include use of premium efficiency motors, electric excavators and blast hole drills, low emitting fuel for space heating, heat recycling, and building insulation, as described in Section 4.1 of Attachment W. Alternative GHG reduction measures such as biological carbon sequestration and carbon offset credits are assessed in Section 4.2 of Attachment W.

The addition of a SAG mill to the Project flow sheet for the FEIS has further reduced indirect emissions due to lower electric power demand. The estimated reduction in power demand is 1.5 MW

## Revision History

| Date | Version | Description |
|---|---|---|
| 10/04/2010 | 1 | Initial version to establish format |
| 12/01/2010 | 2 | Added information on worst case modeling inputs to Section 6.2 |
| 01/18/2011 | 3 | Added discussion of product hauling; further detail on Mine Site model input determination and corrected errors in Table 6.2-1 |
| 6/30/2013 | 4 | Major reorganization. Air Data Package now incorporates by reference all previously approved air emissions reports and memos, as summarized in Table 1. Text briefly summarizes key points and references the approved reports, which are included as attachments. |
| 1/15/2015 | 5 | Revised for FEIS. |

**References**

1. **Poly Met Mining Inc.** NorthMet Project Project Description (v8). December 2014.

2. —. NorthMet Project Air Quality Management Plan - Mine (v5). December 2014.

3. —. NorthMet Project Air Quality Management Plan - Plant (v8). December 2014.

4. —. NorthMet Project Wetland Management Plan (v5). December 2014.

5. —. NorthMet Project Mine Plan (v4). December 2014.

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| Attachment B | Air Impact Assessment Planning Summary Memo |
| Attachment C | Class I Area Air Dispersion Modeling Report |
| Attachment D | Mine Site Class II Air Quality Dispersion Modeling Protocol |
| Attachment E | Plant Site Class II Air Quality Dispersion Modeling Protocol |
| Attachment F | Mine Site Class II Air Quality Dispersion Modeling Report |
| Attachment G | Plant Site Class II Air Quality Dispersion Modeling Report |
| Attachment H | Emission Control Technology Review for NorthMet Project Processing Plant: Revised Addendum 01 Version 3 |
| Attachment I | Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore: Addendum 02 Fine Particle Air Emission Control Update Version 2 |
| Attachment J | Mercury Control Technology Review for NorthMet Project Processing Plant |
| Attachment K | Air Emission Inventory Summaries |
| Attachment L | Summary of Plant Site Emission Inventory as Updated for FEIS |
| Attachment M | Updated Nearby Source Inventory (November 2014) |
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| Attachment S | Work Plan for a Supplemental Air Emissions Risk Analysis (AERA) for the NorthMet Mine Site |
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| Attachment U | Local Mercury Deposition and Bioaccumulation in Fish |
| Attachment V | Local Mercury Deposition and Bioaccumulation in Fish Addendum 1 |
| Attachment W | Greenhouse Gas and Climate Change Evaluation v5 |
| Attachment X | Addendum 1 to Appendix A: Greenhouse Gas Emission Inventory and Energy Efficiency Analysis of the NorthMet Project Greenhouse Gas and Climate Change Evaluation v5 |
| Attachment Y | Addendum 2 to Appendix A of the Greenhouse Gas and Climate Change Evaluation v5 |
| Attachment Z | Climate Change Report Scope |

## Large Tables

**Large Table 1 Summary of Air Data Reports**

| Report | Version | Submitted | Approved | Attachment |
|---|---|---|---|---|
| **Technology Review** | | | | |
| Emission Control Technology Review for NorthMet Project Processing Plant: Revised Addendum 01 | 3 | February 2012 | March 6, 2012 | H |
| Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore: Addendum 02 | 2 | December 2011 | December 21, 2011 | I |
| Mercury Emission Control Technology Review | 2 | February 2012 | March 15, 2012 | J |
| **Class I Modeling** | | | | |
| Class I Area Air Dispersion Modeling (includes Protocol as Appendix B) | 2 | May 2012 | July 31, 2012 | C |
| Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota | 3 | January 2012 | January 24, 2012 | N |
| Assessment of Potential Ecosystem Acidification Cumulative Impacts in Northeast Minnesota | 2 | November 2011 | December 1, 2011 | O |
| **Class II modeling** | | | | |
| Mine Site Class II Air Quality Dispersion Modeling Report | 2 | August 2012 | September 21, 2012 | F |
| Mine Site Class II Air Quality Dispersion Modeling Protocol | 2 | March 2012 | April 5, 2012 | D |
| Plant Site Class II Air Quality Dispersion Modeling Report | 2 | November 2012 | December 11, 2012 | G |
| Plant Site Class II Air Quality Dispersion Modeling Protocol | 3 | May 2012 | June 12, 2012 | E |
| **Air Emissions Risk Analysis (AERA)** | | | | |
| Supplemental AERA - Mine Site | 3 | February 2013 | March 4, 2013 | R |
| Work Plan for Supplemental AERA - Mine Site | | July 2011, amended August 2012 | November 29, 2011 | S |
| Supplemental AERA - Plant Site | 3 | March 2013 | March 29, 2013 | P |
| Work Plan for Supplemental AERA- Plant Site | 2 | August 2011 | September 21, 2011 | T |
| **Mercury** | | | | |
| Cumulative Impacts Analysis: Local Mercury Deposition and Bioaccumulation in Fish | 3 | July 2012 | August 6, 2012 | U |
| Local Mercury Deposition and Bioaccumulation in Fish Addendum 01 | 2 | March 2013 | April 1, 2013 | V |
| **FEIS Project Changes** | | | | |
| NorthMet FEIS Changes and Potential Air Quality Impacts | 2 | December 2014 | TBD | A |
| **Greenhouse Gas and Climate Change Evaluation** | | | | |
| Greenhouse Gas and Climate Change Evaluation | 5 | June 2012 | July 7, 2012 | W |
| Addendum 1 to Appendix A: Greenhouse Gas Emission Inventory and Energy Efficiency Analysis of the Greenhouse Gas and Climate Change Evaluation v5 | 2 | March 2013 | April 12, 2013 | X |
| Addendum 2 to Appendix A: Greenhouse Gas Emission Inventory and Energy Efficiency Analysis of the Greenhouse Gas and Climate Change Evaluation v5 | 1 | January 2015 | TBD | Y |
| Climate Change Report Scope | 2 | April 2011 | November 9, 2011 | Z |

**Large Table 2 Operating Scenarios and Worst Case for NorthMet Plant Site Emission Units**

| SDEIS SV ID | SDEIS EU ID | Operator Description | Operating Modes: Flotation Concentrate Only | Operating Modes: Hydrometallurgical Mode | Emission Comparison for Modes | Emission Point Location Comparison for Modes | Worst Case for Initial Modeling |
|---|---|---|---|---|---|---|---|
| **Crushing Plant** | | | | | | | |
| SV003(M) | EU003 | Primary Crushing - North 60" | X | X | No difference between modes | | Hourly Potential to Emit (PTE) |
| SV004(M) | EU004 | Primary Crushing - South 60" | X | X | No difference | | Hourly PTE |
| SV401(M) | EU401 | North 60 Distribution Box and Secondary crushing - 36" Crushers | X | X | No difference | | Hourly PTE |
| SV005(M) | EU005 | North 36" Pan Feeders to Conveyor 1A | X | X | No difference | | Hourly PTE |
| SV402(M) | EU006 | North 36" Pan Feeders to Conveyor 1B | X | X | No difference | | Hourly PTE |
| SV403(M) | EU402 | South 60 distribution box and Secondary crushing - 36" Crushers | X | X | No difference | | Hourly PTE |
| SV404(M) | EU007 | South 36" Pan Feeders to Conveyor 1A | X | X | No difference | | Hourly PTE |
| | EU008 | South 36" Pan Feeders to Conveyor 1B | X | X | No difference | | Hourly PTE |
| SV008(M) | EU009 | South Pan Feeder | X | X | No difference | | Hourly PTE |
| SV009(M) | EU010 | North Pan Feeder | X | X | No difference | | Hourly PTE |
| SV405(M) | EU011 | Drive House 1 East Transfer | X | X | No difference | | Hourly PTE |
| SV406(M) | EU012 | Drive House 1 West Transfer | X | X | No difference | | Hourly PTE |
| FineCrush | EU501 | Conveyor Transfer Chute - 2A and 2B to 4B/4A | X | X | No difference | | Hourly PTE |
| FineCrush | EU403 | 2A Tripper Car | X | X | No difference | | Hourly PTE |
| SV407(M) | EU015 | Fine Crushing - East 1 | X | X | No difference | | Hourly PTE |
| | EU018 | Fine Crushing - West 1 | X | X | No difference | | Hourly PTE |
| SV014(M) | EU019 | Fine Crushing - West 2 | X | X | No difference | | Hourly PTE |
| SV408(M) | EU022 | North Transfer Point | X | X | No difference | | Hourly PTE |
| Conc B V | EU405 | 5N Tripper Car | X | X | No difference | | Hourly PTE |
| SV016(M) | EU023 | South Transfer Point | X | X | No difference | | Hourly PTE |
| Conc B V | EU406 | 5S Tripper Car | X | X | No difference | | Hourly PTE |
| | EU502 | Fine Ore Feeders - North 1-2 | X | X | No difference | Different equipment may operate at times, but independent of mode. Initial modeling will include all equipment | Hourly PTE |
| | EU503 | Conveyor Transfer: Collection Belt to Transfer Belt | X | X | No difference | | Hourly PTE |
| SV502(M) | EU504 | Conveyor Transfer: Transfer Belt to SAG Feed Belt | X | X | No difference | | Hourly PTE |
| SV503(M) | EU505 | Fine Ore Feeders - North 3-5 | X | X | No difference | | Hourly PTE |
| SV504(M) | EU506 | Fine Ore Feeders - North 6-8 | X | X | No difference | | Hourly PTE |
| SV505(M) | EU507 | Fine Ore Feeders - North 9-11 | X | X | No difference | | Hourly PTE |
| SV506(M) | EU508 | Fine Ore Feeders - North 12-14 | X | X | No difference | | Hourly PTE |
| SV507(M) | EU509 | Fine Ore Feeders - North 15-17 | X | X | No difference | | Hourly PTE |
| SV508(M) | EU510 | Fine Ore Feeders - North 18-20 | X | X | No difference | | Hourly PTE |
| SV509(M) | EU511 | Fine Ore Feeders - North 21-24 | X | X | No difference | | Hourly PTE |
| SV421(M) | EU030 | Fine Ore Feeders - South 1-3 | X | X | No difference | | Hourly PTE |
| SV422(M) | EU031 | Fine Ore Feeders - South 4-6 | X | X | No difference | | Hourly PTE |
| SV423(M) | EU032 | Fine Ore Feeders - South 7-9 | X | X | No difference | | Hourly PTE |
| SV424(M) | EU409 | Fine Ore Feeders - South 10-12 | X | X | No difference | | Hourly PTE |
| SV409(M) | EU136 | Coarse Ore Storage (West) | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU137 | Fine Ore Storage - North | X | X | No difference | | Hourly PTE |
| Conc B V | EU138 | Fine Ore Storage - South | X | X | No difference | | Hourly PTE |
| Conc B V | EU138 | Fine Ore Storage - South | X | X | No difference | | Hourly PTE |
| Conc B V | EU138 | Fine Ore Storage - South | X | X | No difference | | Hourly PTE |
| Conc B V | EU138 | Fine Ore Storage - South | X | X | No difference | | Hourly PTE |
| **General Support Equipment** | | | | | | | |
| SV108(M) | EU128 | Back-up Generator #1 | X | X | No difference | No difference | Hourly PTE |
| SV109(M) | EU129 | Back-up Generator #2 | X | X | No difference | No difference | Hourly PTE |
| Various Bldgs. | EU302 | Space Heating | X | X | No difference | No difference | Hourly PTE |
| SV304(M) | EU304 | Fire Pump #1 | X | X | No difference | No difference | Hourly PTE |
| SV305(M) | EU305 | Fire Pump #2 | X | X | No difference | No difference | Hourly PTE |
| **Waste Water Treatment Plant** | | | | | | | |
| TBWWTPBV | EU416 | Tailings Basin WWTP Acid Tank | X | X | No difference | No difference | Hourly PTE |
| TBWWTPBV | EU418 | Tailings Basin WWTP Acid Unloading | X | X | No difference | No difference | Hourly PTE |
| TBWWTPBV | EU512 | Tailings Basin WWTP Calcite Handling | X | X | No difference | No difference | Hourly PTE |
| TBWWTPBV | EU513 | Talings Basin WWTP degasifier | X | X | No difference | No difference | Hourly PTE |
| SV426 | EU412 | Tailings Basin WWTP Back-up Generator | X | X | No difference | No difference | Hourly PTE |
| **Hydrometallurgical Plant** | | | | | | | |
| SV 2532 | EU2012, EU2022 | Autoclave 1 and Flash Vessel | | X | | | |
| SV8003, SV2532 | EU3002, EU3512, EU5522, EU6002, EU1180 | Hydrometallurgical Process Tanks 1 | | X | Only operates during one mode. | No difference | Model hourly PTE. |
| SV301 | EU301 | Autoclave Startup Boiler | | X | | No difference | |
| SV328 | EU335 | Oxygen Plant Regeneration Heater | | X | | No difference | |
| SV327 | EU333 | Oxygen Plant Cooling Tower | | X | | No difference | Model hourly PTE. |
| **Flotation Concentrate Handling and Loadout** | | | | | | | |
| SV331 | EU338 | Concentrate Storage Area #1 | X | X | Mass handled may be slightly higher under Hydrometallurgical mode due to better copper recovery. | No difference | Hydrometallurgical Mode |
| SV332 | EU339 | Concentrate Storage Area #2 | X | | Only operates during one mode. | No difference | Concentrate Only |
| SV333 | EU340 | Copper Concentrate Loadout | X | X | Mass handled may be slightly higher under Copper Concentrate mode due to better copper recovery. No difference for Dry Closure. | No difference | Hydrometallurgical Mode |
| SV334 | EU341 | Nickel Concentrate Loadout | X | | Only operates during one mode. | No difference | Concentrate Only |
| **Lime and Limestone** | | | | | | | |
| | | Limestone Unloading | | X | Only operates during one mode. | No difference | |
| SV323 | EU326 | Limestone Transport to Storage Pile | | X | | No difference | |
| | | Limestone Reclaim | | X | | No difference | |
| SV322 | EU323 | Limestone Crusher | | X | | No difference | Hydrometallurgical Mode |
| Reagent V | EU220 | Lime Silo | X | X | Rough lime usage: Concentrate Only = 6,000 ton/yr; Hydrometallurgical Mode = 38,000 ton/yr; | No difference | |
| Reagent V | EU221 | Lime Conveying | X | X | | No difference | |
| SV221 | EU321 | Lime Slaker | X | X | | No difference | Hydrometallurgical Mode |
| **Other Raw Material Unloading/Storage/Handling** | | | | | | | |
| | | Flotation Flocculent | X | X | No difference | No difference | Hourly PTE |
| | | Acid Flocculent | | X | Only used during one mode. | No difference | Hydrometallurgical Mode |
| | | Xanthate Collector | X | X | No difference | No difference | Hourly PTE |
| | | Carboxymethycellulose | X | X | No difference | No difference | Hourly PTE |
| | | NaHS | | X | Only operates during one mode. | No difference | Hydrometallurgical Mode |
| | | Sulfuric Acid | | X | Only used during one mode. | No difference | Hydrometallurgical Mode |
| | | Hydrochloric Acid | | X | Only used during one mode. | No difference | Hydrometallurgical Mode |
| **Fugitive Sources** | | | | | | | |
| FS029 | FS029 | Liquid SO2 Unloading | | X | Only used during one mode. | No difference | Hydrometallurgical Mode |
| FS012 | FS012 | Unpaved Road Traffic (Dunka Road within Plant Site) | X | X | No difference | No difference | Daily PTE |
| FS016 | FS016 | Unpaved Roads, Tailings Basin Light Truck Traffic | X | X | No difference | No difference | Hourly PTE |
| FS032 | FS032 | Tailings Basin Wind Erosion | X | X | No difference | No difference | PTE |
| FS051 | FS051 | Tailings Basin Ongoing Construction | X | X | No difference | No difference | Daily PTE |

[1] The crushing plant has excess capacity, but utilization will be the same regardless of the operating mode (i.e. still processing 32,000 tpd ore)

## Attachments

**Attachment A**

**NorthMet FEIS Changes and Potential Air Quality Impacts v2**

**NorthMet FEIS Changes and Potential Air Quality Impacts**

**Version 2**

**December 2014**

**NorthMet Project**

**Poly Met Mining Incorporated**

**Hoyt Lakes, MN**

This document provides individual write-ups and attached figures and tables for the four NorthMet Project changes to be included in the Final Environmental Impact Statement that potentially affect air quality. These changes are:

1. SAG Mill
2. Coal Ash Landfill Relocation
3. Flotation Tailings Basin Containment System: East Dam Extension
4. Waste Water Treatment Plant (WWTP)

The tables and figures associated with the individual write-ups are included at the end of the document and are listed below.

**Tables:**

Table 1 - SAG Mill Crushing/Concentrator Plant Sources
Table 2 - Stacks/Sources Removed from Design
Table 3 - SDEIS/SAG Mill Stack Comparison
Table 4 - Existing, New, Removed and Modified Equipment
Table 5 - Crusher/Concentrator Building Heating Capacity
Table 6 – Crusher/Concentrator Space Heating Emissions

**Figures**:

Figure 1 - Crusher/Concentrator PFD 1 of 3

Figure 2 - Crusher/Concentrator PFD 2 of 3

Figure 3 - Crusher/Concentrator PFD 3 of 3

Figure 4 - FEIS Site Layout; Crushing and Concentrator Sources

Figure 5 - Stack Location Comparison; FEIS Compared to SDEIS

Figure 6 - FEIS Tailings Basin Layout

Large Figure 24 - EXISTING TAILINGS BASIN [Figure from Project Description, attached for convenience]

Large Figure 25 - PROPOSED FLOTATION TAILINGS BASIN LAYOUT [Figure from Project Description, attached for convenience]

# NorthMet FEIS Change Description - SAG Mill

December 2, 2014 – version 2

This document describes a proposed change to the NorthMet Project (Project) Beneficiation Process – SAG Mill addition, to be included in the Final Environmental Impact Statement (FEIS) for the Project. This write up focuses on how this proposed change may impact air emissions and air quality.

**Crusher/Concentrator Emissions**

A Semi-Autogenous Grinding (SAG) Mill and an associated Ball Mill is proposed to be installed in the Concentrator Building at the Plant Site. This proposed change affects the Crusher/Concentrator operation (i.e. the beneficiation process). The SAG Mill and the Ball Mill will replace the existing Rod and Ball Mills as well as the Tertiary and Quaternary Crushers in the Fine Crusher Building in the process flow sheet. Additional conveyors and transfer points relative to the design evaluated in the supplemental draft environmental impact statement (SDEIS) will be needed to deliver the ore to the SAG Mill, but an overall reduction in ventilation air will result, with a corresponding reduction in emissions to the air. The SAG Mill and Ball Mill are wet processes, so there will be no particulate emissions from them or need for associated particulate emission control devices. New material handling operations upstream of the SAG Mill will have the potential for particulate emissions and will be vented to the same type of cartridge filter dust collector as has been proposed previously for many of the Crusher/Concentrator emissions units.

In order to maintain operational flexibility and allow options for process optimization, PolyMet will maintain three of the seven fine crushing lines in the SAG Mill configuration along with the portion of the Coarse Ore Bin that feeds these crushers. Specifically, the East 1, West 1, and West 2 Fine Crushing Lines (EU 015, 018, and 019) will continue to be included in the Emission Inventory and air permit application and any future modeling. The 2A Tripper Car and West Coarse Ore Bin will also be included (EU 403 and EU 136).

The crushers and transfer points in the Coarse Crusher Building and Drive House #1 will remain the same as proposed for the SDEIS.

The updated process flow diagrams for the Crusher/Concentrator are attached as Figures 1 through 3.

A complete list of stacks to be included in the FEIS Emission Inventory is provided in Table 1. Equipment highlighted in yellow is being added as part of the proposed SAG Mill change, the equipment highlighted in green represents the Fine Crusher Lines and associated equipment being retained to allow operational flexibility.

Table 2 lists the equipment that will be removed from the Crusher/Concentrator Flow Sheet for the FEIS, including four of the seven existing Fine Crusher Lines, the 2B Tripper Car, the East Coarse Ore Bin and related conveyor transfer points.

The Crusher/Concentrator will continue to be configured to process an average of 32,000 tons per day of ore. This rate will be accommodated with the utilization of 14 Fine Ore Bins and their associated Fine Ore Feeders in the Concentrator Building. There are a total of 34 bins and feeders currently in the Concentrator Building and space for the original design of 36 bins. PolyMet may use the full number of Fine Ore Bins (i.e. 36) to provide surge capacity and scheduling flexibility, but only 14 Fine Ore Feeders will be operated at a given time to meet average production rates. Emission points are listed in Table 1 for all 36 Fine Ore Feeders, but actual emissions are based on 14 Fine Ore Feeders operating at a time[1]. For any

[1] Potential emissions in the FEIS Emission Inventory submitted on November 6, 2014 are based on all 36 bins operating.

air dispersion modeling required for the SAG Mill Configuration, either all 36 Fine Ore Feeders will be modeled as an artificial worst case or other measures will be used to ensure that worst case conditions are modeled (e.g. model multiple scenarios of sets of 14 Fine Ore Feeders operating to determine the worst case).

Table 3 compares the airflow for the SDEIS configuration stacks to the SAG Mill configuration stacks. For the Fine Ore Feeders on the north side of the Concentrator Building (i.e. 1N through 36N), the feeders routed to each dust collector and stack are not exactly the same for the SDEIS and SAG Mill configurations – the SDEIS feeders as shown in brackets for comparison. As shown in the totals at the bottom of the page, the total airflow in the Crusher/Concentrator is lower for the SAG Mill configuration than for the SDEIS Configuration and particulate emissions will be reduced proportionally. Table 4 provides additional comparison between the SDEIS configuration stacks and the SAG Mill configuration stacks, including emission rates and stack parameters.

Figure 4 shows the location of the stacks for the SAG Mill configuration. Figure 5 shows the location of both the SDEIS and SAG Mill stacks for comparison. As can be seen in the figures, all of the stacks are within the footprints of the existing buildings, as were the stacks for the SDEIS configuration. The heights for the SAG Mill configuration stacks will be the same as for the previously modeled stacks at a given building level. The stacks will be sized to provide a similar exit velocity to those modeled for the SDEIS (see Table 4). The stack exhaust temperatures will be essentially ambient as was modeled for the SDEIS (77 degrees Fahrenheit).

**Space Heating**

Proposed heating capacities to be modeled, by building, are shown Table 5. The Coarse Crusher Building and Drive House #1 would be unchanged from the SDEIS. The reduced Fine Crusher Building heating demand was estimated based on the proposal to include three of the seven existing fine crushing lines in the emission inventory as spare equipment and/or for use in optimizing SAG Mill performance. The reduced work areas of the Fine Crusher Building would require heating under the proposed configuration and as necessary barriers, insulation, or other engineered means would be installed. The Concentrator Building demand is based on the SDEIS modeled value of 34.08 MMBtu/hr plus the increase for the SAG Mill Configuration of 2.874 MMBtu/hr as determined by the Project mechanical design consultant, KFI (34.08 MMBtu/hr + 2.874 MMBtu/hr = 36.95 MMBtu/hr). The overall reduction in heating demand as compared to the modeled values for the SDEIS is 3.5 MMBtu/hr. The natural gas heaters are a minor contributor to particulate emissions and are more important for $NO_x$ modeling at the property line (Class II) and visibility modeling in the Boundary Waters (Class I). A comparison of $NO_x$ and PM emissions from space heating for each Crusher/Concentrator building for the SDEIS and SAG mill configurations is shown in Table 6.

# NorthMet FEIS Change Description – Coal Ash Landfill Relocation

December 2, 2014 – version 2

PolyMet is proposing to relocate the Coal Ash Landfill which is currently located within the footprint of the future Flotation Tailings Basin (FTB). This document describes how this proposed change to the NorthMet Project (Project), which will be included in the Final Environmental Impact Statement (FEIS), may impact air emissions and air quality.

**Background**

The Coal Ash Landfill (Landfill) is located on the east side of the former LTV Steel Mining Company (LTVSMC) Tailings Basin Cell 1E in Township 59, Range 14, Section 10, in approximately the northeast quarter, as shown on Large Figure 24 (attached) from the updated Project Description. The Coal Ash Landfill was operated by LTVSMC to accept coal ash from LTV's Taconite Harbor facility and coal contaminated soil from the LTVSMC abandoned coal yard. The Landfill was closed per the "Closure Plan for the Tailings Basin Coal Ash Disposal Area" (Plan) prepared by Wenck Associates for LTVSMC in May 2000, and filed with the Minnesota Pollution Control Agency (MPCA). The Landfill ceased accepting coal ash on approximately August 1, 2000.

Per the Plan, the Landfill was closed as follows:

1. The coal ash pile was compacted and graded to a slope between 3 and 20 percent.
2. A 6-inch buffer layer consisting of LTVSMC tailings was placed over the coal ash pile.
3. A minimum 40-mil linear low-density polyethylene synthetic flexible membrane liner was installed.
4. A minimum of 6 inches of tailings was installed over the liner.
5. Twelve inches of soil fill were placed and graded.
6. Six inches of vegetation supporting topsoil was placed.
7. The final covered area was seeded and mulched.

The final footprint of the Landfill is estimated to cover approximately 4 acres and contain approximately 260,000 cubic yards total of material (including coal ash, tailings, and soil covers).

The current footprint of the Landfill lies within the future footprint of an area to be inundated by NorthMet Project flotation tailings. To mitigate environmental risks, PolyMet proposes to relocate the Landfill to an appropriate storage facility. The Hydrometallurgical Residue Facility (HRF) is part of the planned NorthMet Project and is an appropriate storage facility. This double-lined facility is currently planned to be constructed and commissioned prior to the time period at which the Landfill should be relocated.

Currently it is estimated the transport of the landfilled material could be accomplished using five to six, sixty-ton capacity mining haul trucks to move the material over an approximate two and one-half mile haul (one-way). The materials would be removed from the landfill using a tracked excavator or front end loader. Other equipment utilized would consist of a grader, dozer, and water truck. It is expected it would take approximately fifty shifts (8-hour shifts) to move this material. This effort would require no new roads as existing tailings basin roads would be utilized. Some economies could be realized by utilizing other road grading and watering equipment likely in use for other tailings basin construction activities at that time.

**Potential Air Emissions and Impacts**

In order to develop a movement schedule for this activity, it was assumed that five 60-ton trucks would operate for eight hours per day. This results in 48 days being needed to complete the transportation of the coal ash. Approximately 160 round trips would be required during each 8-hour shift.

As noted above, the coal ash will be placed in the HRF. The time window available to conduct this work is between the time when the HRF is constructed and commissioned and the inundation of the current location of the coal ash landfill. Therefore, this operation could occur roughly from Year 2 until Year 6. The trucks transporting the coal ash would travel on parts of Tailings Basin Haul Road N and J and on the Tailings WWTP Road and the HydroMet Residue Facility Road (see route on Figure 6 – note: existing roads would be used although that may not be clear on the figure). The traffic level for this activity, based on trips per day, is below the maximum activity on any of the road segments that will be travelled (see Table 1). Therefore, if this work is done during Mine Year 2, it will not create a new worst case because there is currently no FTB Dam construction scheduled for Mine Year 2 (there may be some HRF construction, but this necessarily must be completed before the coal ash is transported).

Mine Years 3 through 6 have moderately busy traffic levels on Tailings Basin Haul Road J. However, the movement schedule is based on construction activities only occurring at the Tailings Basin five days per week. Class I and Class II modeling assumed the emissions occur seven days per week. Therefore, the additional construction traffic for hauling the coal ash can be accommodated in Mine Years 3 through 6 by extending work at the Tailings Basin to seven days per week for roughly one construction season (22 week season * 2 weekend days = 44 available days for construction). As described below, the activity levels would be lower for this work than the modeled worst case for FTB dam and HRF construction. Table 1 compares the traffic levels for the coal ash hauling to the modeled worst case values for dam construction; the coal ash hauling traffic is less than the modeled rate for each road segment affected.

The tailpipe emission calculations assumed that at least 12 haul trucks would be operated at the Tailings Basin and as noted above, the coal ash movement schedule is based on five trucks. Therefore, a new worst case for fugitive dust or tailpipe emissions would not be created and the relocation of the Coal Ash Landfill can be accomplished under the modeling assumptions used for the Supplemental Draft Environmental Impact Statement (SDEIS). Tailpipe emission calculations are included in the emission inventory as Scenario 1B/2B. Note: these emissions would only occur when the regular Scenario 1 or Scenario 2 emissions are not occurring. Emissions are lower for the Coal Ash Landfill Relocation work than for either the Scenario 1 or Scenario 2 Tailings Basin Dam construction. For example, during Coal Ash Landfill Relocation, $NO_x$ emissions are 109 lb/day and the $NO_x$ emissions during Tailing Basin Dam construction are 517 lb/day for Scenario 1 and 251 lb/day for Scenario 2.

**Table 1 NorthMet Project – Coal Ash Landfill Relocation**
**Traffic Level Comparison**

| TB Haul Road | Trips per Day | | Notes |
|---|---|---|---|
| | SDEIS Modeling | FEIS Coal Ash Haul | |
| TB N | 473 | 160 | SDEIS Modeling = Mine Year 7 |
| TB J | 300 | 160 | SDEIS Modeling = Mine Year 3 |
| WWTP Rd | 402 | 160 | SDEIS Modeling = Worst case for all years |
| HydroMet Rd | 358 | 160 | SDEIS Modeling = Worst case for all years |

The trucks transporting the coal ash must also be loaded and unloaded. Approximately 9,600 tons per day would be loaded at the Landfill and unloaded at the HRF. The SDEIS modeled material handling value at the HRF was about 24,000 tons/day, so unloading the coal ash does not create a new worst case. A material handling source was not located exactly at the Landfill in the SDEIS modeling, but a road source was located right at the border of the landfill and material handling emissions were modeled to the southwest. Truck loading of borrow material at Material Handling Source S3 and unloading of material at Material Handling Source 1ES (see Figure 6) were both modeled at about 30,700 tons per day. These sources are closer to the ambient air boundary than the Landfill. To the northeast at the Material Handling Source at Area 5, a truck loading rate of about 26,400 tons per day was modeled. Therefore, much greater quantities were modeled for truck loading and unloading to the northeast and southwest of the coal ash landfill and impacts are not expected be greater than the results of the SDEIS modeling for the coal ash truck loading operation.

**NorthMet FEIS Change Description – Flotation Tailings Basin Containment System: East Dam Extension**

Version 2 - December 2, 2014

This document describes the potential for air quality impacts due to a change to the NorthMet Project (Project) that will be incorporated into the Project Description for the Final Environmental Impact Statement (FEIS). The change is the extension of the FTB Containment System to the East Dam at the Flotation Tailings Basin (FTB) (see Large Figure 25 from updated Project Description (ver. 6, November 2014)).

The East Dam segment of the FTB Containment System will have the same design as the rest of the system, with a cutoff wall and collection trench with slotted drain pipe. Potential air emission sources include: cutoff wall and trench excavation, hauling and placement of fill, and tailpipe emissions from construction equipment. The installation of the East Dam segment of the FTB Containment System is expected to occur during Mine Year 6. Construction is expected to last approximately five months.

The quantity of fill required has been estimated as approximately 1,400 cubic yards of aggregate and 6,400 cubic yards of common borrow (silty sand and gravel). This is equivalent to about 14,000 tons of fill material. Assuming trucks with a 60-ton payload would be used to haul this material, as for FTB dam construction, this corresponds to approximately 230 truck trips to haul the required fill.

During Mine Year 6 at the FTB, dams will be constructed from excavated LTV Steel Mining Company (LTVSMC) tailings or other borrow material. During Mine Year 6, almost 2 million tons of borrow material will be used to build dams at the FTB, requiring about 32,000 truck trips. The amount of fill associated with the East Dam segment of the FTB Containment System is less than 1% of the quantity of material needed for FTB dam construction in Mine Year 6. The dam construction is included in the Plant Site Emission Inventory and was included in air quality modeling completed for the Supplemental Draft Environmental Impact Statement (SDEIS). Dam construction will also occur during other years of FTB operation and Mine Year 6 was not worst case for borrow material handling or traffic on any of the FTB roads (e.g. almost 5 million tons are projected to be handled in Mine Year 3). Therefore, the additional activity in Mine Year 6 to install the East Dam segment of the FTB Containment System will not create a new worst case and will not require additional modeling for the FEIS.

The source of the fill material has not been determined, but a reasonable assumption is that it would be hauled on Tailings Haul Road N and part of Tailings Haul Road J (see Figure 6). These road sections are close to the ambient air boundary and would be most likely to affect modeled impacts if there was an emission increase. The modeled worst case for Road N occurs during Mine Year 7 and is based on 383 trips per day. There are currently no trips assigned to Road N during Mine Year 6; a maximum of 5 trips per day are expected for the East Dam Containment System construction. The modeled worst case for Road J is during Mine Year 3 and is based on 300 trips per day. During Mine Year 6 the maximum trips per day on Road J is also 300, but there is sufficient flexibility in the construction schedule to allow one haul truck to be reassigned to haul fill for the East Dam segment of the FTB Containment System construction on 83 days of the 110 day construction schedule. This results in 288 trips per day on Road J, so the addition of 5 trips per day from the construction of the East Dam segment of the FTB Containment System would not create a new worst case. See Table 1 below for additional details.

**Table 1 NorthMet Project – East Dam Extension Traffic Level Comparison**

| TB Haul Road | Trips per Day | | | | Notes |
|---|---|---|---|---|---|
| | SDEIS Modeling Worst Case | Mine Year 6 | East Dam Containment Extension | Mine year 6 with East Dam Extension | |
| TB N | 473 | 0 | 5 | 5 | SDEIS Modeling = Mine Year 7 |
| TB J | 300 | 288 [1] | 5 | 293 | SDEIS Modeling = Mine Year 3 |

[1] For 83 out of 110 days of the construction season.

As noted above, the quantity of fill handled for the East Dam segment of the FTB Containment System is less than 1% of the quantity handled for dam construction during Mine Year 6, so no significant increase in tailpipe emissions are expected to occur. Specifically, emissions for the East Dam segment of the FTB Containment System were estimated to be 12.1 lb/day $NO_x$. This is about 5% of the 251.2 lb/day $NO_x$ for Tailings Basin Construction Activities in Scenario 2 (Mine Years 6 – 8). If these emissions are added together, the combined emissions would be 251.2 + 12.1 = 263.3 lb/day (Table 2). This combined quantity for Scenario 2 (263.3 lb/day $NO_x$) is less than the quantity modeled for Scenario 1 (517.4 lb/day $NO_x$). Even including the modeled quantities of emissions at the Mine Site (see Table 2), a new worst case scenario will not be created based on tailpipe emissions.

The AERA modeling was based on the worst case scenario, SDEIS Scenario 1, so this change would not result in an increase in modeled toxic pollutant emissions.

Some peat containing soils may be excavated as part of the installation of the East Dam segment of the FTB Containment System, which could lead to stockpiling of additional peat at the Plant Site. Carbon footprint calculations will be amended, if necessary, to account for any additional carbon dioxide emission resulting from the oxidation of peat.

**Table 2 – Modeled Mining and Construction Equipment $NO_x$ Emission Rates**

| Scenario | Number of Haul Trucks at Tailings Basin | Modeled NOx – Tailings Basin Construction (lb/day) | Modeled NOx – Tailings Basin Construction plus East Dam (lb/day) | Modeled NOx – Mine Site Mining Equipment (lb/day) | Total Modeled NOx - Tailings Basin + Mine Site (lb/day) |
|---|---|---|---|---|---|
| 1 (Mine Years 1 – 5) | 28 | 517.4 | na | 1264.8 | 1782.2 |
| 2 (Mine Years 6 – 8) | 12 | 251.2 | 251.2 + 12.1 = **263.3** | 1224.9 | 1488.2 |
| 3 (Mine Years 9-10) | 12 | 251.2 | na | 1237.5 | 1488.7 |
| 4 (Mine Years 11-20) | 16 | 317.8 | na | 865.4 | 1183.2 |

na = not applicable as east dam containment system extension to be constructed in Mine Year 6

**NorthMet FEIS Change Description - WWTP**

December 2, 2014 – version 2

This document describes proposed changes to the NorthMet Project (Project) Tailings Basin Waste Water Treatment Plant (WWTP) to be included in the Final Environmental Impact Statement (FEIS) Air Emission Inventory for the Project.

## Background

Changes in plans for stream augmentation have resulted in the need for additional water treatment at the WWTP in the early years of the Project. Additionally, further design details have been developed for the WWTP in the time since the emission calculations were last updated (ver. 7, February 2013). The updated Emission Inventory prepared for the FEIS incorporates the additional design details and accounts for the increased water volume.

## Summary of Potential FEIS Changes

*Use of Carbon Dioxide for pH adjustment*

Carbon dioxide ($CO_2$) will be the primary means of pH reduction for the Vibratory Shear Enhanced Process (VSEP) treatment unit in the WWTP. The estimated usage for $CO_2$ is about 650 tons per year (tpy) and the efficiency of the process is estimated as 95% to 99% (i.e. only 1 to 5% of the $CO_2$ used would be potentially vented to the air) as described in the $CO_2$ emissions section below. Hydrochloric acid will continue to be an option for pH adjustment for the primary membranes.

*Waste Hauled by Rail*

The SDEIS emission inventory includes truck traffic to transport solids from the WWTP to Hydrometallurgical Residue facility (HRF) and concentrate from the WWTP to the Mine Site Waste Water Treatment Facility (WWTF). The current plan, developed late in the SDEIS process, is to haul all VSEP concentrate to the WWTF via railcars attached to ore trains returning to the Mine Site. Solids are not produced by the latest WWTP design. An emission reduction could be obtained by eliminating the truck traffic, but for the FEIS emission inventory, the truck traffic has been left in to allow maximum overall flexibility.

*Space Heating Switched to Electric*

The natural gas fired space heaters in the WWTP may be switched to electric. This would result in a direct emission reduction. Emissions from natural gas fired space heaters in the SDEIS emission inventory are 0.3 tpy $PM_{10}/PM_{2.5}$ and 4,250 tpy $CO_2$. However, there would be a corresponding increase in electricity usage for electric heaters and therefore indirect greenhouse gas emissions (see electricity usage section below). For the FEIS emission inventory, the natural gas space heaters have been included to allow maximum flexibility going forward.

*Calcite Usage*
Based on a maximum of 730 tpy calcite usage, $PM_{10}$ emissions will be about 0.007 tpy and $PM_{2.5}$ emissions will be about 0.004 tpy. Some fraction of the carbon in the calcite could also be released to the atmosphere as $CO_2$ – see $CO_2$ emissions section below.

*Emergency Generator*
A 500 electrical kilowatt (ekW) emergency generator was included in the SDEIS emission inventory to keep critical systems at the WWTP operating during power failure. This generator is also anticipated to be large enough to power critical systems for the Project as described in the FEIS.

*$CO_2$ Emissions*
The total $CO_2$ emissions from the wastewater treatment process, from $CO_2$ and calcite usage, were determined through modeling of the degasifier, which would be the point in the WWTP where any $CO_2$ would be emitted. The results were that less than 150 lb/day of $CO_2$ will be emitted from the process.

**Effect of Emission Changes on Air Impacts**
As discussed above, there are very small additional emissions of particulate matter and $CO_2$ from the handling and usage of process chemicals. There is also a potential reduction in fugitive dust from the transport of waste products that has not been quantified to date. All emissions at the WWTP are assumed to exhaust through general building ventilation (vent ID: TBWWTPBV), so there is no change to the emission point. With no emission point configuration changes and little or no emissions increase (maximum increase of less than 0.005% of Plant Site point source emissions for $PM_{10}$ and $PM_{2.5}$ and less than 0.05% for greenhouse gas emissions), there are no expected air impacts from the changes proposed at the WWTP.

**Changes in Electricity Usage**
Any changes in electricity usage will be identified and quantified for the FEIS along with associated changes in indirect greenhouse gas emissions. This analysis will be included in a separate carbon footprint document.

## Table 1 - SAG Mill Crushing/Concentrator Plant Sources

| SV | EU | Description | ACFM | Stack Height (ft) | Exit Diam (ft) | Notes |
|---|---|---|---|---|---|---|
| Coarse Crusher Building | | | | | | |
| SV 003 | EU 003 | North 60" Crusher | 159000 | 130 | 6.5 | |
| SV 004 | EU 004 | South 60" Crusher | 159000 | 130 | 6.5 | |
| SV 401 | EU 401 | North 60 Distribution Box and 36" Crushers | 30300 | 130 | 3.2 | |
| SV 005 | EU 005 | North 36" Pan Feeders to Conveyor 1A | 22000 | 128 | 2.2 | |
| SV 402 | EU 006 | North 36" Pan Feeders to Conveyor 1B | 22000 | 68 | 2.7 | |
| SV 403 | EU 402 | South 60 Distribution Box and 36" Crushers | 30300 | 130 | 3.2 | |
| SV 404 | EU 007 | South 36" Pan Feeders to Conveyor 1A | 22000 | 128 | 2.7 | |
| SV 008 | EU 008 | South 36" Pan Feeders to Conveyor 1B | 22000 | | | |
| SV 008 | EU 009 | South Pan Feeders | 17400 | 130 | 3.8 | |
| SV 009 | EU 010 | North Pan Feeders | 17400 | 68 | 2.5 | |
| Drive House #1 | | | | | | |
| SV 405 | EU 011 | Drive House 1 East Transfer | 13800 | 52 | 2.2 | |
| SV 406 | EU 012 | Drive House 1 West Transfer | 13800 | 52 | 2.2 | |
| Fine Crusher Building | | | | | | |
| Fine Crush | EU 501 | Conveyor Transfer Chute - 2A and 2B to 4B/4A (Fine Crusher Building) | 24,200 | NA | NA | |
| FineCrush | EU 403 | 2A Tripper Car | 5,000 | NA | NA | |
| SV 409 | EU 136 | West - Coarse Ore Bin | 46,400 | 144.4 | 4.0 | |
| SV 407 | EU 015 | E1 Crushing Line | 51,800 | 150 | 4.0 | |
| | EU 018 | W1 Crushing Line | 48,000 | | | |
| SV 014 | EU 019 | W2 Crushing Line | 51,800 | 150 | 5.8 | Diameter Adjusted for Airflow |
| Concentrator Building | | | | | | |
| SV 408 | EU 022 | North Transfer Point (4B to 5N) | 15,400 | 63 | 63 | |
| Conc B V | EU 405 | 5N Tripper Car | 5,000 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - North | 4,400 | NA | NA | |
| Conc B V | EU0137 | Fine Ore Storage - North | 4,400 | NA | NA | |
| | EU 502 | Fine Ore Feeders - North 1N-2N | 19,100 | | | |
| | EU 503 | Conv. Trans. Collection Belt to Transfer Belt | 5,200 | | | |
| SV 502 | EU 504 | Conv. Trans. Transfer Belt to SAG Feed Belt | 3,100 | 63 | 3 | |
| SV 503 | EU 505 | Fine Ore Feeders - North 3N-5N | 27,400 | 63 | 3 | |
| SV 504 | EU 506 | Fine Ore Feeders - North 6N-8N | 27,400 | 63 | 3 | |
| SV 505 | EU 507 | Fine Ore Feeders - North 9N-11N | 27,400 | 63 | 3 | |
| SV 506 | EU 508 | Fine Ore Feeders - North 12N-14N | 27,400 | 63 | 3 | |
| SV 016 | EU 023 | South Transfer Point | 15,400 | 63 | 2.3 | |
| Conc B V | EU 406 | 5S Tripper Car | 5,000 | NA | NA | |
| Conc B V | | Fine Ore Storage - South | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - South | 4,400 | NA | NA | |
| Conc B V | | Fine Ore Storage - South | 4,400 | NA | NA | |
| Conc B V | EU 138 | Fine Ore Storage - South | 4,400 | NA | NA | |
| SV 507 | EU 509 | Fine Ore Feeders - North 15N-17N | 27,400 | 63 | 3 | |
| SV 508 | EU 510 | Fine Ore Feeders - North 18N-20N | 27,400 | 63 | 3 | |
| SV 509 | EU 511 | Fine Ore Feeders - North 21N-24N | 36,533 | 63 | 3.46 | Diameter adjusted for airflow |
| SV 421 | EU 030 | Fine Ore Feeders - South 1S-3S | 27,400 | 63 | 3 | Left in SDEIS Stack ID - same lines |
| SV 422 | EU 031 | Fine Ore Feeders - South 4S-6S | 27,400 | 63 | 3 | Left in SDEIS Stack ID - same lines |
| SV 423 | EU 032 | Fine Ore Feeders - South 7S-9S | 27,400 | 63 | 3 | Left in SDEIS Stack ID - same lines |
| SV 424 | EU 409 | Fine Ore Feeders - South 10S-12S | 27,400 | 63 | 3 | Left in SDEIS Stack ID - same lines |
| NA | NA | SAG Mill | NA | NA | NA | Wet process, no emissions |
| NA | NA | Ball Mill | NA | NA | NA | Wet process, no emissions |

New Equipment

Existing Equipment Included to Retain Operational Flexibility

## Table 2 - Stacks/Sources Removed from Design

| SV | EU | Description | ACFM | Stack Height (ft) | Exit Diam (ft) | Notes |
|---|---|---|---|---|---|---|
| FineCrush | EU 404 | 2B Tripper Car | 5000 | NA | NA | |
| SV 410 | EU 136 | East - Coarse Ore Bin | 46400 | 144.4 | 4.0 | EU 136 in SDEIS inventory also included the West Coarse Ore Bin |
| SV 014 | EU 021 | 3A & 3B Conveyor Transfer to Conveyor 4B & 4A | 24200 | 160 | 6.5 | 24,200 ACFM is the reduction in SV 014 airflow from the removal of this source. The equipment venting to SV 014 still in the process flowsheet is shown in Table 1. |
| SV 012 | EU 014 | Fine Crushing - West 4 | 51800 | 151 | 4.0 | |
| SV 013 | EU 016 | Fine Crushing - East 2 | 51800 | 150 | 6 | |
| SV 013 | EU 017 | Fine Crushing - East 3 | 51800 | | | |
| SV 013 | EU 020 | Fine Crushing - West 3 | 51800 | | | |

## Table 3 - SDEIS/SAG Mill Stack Comparison

| SDEIS SV | SAG SV | EU | Description | SDEIS ACFM | SAG ACFM |
|---|---|---|---|---|---|
| **Coarse Crusher Building** | | | | | |
| SV 003 | SV 003 | EU 003 | North 60" Crusher | 159000 | 159000 |
| SV 004 | SV 004 | EU 004 | South 60" Crusher | 159000 | 159000 |
| SV 401 | SV 401 | EU 401 | North 60 Distribution Box and 36" Crushers | 30300 | 30300 |
| SV 005 | SV 005 | EU 005 | North 36" Pan Feeders to Conveyor 1A | 22000 | 22000 |
| SV 402 | SV 402 | EU 006 | North 36" Pan Feeders to Conveyor 1B | 22000 | 22000 |
| SV 403 | SV 403 | EU 402 | South 60 Distribution Box and 36" Crushers | 30300 | 30300 |
| SV 404 | SV 404 | EU 007 | South 36" Pan Feeders to Conveyor 1A | 22000 | 22000 |
| SV 008 | SV 008 | EU 008 | South 36" Pan Feeders to Conveyor 1B | 22000 | 22000 |
| SV 008 | SV 008 | EU 009 | South Pan Feeders | 17400 | 17400 |
| SV 009 | SV 009 | EU 010 | North Pan Feeders | 17400 | 17400 |
| **Drive House #1** | | | | | |
| SV 405 | SV 405 | EU 011 | Drive House 1 East Transfer | 13800 | 13800 |
| SV 406 | SV 406 | EU 012 | Drive House 1 West Transfer | 13800 | 13800 |
| **Fine Crusher Building** | | | | | |
| NA | FineCrush | EU 501 | Conveyor Transfer Chute - 2A and 2B to 4B/4A (Fine Crusher Building) | NA | 24,200 |
| SV 012 | NA | EU 014 | Fine Crushing - West 4 | 51800 | NA |
| SV 013 | NA | EU 016 | Fine Crushing - East 2 | 51800 | NA |
| SV 013 | NA | EU 017 | Fine Crushing - East 3 | 51800 | NA |
| SV 013 | NA | EU 020 | Fine Crushing - West 3 | 51800 | NA |
| FineCrush | FineCrush | EU 403 | 2A Tripper Car | 5,000 | 5,000 |
| FineCrush | NA | EU 404 | 2B Tripper Car | 5000 | NA |
| SV 409 | SV 409 | EU 136 | West - Coarse Ore Bin | 46,400 | 46,400 |
| SV 410 | NA | EU 136 | East - Coarse Ore Bin | 46400 | NA |
| SV 407 | SV 407 | EU 015 | E1 Crushing Line | 51,800 | 51,800 |
| SV 014 | SV 014 | EU 018 | W1 Crushing Line | 48,000 | 48,000 |
| | | EU 019 | W2 Crushing Line | 51,800 | 51,800 |
| | | EU 021 | 3A & 3B Conveyor Transfer to Conveyors 4B & 4A | 24,200 | NA |
| **Concentrator Building** | | | | | |
| SV 408 | SV 408 | EU 022 | North Transfer Point (4B to 5N) | 15,400 | 15,400 |
| Conc B V | Conc B V | EU 405 | 5N Tripper Car | 5,000 | 5,000 |
| Conc B V | Conc B V | EU0137 | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 4,400 |
| | | EU 502 | Fine Ore Feeders - North 1N-2N {was 1N-3N} | | 19,100 |

## Table 3 - SDEIS/SAG Mill Stack Comparison

| SDEIS SV | SAG SV | EU | Description | SDEIS ACFM | SAG ACFM |
|---|---|---|---|---|---|
| SV 413 | SV 502 | EU 503 | Conv. Trans. Collection Belt to Transfer Belt | 27,400 | 5,200 |
| | | EU 504 | Conv. Trans. Transfer Belt to SAG Feed Belt | | 3,100 |
| SV 414 | SV 503 | EU 505 | Fine Ore Feeders - North 3N-5N {was 4N-6N} | 27,400 | 27,400 |
| SV 415 | SV 504 | EU 506 | Fine Ore Feeders - North 6N-8N {was 7N-9N} | 27,400 | 27,400 |
| SV 416 | SV 505 | EU 507 | Fine Ore Feeders - North 9N-11N {was 10N-12N} | 27,400 | 27,400 |
| SV 417 | SV 506 | EU 508 | Fine Ore Feeders - North 12N-14N {was 13N-15N} | 27,400 | 27,400 |
| SV 016 | SV 016 | EU 023 | South Transfer Point | 15,400 | 15,400 |
| Conc B V | Conc B V | EU 406 | 5S Tripper Car | 5,000 | 5,000 |
| Conc B V | Conc B V | EU 138 | Fine Ore Storage - South | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - South | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - South | 4,400 | 4,400 |
| Conc B V | Conc B V | | Fine Ore Storage - South | 4,400 | 4,400 |
| SV 418 | SV 507 | EU 509 | Fine Ore Feeders - North 15N-17N {was 16N-18N} | 27,400 | 27,400 |
| SV 419 | SV 508 | EU 510 | Fine Ore Feeders - North 18N-20N {was 19N-21N} | 27,400 | 27,400 |
| SV 420 | SV 509 | EU 511 | Fine Ore Feeders - North 21N-24N {was 22N-24N} | 27,400 | 36,533 |
| SV 421 | SV 421 | EU 030 | Fine Ore Feeders - South 1S-3S | 27,400 | 27,400 |
| SV 422 | SV 422 | EU 031 | Fine Ore Feeders - South 4S-6S | 27,400 | 27,400 |
| SV 423 | SV 423 | EU 032 | Fine Ore Feeders - South 7S-9S | 27,400 | 27,400 |
| SV 424 | SV 424 | EU 409 | Fine Ore Feeders - South 10S-12S | 27,400 | 27,400 |
| NA | NA | NA | SAG Mill | NA | NA |
| NA | NA | NA | Ball Mill | NA | NA |
| **Total Airflow** | | | | 1,437,200 | 1,187,733 |

New Equipment

Existing Equipment Included to Retain Operational Flexibility

**Table 4 - Existing, New, Removed and Modified Equipment**

| | | | | SDEIS Parameters | | | | | | SAG (FEIS) Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SDEIS SV | SAG SV | EU | Description | ACFM | PM CPTE [1] lb/hr | PM CPTE ton/yr | Exist Temp (F) | Stack Height (ft.) | Stack Diam. (ft.) | SAG ACFM | PM CPTE lb/hr | PM CPTE ton/yr | Exist Temp (F) | Stack Height (ft.) | Stack Diam. (ft.) |
| **Coarse Crusher Building** | | | | | | | | | | | | | | | |
| SV 003 | SV 003 | EU 003 | North 60" Crusher | 159000 | 3.41 | 14.92 | 77 | 130 | 6.5 | 159000 | 3.41 | 14.92 | 77 | 130 | 6.5 |
| SV 004 | SV 004 | EU 004 | South 60" Crusher | 159000 | 3.41 | 14.92 | 77 | 130 | 6.5 | 159000 | 3.41 | 14.92 | 77 | 130 | 6.5 |
| SV 401 | SV 401 | EU 401 | North 60 Distribution Box and 36" Crushers | 30300 | 0.65 | 2.84 | 77 | 130 | 3.2 | 30300 | 0.65 | 2.84 | 77 | 130 | 3.2 |
| SV 005 | SV 005 | EU 005 | North 36" Pan Feeders to Conveyor 1A | 22000 | 0.47 | 2.06 | 77 | 128 | 2.2 | 22000 | 0.47 | 2.06 | 77 | 128 | 2.2 |
| SV 402 | SV 402 | EU 006 | North 36" Pan Feeders to Conveyor 1B | 22000 | 0.47 | 2.06 | 77 | 68 | 2.7 | 22000 | 0.47 | 2.06 | 77 | 68 | 2.7 |
| SV 403 | SV 403 | EU 402 | South 60 Distribution Box and 36" Crushers | 30300 | 0.65 | 2.84 | 77 | 130 | 3.2 | 30300 | 0.65 | 2.84 | 77 | 130 | 3.2 |
| SV 404 | SV 404 | EU 007 | South 36" Pan Feeders to Conveyor 1A | 22000 | 0.47 | 2.06 | 77 | 128 | 2.7 | 22000 | 0.47 | 2.06 | 77 | 128 | 2.7 |
| | | EU 008 | South 36" Pan Feeders to Conveyor 1B | 22000 | 0.47 | 2.06 | | | | 22000 | 0.47 | 2.06 | | | |
| SV 008 | SV 008 | EU 009 | South Pan Feeders | 17400 | 0.37 | 1.63 | 77 | 130 | 3.8 | 17400 | 0.37 | 1.63 | 77 | 130 | 3.8 |
| SV 009 | SV 009 | EU 010 | North Pan Feeders | 17400 | 0.37 | 1.63 | 77 | 68 | 2.5 | 17400 | 0.37 | 1.63 | 77 | 68 | 2.5 |
| **Drive House #1** | | | | | | | | | | | | | | | |
| SV 405 | SV 405 | EU 011 | Drive House 1 East Transfer | 13800 | 0.30 | 1.30 | 77 | 52 | 2.2 | 13800 | 0.30 | 1.30 | 77 | 52 | 2.2 |
| SV 406 | SV 406 | EU 012 | Drive House 1 West Transfer | 13800 | 0.30 | 1.30 | 77 | 52 | 2.2 | 13800 | 0.30 | 1.30 | 77 | 52 | 2.2 |
| **Fine Crusher Building** | | | | | | | | | | | | | | | |
| NA | FineCrush | EU 501 | Conveyor Transfer Chute - 2A and 2B to 4B/4A (Fine Crusher Building) | NA | 0 | 0 | NA | NA | NA | 24,200 | 0.52 | 2.27 | NA | NA | NA |
| SV 012 | NA | EU 014 | Fine Crushing - West 4 | 51800 | 1.11 | 4.86 | 77 | 151 | 4 | NA | 0 | 0 | NA | NA | NA |
| SV 013 | NA | EU 016 | Fine Crushing - East 2 | 51800 | 1.11 | 4.86 | 77 | | | NA | 0 | 0 | NA | NA | NA |
| SV 013 | NA | EU 017 | Fine Crushing - East 3 | 51800 | 1.11 | 4.86 | 77 | | | NA | 0 | 0 | NA | NA | NA |
| SV 013 | NA | EU 020 | Fine Crushing - West 3 | 51800 | 1.11 | 4.86 | 77 | 150 | 6 | NA | 0 | 0 | NA | NA | NA |
| FineCrush | FineCrush | EU 403 | 2A Tripper Car | 5,000 | 0.11 | 0.47 | 77 | NA | NA | 5,000 | 0.11 | 0.47 | 77 | NA | NA |
| FineCrush | NA | EU 404 | 2B Tripper Car | 5000 | 0.11 | 0.47 | 77 | NA | NA | NA | 0 | 0 | NA | NA | NA |
| SV 409 | SV 409 | EU 136 | West - Coarse Ore Bin | 46,400 | 0.99 | 4.35 | 77 | 144.4 | 4 | 46,400 | 0.99 | 4.35 | 77 | 144.4 | 4 |
| SV 410 | NA | EU 136 | East - Coarse Ore Bin | 46400 | 0.99 | 4.35 | 77 | 144.4 | 4 | NA | 0 | 0 | 77 | NA | NA |
| SV 407 | SV 407 | EU 015 | E1 Crushing Line | 51,800 | 1.11 | 4.86 | 77 | 150 | 4 | 51,800 | 1.11 | 4.86 | 77 | 150 | 4 |
| | | EU 018 | W1 Crushing Line | 48,000 | 1.03 | 4.51 | 77 | | | 48,000 | 1.03 | 4.51 | 77 | | |
| SV 014 | SV 014 | EU 019 | W2 Crushing Line | 51,800 | 1.11 | 4.86 | 77 | | | 51,800 | 1.11 | 4.86 | 77 | 150 | 5.8 |
| | | EU 021 | 3A & 3B Conveyor Transfer to Conveyors 4B & 4A | 24,200 | 0.52 | 2.27 | 77 | 150 | 6.5 | NA | 0 | 0 | 77 | NA | NA |
| **Concentrator Building** | | | | | | | | | | | | | | | |
| SV 408 | SV 408 | EU 022 | North Transfer Point (4B to 5N) | 15,400 | 0.33 | 1.45 | 77 | 63 | 2.3 | 15,400 | 0.33 | 1.45 | 77 | 63 | 2.3 |
| Conc B V | Conc B V | EU 405 | 5N Tripper Car | 5,000 | 0.11 | 0.47 | 77 | NA | NA | 5,000 | 0.11 | 0.47 | 77 | NA | NA |
| Conc B V | Conc B V | EU0137 | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - North | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| SV 413 | SV 502 | EU 502 | Fine Ore Feeders - North 1N-2N {was 1N-3N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 19,100 | 0.41 | 1.79 | | | |
| | | EU 503 | Conv. Trans. Collection Belt to Transfer Belt | NA | 0 | 0 | NA | NA | NA | 5,200 | 0.11 | 0.49 | 77 | | |
| | | EU 504 | Conv. Trans. Transfer Belt to SAG Feed Belt | NA | 0 | 0 | NA | NA | NA | 3,100 | 0.07 | 0.29 | | 63 | 3 |
| SV 414 | SV 503 | EU 505 | Fine Ore Feeders - North 3N-5N {was 4N-6N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 415 | SV 504 | EU 506 | Fine Ore Feeders - North 6N-8N {was 7N-9N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 416 | SV 505 | EU 507 | Fine Ore Feeders - North 9N-11N {was 10N-12N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 417 | SV 506 | EU 508 | Fine Ore Feeders - North 12N-14N {was 13N-15N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |

**Table 4 - Existing, New, Removed and Modified Equipment**

| | | | | SDEIS Parameters | | | | | | SAG (FEIS) Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SDEIS SV | SAG SV | EU | Description | ACFM | PM CPTE [1] lb/hr | PM CPTE ton/yr | Exist Temp (F) | Stack Height (ft.) | Stack Diam. (ft.) | SAG ACFM | PM CPTE lb/hr | PM CPTE ton/yr | Exist Temp (F) | Stack Height (ft.) | Stack Diam. (ft.) |
| SV 016 | SV 016 | EU 023 | South Transfer Point | 15,400 | 0.33 | 1.45 | 77 | 63 | 2.3 | 15,400 | 0.33 | 1.45 | 77 | 63 | 2.3 |
| Conc B V | Conc B V | EU 406 | 5S Tripper Car | 5,000 | 0.11 | 0.47 | 77 | NA | NA | 5,000 | 0.11 | 0.47 | 77 | NA | NA |
| Conc B V | Conc B V | EU 138 | Fine Ore Storage - South | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - South | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - South | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| Conc B V | Conc B V | | Fine Ore Storage - South | 4,400 | 0.09 | 0.41 | 77 | NA | NA | 4,400 | 0.09 | 0.41 | 77 | NA | NA |
| SV 418 | SV 507 | EU 509 | Fine Ore Feeders - North 15N-17N {was 16N-18N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 419 | SV 508 | EU 510 | Fine Ore Feeders - North 18N-20N {was 19N-21N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 420 | SV 509 | EU 511 | Fine Ore Feeders - North 21N-24N {was 22N-24N} | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 36,533 | 0.78 | 3.43 | 77 | 63 | 3.46 |
| SV 421 | SV 421 | EU 030 | Fine Ore Feeders - South 1S-3S | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 422 | SV 422 | EU 031 | Fine Ore Feeders - South 4S-6S | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 423 | SV 423 | EU 032 | Fine Ore Feeders - South 7S-9S | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| SV 424 | SV 424 | EU 409 | Fine Ore Feeders - South 10S-12S | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 | 27,400 | 0.59 | 2.57 | 77 | 63 | 3 |
| NA | NA | NA | SAG Mill | NA | 0 | 0 | NA | NA | NA | NA | 0 | 0 | NA | NA | NA |
| NA | NA | NA | Ball Mill | NA | 0 | 0 | NA | NA | NA | NA | 0 | 0 | NA | NA | NA |
| **Totals** | | | | 1,437,200 | 30.80 | 134.89 | | | | 1,187,733 | 25.45 | 111.48 | | | |

[1] CPTE = controlled potential to emit; PM assumed equivalent to PM10 and PM2.5.

New Equipment

Existing Equipment Included to Retain Operational Flexibility

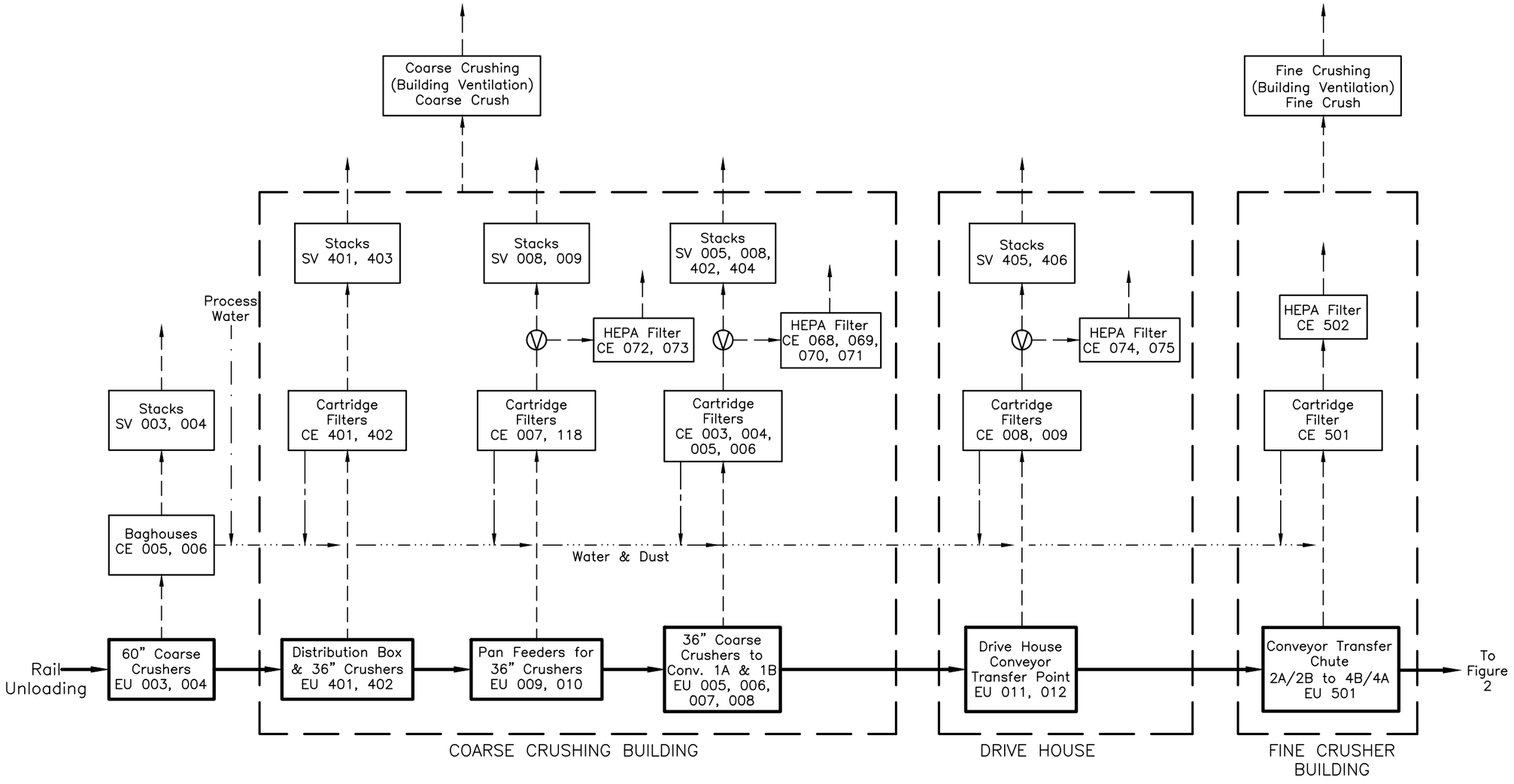
Removed Equipment

## Table 5 - Crusher/Concentrator Building Heating Capacity

| SV | Building | SAG Mill Heating Demand MMBtu/hr | SDEIS Heating Demand MMBtu/hr | Notes |
|---|---|---|---|---|
| CoarseCrush | Coarse Crusher Building | 10.48 | 10.48 | Same as SDEIS Modeling |
| DH | Drive House #1 | 1.72 | 1.72 | Same as SDEIS Modeling |
| FineCrush | Fine Crusher Building | 10.83 | 17.22 | Reduced capacity due to 4 of 7 Fine Crushing Lines being removed from the process flow sheet. |
| Conc B V | Concentrator Building | 36.95 | 34.08 | Updated demand sum of supplemental draft environmental impact statement modeled heating capacity for Concentrator plus increase for SAG Mill from KFI (34.08 MMBtu/hr. + 2.874 MMBtu/hr. = 36.95 MMBtu/hr). |

**Table 6 - Crusher/Concentrator Space Heating Emissions**

| | | | | SAG Mill Configuration | | | | | SDEIS Configuration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total PM Emission Factor (lb/MMcf) | Nox Emission Factor (lb/MMcf) | SAG Mill Heating Demand | Lb/hr PM | ton/yr PM | lb/hr Nox | ton/yr Nox | SDEIS Heating Demand | Lb/hr PM | ton/yr PM | lb/hr Nox | ton/yr Nox |
| CoarseCrush | Coarse Crusher Building | 7.5 | 50 | 10.48 | 0.07 | 0.33 | 0.50 | 2.19 | 10.48 | 0.07 | 0.33 | 0.50 | 2.19 |
| DH | Drive House #1 | 7.5 | 50 | 1.72 | 0.01 | 0.05 | 0.08 | 0.36 | 1.72 | 0.01 | 0.05 | 0.08 | 0.36 |
| FineCrush | Fine Crusher Building | 7.5 | 50 | 10.83 | 0.08 | 0.34 | 0.52 | 2.26 | 17.22 | 0.12 | 0.54 | 0.82 | 3.59 |
| Conc B V | Concentrator Building | 7.5 | 50 | 36.95 | 0.26 | 1.16 | 1.76 | 7.71 | 34.08 | 0.24 | 1.07 | 1.62 | 7.11 |
| | **Totals** | | | 59.98 | 0.43 | 1.88 | 2.86 | 12.51 | 63.49 | 0.45 | 1.99 | 3.02 | 13.24 |




LEGEND

- Main Process Flow – Ore/Ore Processing
- Water
- Collected Dust
- Water and Dust Combined
- Air Flow
- Damper to Direct Airflow to Stack or HEPA Filter

GI–02 PROCESS FLOW DIAGRAM

Figure 1

CRUSHER/CONCENTRATOR 1/3
NorthMet Project
PolyMet Mining, Inc.
Hoyt Lakes, Minnesota
November 6, 2014

rlg M:\ADEPTWORK\RLG\2369086248_PFD Crushing Plant_Flotation 1 of 3.dwg Plot at 0 11/06/2014 10:57:47

Concentrator Building (Building Ventilation)

Stacks SV 016, 408

HEPA Filter CE 088, 089

HEPA Filter CE 092, 093, 094, 095, 096, 097, 098, 099, 100, 101

Stacks SV 502

Stacks SV 503, 504, 505, 506, 507, 508, 509, 421, 422, 423, 424

Cartridge Filters CE 013, 014

Cartridge Filters CE 405, 406

Cartridge Filters CE 143, 144, 145, 146, 147, 148, 410, 411, 412, 413, 414, 415

Cartridge Filter CE 503

Cartridge Filters CE 504, 505, 506, 507, 508, 509, 510, 021, 022, 023, 409

Water & Dust

From Figure 1

Fine Ore Conveyors Transfer Pt. 4A/5N EU 022 4B/5S EU 023

5N & 5S Tripper Cars EU 405, 406

Fine Ore Storage EU 137, 138

Fine Ore Feeders 1N, 2N EU 502

Fine Ore Feeders 3N–5N, 6N–8N, 9N–11N, 12N–14N, 15N–17N, 18N–20N, 21N–24N, 1S–3S, 4S–6S, 7S–9S, 10S–12S EU 505, 506, 507, 508, 509, 510, 511, 030, 031, 032, 409

Conveyor Transfer Collection Belt to Transfer Belt EU 503

Conveyor Transfer Transfer Belt to SAG Mill Feed Belt EU 504

Water

Sag Mill (Wet Process)

Ball Mill (Wet Process)

To Figure 3

CONCENTRATOR BUILDING

LEGEND

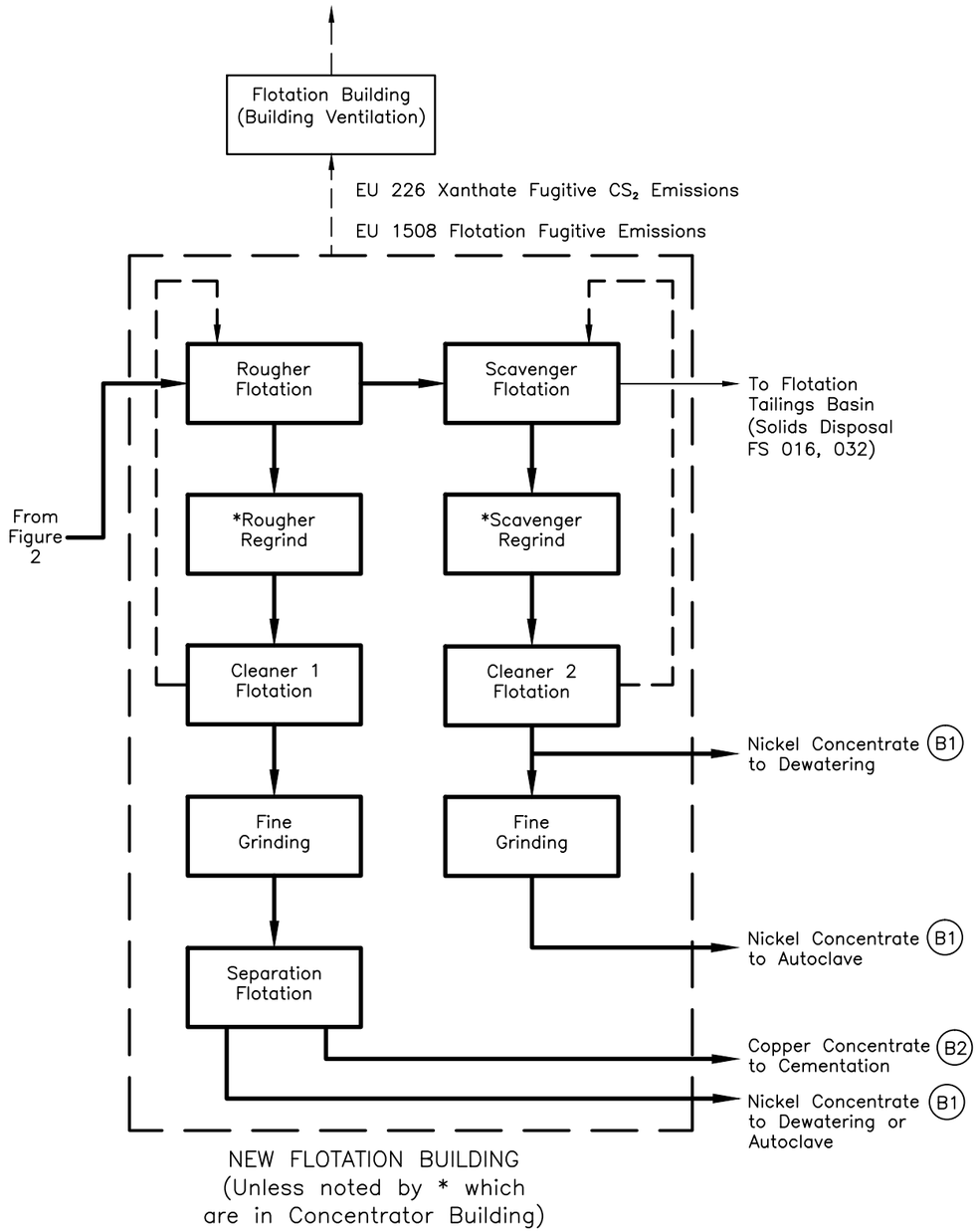
- Main Process Flow – Ore/Ore Processing
- Air Flow
- Collected Dust
- Water and Dust Combined
- Water

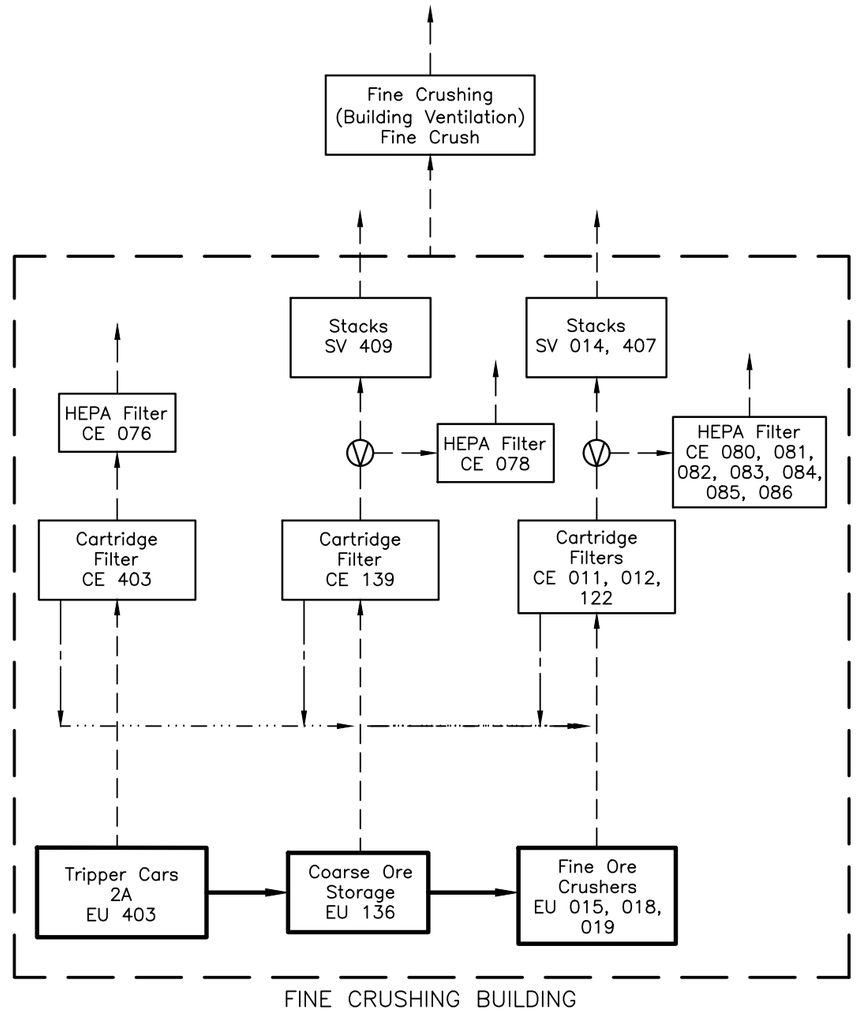
GI–02 PROCESS FLOW DIAGRAM

Figure 2

CRUSHER/CONCENTRATOR 2/3
NorthMet Project
PolyMet Mining, Inc.
Hoyt Lakes, Minnesota
November 6, 2014

rlg M:\ADEPTWORK\RLG\2369086200_PFD Crushing Plant_Flotation 2 of 3.dwg Plot at 0 10/31/2014 14:26:29




LEGEND

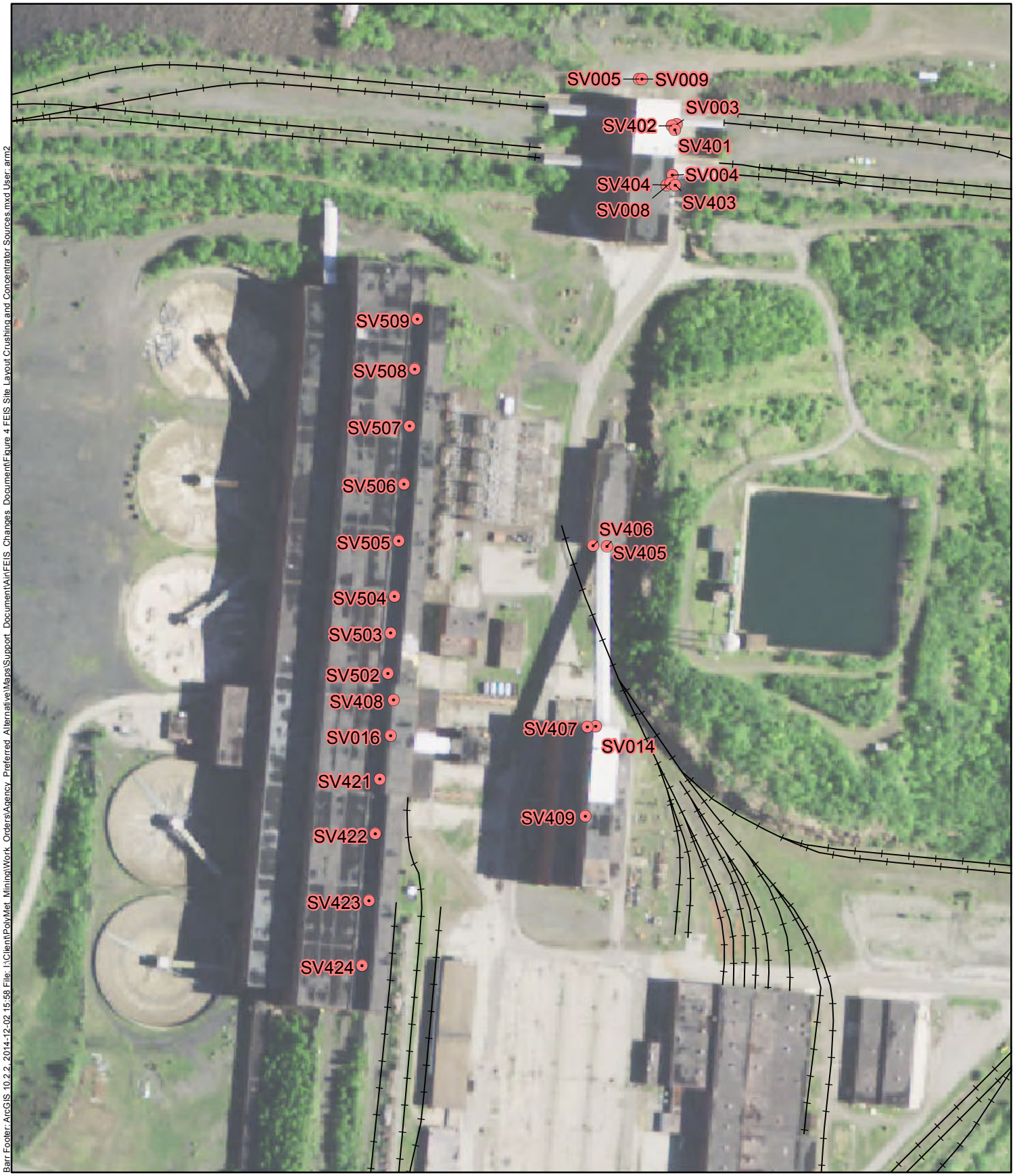
- Main Process Flow – Ore/Ore Processing
- Solid Waste
- Collected Dust
- Water and Dust Combined
- Air Flow
- Damper to Direct Airflow to Stack or HEPA Filter

GI–02 PROCESS FLOW DIAGRAM

Figure 3

CRUSHER/CONCENTRATOR 3/3
NorthMet Project
PolyMet Mining, Inc.
Hoyt Lakes, Minnesota
November 6, 2014

rlg M:\AdeptWork\RLG\2369086248_PFD Crushing Plant_Flotation 3 of 3.dwg Plot at 0 11/06/2014 11:11:25



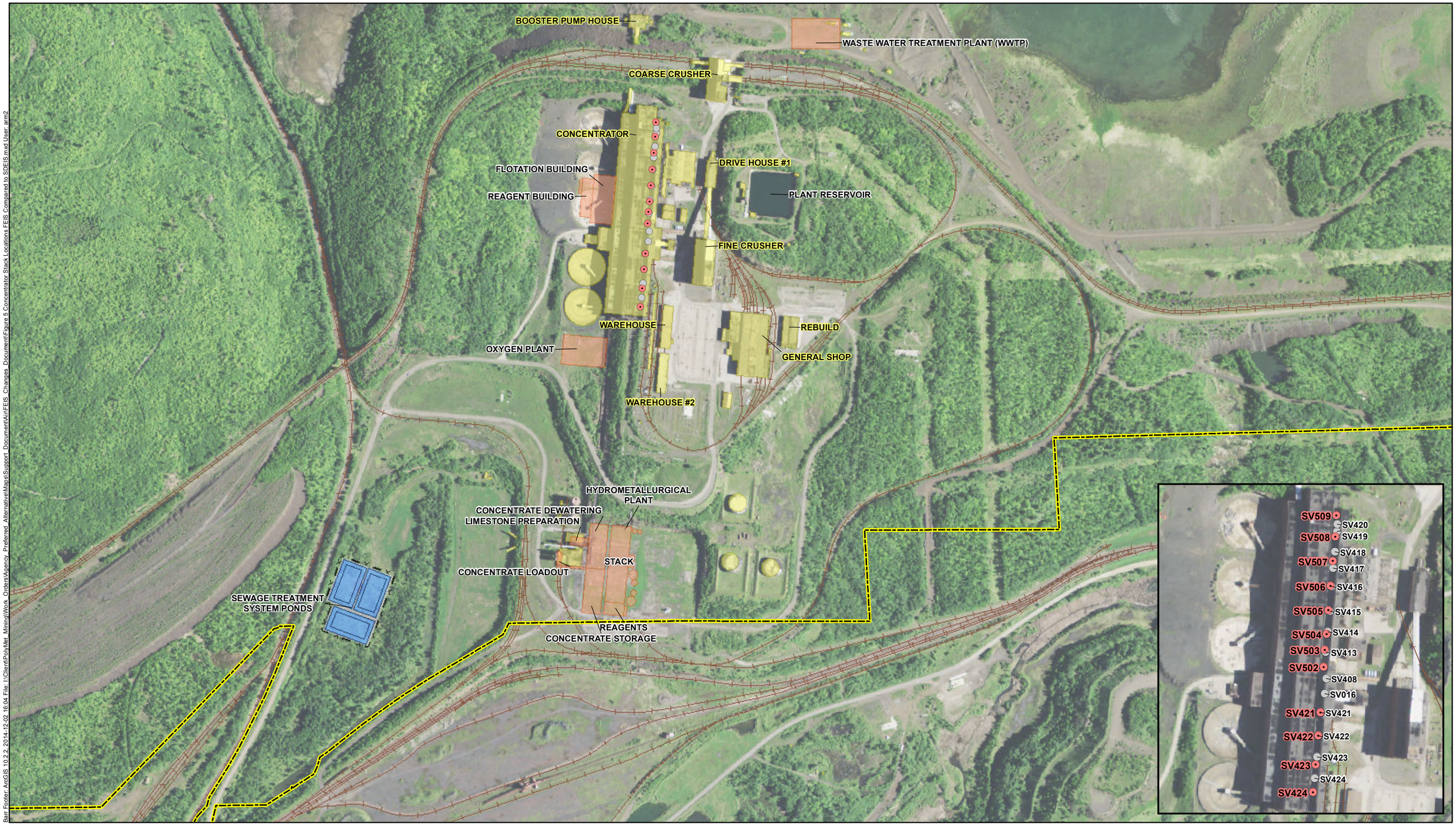

Barr Footer: ArcGIS 10.2.2, 2014-12-02 15:58 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Documents\Air\FEIS_Changes_Document\Figure 4 FEIS Site Layout Crushing and Concentrator Sources.mxd User: arm2

Stack Locations

0 125 250 500

Feet

Figure 4
FEIS - SITE LAYOUT
CRUSHING AND CONCENTRATING SOURCES
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, Minnesota
November 2014

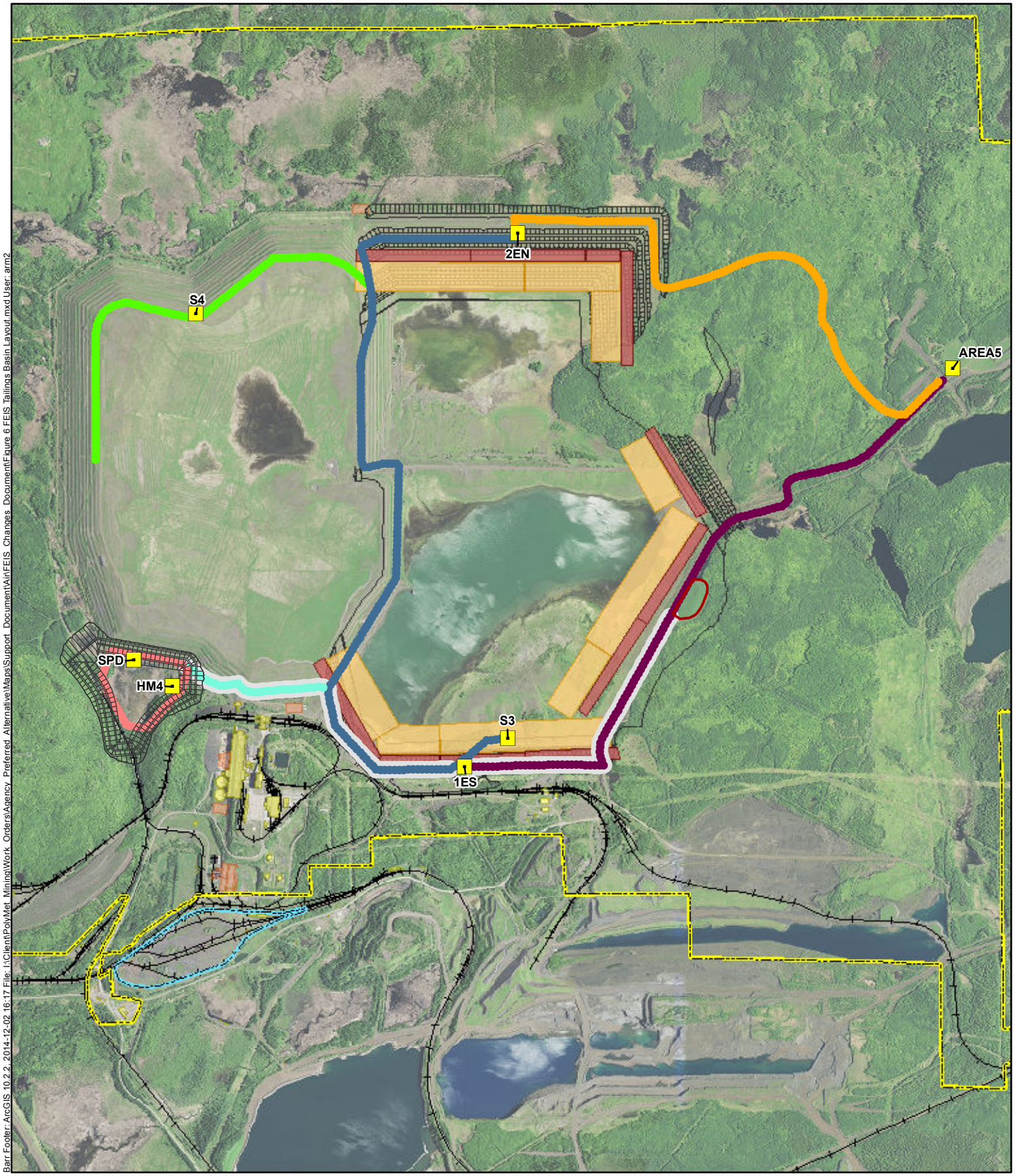



Barr Footer: ArcGIS 10.2.2, 2014-12-02 16:04 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\FEIS_Changes_Document\Figure 6 Concentrator Stack Locations FEIS Compared to SDEIS.mxd User: arm2

- Sag Mill Sources
- Stack Locations
- Ambient Air Boundary
- New Buildings
- Existing Buildings

0 300 600 1,200
Feet

Figure 5
STACK LOCATION COMPARISON
FEIS COMPARED TO SDEIS
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, Minnesota
November 2014




Material Handling Sources
LTV Coarse
PMET Bulk
Cliffs Erie Pellet Yard
Ambient Air Boundary
New Buildings
Existing Buildings

HydroMet Cell Road
Tailings Haul Road I
Tailings Haul Road J
Tailings Haul Road N
Tailings Haul Road W
Tailings WWTP Road
Coal Ash Haul Route

0 1,250 2,500 5,000
Feet

Figure 6
FEIS - TAILINGS BASIN LAYOUT
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, Minnesota
November 2014

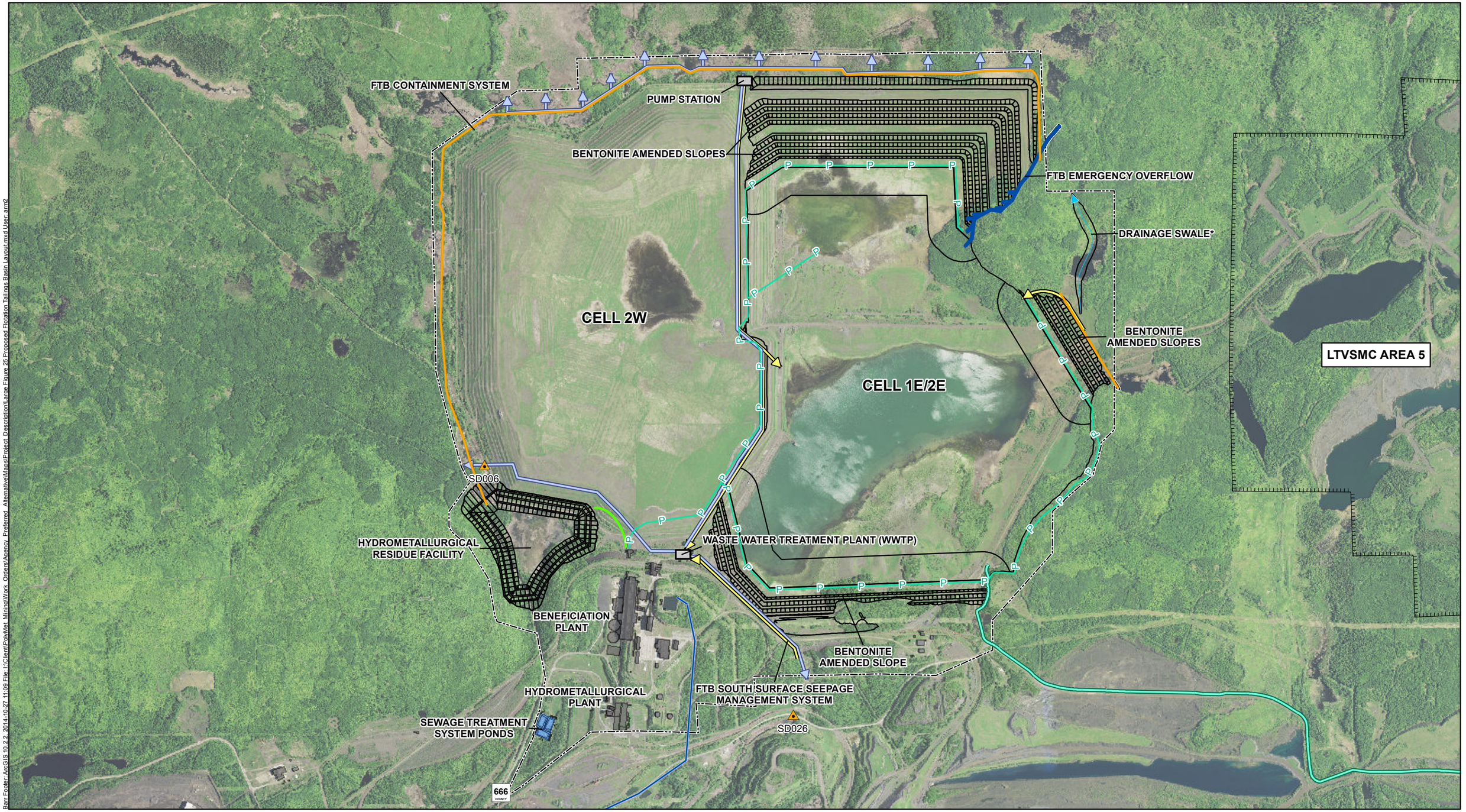
Barr Footer: ArcGIS 10.2.2, 2014-12-02 16:17 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\FEIS_Changes_Document\Figure 6 FEIS_Tailings Basin Layout.mxd User: arm2




Barr Footer: ArcGIS 10.2.2, 2014-10-24 15:12 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Project Description\Large Figure 24 Existing Tailings Basin.mxd User: amm2

0 2,000 4,000
Feet

Large Figure 24
EXISTING TAILINGS BASIN
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN




Existing NPDES Discharge Stations
Treated Water Discharge Pipe
Seepage Water Pipe
Plant Site
LTVSMC Area 5
FTB Containment System
Flotation Tailings Pipeline
Hydrometallurgical Residue Pipeline
Treated Water Pipeline
Drainage Flow Direction
*The drainage swale drains stormwater away from the toe of the dam.

0 2,000 4,000
Feet

Large Figure 25
PROPOSED FLOTATION TAILINGS BASIN LAYOUT
NorthMet Project
Poly Met Mining Inc.
Hoyt Lakes, MN

Barr Footer ArcGIS 10.2.2 2014-10-27 11:09 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Project Description\Large Figure 25 Proposed Flotation Tailings Basin Layout.mxd User: arm2

**Attachment B**

**Air Impact Assessment Planning Summary Memo**

**INTERAGENCY MEMORANDUM**

**To:** **Jim Scott, PolyMet Mining**

**From:** **Bill Johnson/Stuart Arkley, MNDNR Project Managers**
**Jon Ahlness, USACE Project Manager**
**Tom Hale, USFS Project Manager**

**RE:** **NorthMet EIS / Air Resources IAP**
**Final Summary Memo**

**May 6, 2011**

---

Attached please find the Final Summary Memo for the Air Resources Impact Assessment Planning (IAP) process for the NorthMet EIS.

It has been prepared to guide PolyMet and its consultants in the development of work plans for detailed modeling and impact assessment for the Co-lead Agency Draft Alternative.

We look forward to the work plan development and approval process to come. Please contact the EIS Project Managers with any questions.

Minnesota
DEPARTMENT OF NATURAL RESOURCES

US Army Corps of Engineers
St. Paul District

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

**Air Impact Assessment Planning Summary Memo**
**NorthMet Supplemental EIS**
**May 6, 2011**

## Introduction

The Minnesota Department of Natural Resources (MDNR), US Army Corps of Engineers (USACE), and US Forest Service (USFS), collectively known as the Co-Lead Agencies, have prepared this guidance memo as the concluding step in the impact assessment planning (IAP) process for this subject area. This memo provides (1) a summary of workgroup issues considered; and (2) specific guidance to PolyMet Mining and its consultants that is to be incorporated into a work plan for Co-Lead Agency review and approval prior to conducting impact analysis (i.e. modeling and other predictive work) on the Draft Alternative Summary as amended March 4, 2011.

The purpose of the Air Impact Assessment Planning (IAP) group was to determine what evaluations are needed to determine the air quality impacts of the Draft Alternative for the proposed NorthMet project. The evaluations will be used for the preparation of a Supplemental Draft Environmental Impact Statement. In an effort to efficiently determine what evaluations are needed, the IAP broke into five workgroups. The air quality core team was facilitated by Suzanne Baumann (MPCA) and Deb McGovern (ERM) and included Stuart Arkley (MDNR ECO), Dan Kringel (ERM), Ann Foss (MPCA), Kevin Pylka (PolyMet), Pat Sheehy (Barr), and Joy Wiecks (Fond du Lac). The core team attended all workgroup meetings. Technical staff with expertise in each relevant topic area also participated in each workgroup meeting. Each workgroup met at least once. A list of workgroup meeting participants is attached.

## Impact Assessment Requirements of the DA

Workgroups were formed to discuss the following topics: Class I pollutants, Class II pollutants, mercury, greenhouse gases, and control equipment evaluation. In advance of each meeting, workgroup members were asked to review the evaluations completed for the preparation of the October 2009 DEIS, the project changes proposed by PolyMet, and current versions of the Air Data Package, Air Management Plan – Plant, and Air Management Plan – Mine. Each workgroup determined the scope of needed evaluations for the Draft Alternative and advised PolyMet and Barr on any new assumptions, standards, and guidance. Generally, the evaluations required to draft a Supplemental Draft EIS will mirror those needed for development of the 2009 Draft EIS, except that they will need to be updated to reflect the changes to the proposed project and alternatives and to reflect any new standards or other requirements.

See the attached table, titled PolyMet Air Impact Assessment Task List, for a description of each of the needed evaluations and required precursor reports (emissions inventory, work plans, protocols, etc). A recurring PolyMet air group has been formed to track PolyMet air-related environmental review development and permitting data submittals.

## Key Issues and Decisions

There were very few topics of controversy or debate in the air IAP group. Notes were generated by each of the workgroups that details the discussions and outcomes. The following are items raised for decision by the co-lead agencies:

1) Tailpipe Emissions from Third Party Traffic.

Issue Statement: The Air IAP discussed whether tailpipe emissions from third party traffic should be evaluated as part of the risk evaluation or air permitting. The group concluded that as a result of the low number of third party vehicles on-site and because most of the final product will be shipped via rail, the potential impacts are low enough that they don't exceed risk evaluation thresholds and therefore would not be included in MPCA risk analyses. In addition, these on-road tailpipe emissions aren't regulated by air permitting requirements. Therefore, the group raised the issue for co-lead consideration about whether tailpipe emissions from third party traffic should be evaluated for EIS purposes.

Co-lead Resolution: Any impacts are considered minimal such that further consideration in the EIS is not warranted under MEPA and NEPA. This is consistent with the treatment of the issue in other joint MEPA/NEPA Mining EISs in Minnesota. Therefore, tailpipe emissions from third party traffic will not be evaluated in the SDEIS.

2) Short-Term Construction Emissions.

Issue Statement: The Air IAP discussed whether short-term construction emissions (such as the construction of the autoclaves concurrent with operation of crushing and flotation emissions sources) should be evaluated as part of the risk evaluation. The group concluded that potential impacts are low enough and temporary so that they wouldn't exceed risk evaluation thresholds. These emissions aren't regulated by air permitting requirements and would not typically be evaluated in a MPCA risk analysis. Additionally, because PolyMet is required to model its "worst case" emissions, including all emissions sources operating simultaneously (including emissions from scenarios 1 and 2), it is unlikely that emissions from construction would have impacts above the worst case emissions modeled. Therefore, the group raised the issue for co-lead consideration about whether short-term phased construction emissions should be evaluated for EIS purposes.

Co-lead Resolution: Given the low levels of pollutant generation and their temporary nature, further evaluation in the EIS is not warranted under MEPA or NEPA. This is consistent with the treatment of the issue in other joint MEPA/NEPA Mining EISs in Minnesota. Therefore, short-term construction emissions will not be evaluated in the SDEIS.

3) Railcar Dust and Spillage.

Issue Statement: The air IAP group concluded that there would be minimal air impacts from any dust generated from ore hauled in the railcars due to the coarse nature of the ore. Any impacts from dust generated from ore hauled in the railcars would be more appropriately evaluated in one of the water IAP groups. The air IAP group identified a need to coordinate, as needed, with other media regarding railcar handing dust emissions.

Co-lead Resolution: Any depositional effects, if measurable, would be realized in water resources, therefore that is the appropriate place to focus any discussion of the issue in the SDEIS. The Water Resources – Surface Water IAP workgroup did indeed consider this issue under the topic of "Baseline water quality data for outlying streams along the RR corridor" section of the Summary Memo. The Surface Water IAP workgroup recommends the collection of surface water quality data along the rail transport corridor to address the issue.

The co-leads confirmed that the Water Resources IAP did consider the issue of potential impacts from railcar dust and spillage, therefore there is no additional action needed.

4) NEPA Requirements for GHG Evaluations.

Issue Statement: When the air IAP group reaches consensus on the existing state and federal GHG guidance there is a need to engage the co-lead agencies to ensure that NEPA needs for greenhouse gas evaluation are fulfilled.

Co-lead Resolution: The Co-leads will need to monitor changes in GHG-related policy and guidance over the remaining course of the EIS, especially for NEPA-related implications. Because GHG-type evaluations rely on the modeling-generated air emissions inventory, it is possible that new directives might require Co-lead decisions on the appropriateness of new or modified modeling, with subsequent analysis, which in turn could impact the ongoing development of the SDEIS. Whether new analysis is required or not, the Co-leads need to ensure the SDEIS appropriately considers GHGs against the standard(s) in place at the time of SDEIS publication.

Therefore, the co-leads will monitor and evaluate state and federal GHG policy development over the remaining course of the EIS. PolyMet will be required to provide the underlying data and analysis as required to comform to existing guidance. ERM will be required to develop the SDEIS material consistent with available GHG-related guidance as interpreted and approved by the Co-leads.

5) Potential Impacts from Climate Change.

Issue Statement: The air IAP group identified a need to consider effects of climate change in conducting other impact assessments. For instance should any water modeling consider the potential of temperature changes, more extreme weather events, etc? Should the EIS describe how climate change was considered in the impact assessments?

Co-lead Resolution: In addition to the considerations by the air quality IAP, the co-leads confirmed that the Water Resources IAP will evaluate the need to consider global climate change in modeling scenarios for the SDEIS.

**NorthMet EIS Impact Assessment Planning (IAP)**
**Air Resources Group Member List**

Air Quality Core Team
Suzanne Baumann (MPCA) - Facilitator
Deb McGovern (ERM) - Facilitator
Stuart Arkley (MDNR ECO)
Ann Foss (MPCA)
Dan Kringel (ERM)
Kevin Pylka (PolyMet)
Pat Sheehy (Barr)
Joy Wiecks (Fond du Lac)

Class I Workgroup
Catherine Neuschler (MPCA)
Ruth Roberson (MPCA)
Sarah Seelen (MPCA)
Andrew Skoglund (Barr)
Trent Wickman (USFS)

Class II Workgroup
Nick Axtell (1854 Treaty Authority)
Jennifer Darrow (EPA)
Kristie Ellickson (MPCA)
Alex Jackson (Fond du Lac)
Simon Manoyan (EPA)
Eric Edwalds (Barr)
Jenny Koenen (Barr)
Ruth Roberson (MPCA)
Jim Scott (PolyMet)
Sarah Seelen (MPCA)
Cliff Twaroski (Barr)

Mercury Workgroup
Mike Berndt (DNR)
Ned Brooks (MPCA)
Esteban Chiriboga (GLIFWC)
Keith Hanson (Barr)
Anne Jackson (MPCA)
Nancy Schuldt (Fond du Lac)
Ed Swain (MPCA)
Cliff Twaroski (Barr)

Climate Change Workgroup
Yvette Chenaux (Grand Portage)
Peter Ciborowski (MPCA)
Alexander Jackson (Fond du Lac)
Sarah Seelen (MPCA)
Louise Segroves (Barr)

Control Equipment Evaluation Workgroup
Jack Kennedy (Barr)
Sarah Seelen (MPCA)
Cliff Twaroski (Barr)

**IAP Completed Tasks**

| | | |
|---|---|---|
| Baumann | MPCA | Schedule a follow up meeting to finish the discussion, in particular for the tailings |
| | PolyMet/Barr | Modify existing worst case scenario in Air Management Plan to provide greater |
| Baumann | MPCA | Schedule face-to-face meeting to discuss worst case document |
| Seelen | MPCA | Follow up with Pat regarding PM2.5 increment applicability before minor source |
| Sheehy | PolyMet/Barr | Make correction in table 6.2-1 re: lime and limestone use and handling hashmarks. After the meeting, Barr also noted that the hashmarks were in error for PAX (used in |
| Sheehy | PolyMet/Barr | Information on the number and type of trucks hauling products will be provided to aid agency decision on tailpipe emissions from third party trucks. |
| Pylka, Hanson | PolyMet/Barr | Initiate the next meeting to discuss the mercury TMDL |
| Baumann | MPCA | Distribute the updated Air Data Package to the group for comment; goal is conceptual consensus and compile comments |
| | PolyMet/Barr | Update Air Data Package to expand on the discussion on the spatial aspects of mine haul truck emissions and submit to the group for comment |
| Baumann | Air Core Team | Discuss whether fiber emissions resulting from the disturbance of existing LTV tailings and or future disturbances of PolyMet tailings needs to be evaluated, if it has not. (RESOLUTION -- LTV tailings will be included in the PM2.5 modeling and any emissions |
| | Air Core Team | Discuss whether dust emissions from railcars/transport should be evaluated as part of the environmental review process, specifically deposition along the rail line between the mine and plant sites, and deposition of concentrate after the product leaves the processing plant. RESOLUTION - due to the size fraction of the material transported in the railcars, air quality impacts from this activity are insignificant. The |
| Baumann | MPCA | Reserve a time, if needed, to discuss the write up that Barr is providing re: the spatial aspects of mine haul truck emission. (RESOLUTION -- No comments were received on the document, so the meeting was cancelled) |
| | Air Core Team | PM2.5 increment modeling evaluation for EIS-purposes? It is not required for permitting if PolyMet remains a minor source for all pollutants. (RESOLUTION -- The group agreed that, unless PM2.5 increment modeling is needed for permitting purposes, it should not be completed for EIS purposes because the |
| Sheehy, Twaroski | PolyMet/Barr | Determine whether fiber emissions from disturbances of LTV or PolyMet tailings have been evaluated in previously submitted reports. (RESOLUTION -- Fiber emissions from LTV tailings were addressed in a previous memo discussing the size |
| | DNR/ERM | The Co-Lead Agencies will assess the CEQ NEPA guidance and review the DNR |
| Sheehy | PolyMet/Barr | Evaluate and include emissions from a possible waste water treatment plant at area 5 - needs to be added to table 6.2-1 (the worst case emissions table) |
| | PolyMet/Barr | Provide emissions estimates for third party tailpipe emissions |
| | MPCA | Reconvene the worst case emissions group to discuss the changed project |
| | PolyMet/Barr | Update the previous (Feb 27, 2009, DNR memo) protocol, layering in the new CEQ |
| Sheehy | PolyMet/Barr | Evaluate and include emissions from a possible waste water treatment plant at area 5 - needs to be added to the emissions inventory |

| | |
|---|---|
| PolyMet/Barr | Following the meeting a question was raised re: the inclusion of emissions from multi-phased construction for the project. PolyMet and Barr will evaluate and propose whether construction activities should be included in the criteria modeling and AERA; such as the multi-phased construction of the infrastructure for latter scenarios (e.g. autoclaves) be included as part of the worst case emissions in earlier scenario. - |
| PolyMet/Barr | Once agreement is met regarding worst case temporal and spatial aspects on haul roads the company will submit modeling protocol. |

**Attachment C**

**Class I Area Air Dispersion Modeling**

# *Class I Area Air Dispersion Modeling*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining Inc***

***May 2012***

***Version 2***

BARR

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

# Class I Area Air Dispersion Modeling

## May 2012

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# 1.0 Introduction and Executive Summary

The requested air quality analysis conducted for the proposed NorthMet Project (Project) near Hoyt Lakes, Minnesota demonstrates that the Project will not deteriorate air quality and also concludes that the Project will not have an adverse effect on flora and fauna or terrestrial or aquatic ecosystems. When compared to pristine conditions, visibility impacts are below "presumptive no adverse impact" criteria when using conservative modeling procedures.

Air emission permits for Prevention of Significant Deterioration (PSD) major sources require that an air quality analysis be conducted to demonstrate that national ambient air quality standards will not be exceeded and that the Project will not significantly deteriorate air quality. PolyMet Mining Inc (PolyMet) plans to request limits to allow the Project to be permitted as a synthetic minor source, but PolyMet has agreed to complete dispersion modeling that is generally consistent with what would be required for a major source permit. The general proposed approach to limit emissions below the major source level is described in version 2 of NorthMet Proposed Synthetic Minor Limits, submitted November 4, 2011.

For air quality purposes, areas are generally divided into two classes based on local land use. These are referred to as Class I and Class II areas. Wilderness and national park areas are designated as Class I areas. All other areas are designated as Class II areas.

Each classification differs in terms of the amount of growth that is allowed. When developing the air permitting regulations, Congress anticipated that increases in ambient air concentrations would be necessary in order for economic growth to occur. Ambient air concentrations are capped at the National Ambient Air Quality Standards, which are set to protect human health. No increases are allowed that would cause ambient air concentrations to go above these standards. The air permitting regulations were also designed to keep ambient air concentrations relatively unchanged from where they were at the time of the baseline, except for small increases to allow for growth. In the area around the Project, the major source baseline was set in 1975 for $PM_{10}$ and the minor source baseline date for $PM_{10}$ was set in 1979 for St Louis County and 1999 for Lake County.

The allowed growth, or increase in ambient air concentrations, is referred to as increment. In addition to growth allowed for in terms of the increment that was set aside in the regulations, growth can also be accommodated for through decreases in ambient air concentrations resulting from reductions in air emissions from sources in an area since the baseline. In addition to growth, potential impacts to Air Quality Related Values (AQRVs) such as visibility and impacts on flora and fauna are required to be assessed for Class I areas.

This report describes the Class I area air quality impacts assessment that was conducted for the proposed Project. The air quality assessment for Class II areas will be prepared and reported separately. The Class I area analysis provides an assessment of air quality impacts at the following Class I areas:

- Boundary Waters Canoe Area Wilderness (BWCAW),
- Rainbow Lake Wilderness,
- Voyageurs National Park, and
- Isle Royale National Park.

Federal Land Managers (FLMs) have responsibility for protecting air quality in the Class I areas. The US Forest Service (USFS) has responsibility for the BWCAW and Rainbow Lake Wilderness. The National Park Service has responsibility for Voyageurs National Park and Isle Royale National Park. This report is being submitted to the above FLMs, the state air permitting authority (the Minnesota Pollution Control Agency (MPCA)) and the Co-lead and Cooperating Agencies preparing the Project Supplemental Draft Environmental Impact Statement (SDEIS)[1]. The following conclusions were drawn from the modeling analysis conducted for the Project; additional details of the conclusions are discussed in Sections 4, 5 and 6:

[1] The U.S. Forest service is both the FLM for BWCAW and Rainbow Lake and a co-lead agency for the SDEIS.

- No adverse impact on flora and fauna is expected.
- Deposition values were below the "Green Line Values" set by the USFS and National Park Service. Therefore, no adverse impact on terrestrial and aquatic ecosystems is expected.
- When compared to pristine conditions as prescribed in current guidance, no adverse visibility impacts are indicated.
- The Class I increment analysis demonstrates that air quality will not be deteriorated as a result of the Project. The increase in criteria pollutant ambient air concentrations are all below the Significant Impact Levels (SILs) except for $PM_{10}$ in the BWCAW. When modeled concentrations are greater than the SIL, a cumulative increment analysis is required. Based on increment modeling conducted, the Project, along with other projects, has not consumed the available increment for $PM_{10}$ in the BWCAW. This conclusion is also supported by the fact that monitored concentrations have decreased in this area, indicating an increase in the increment concentration available for growth.

## 2.0 Project Description

PolyMet plans to construct and operate a mine area near the town of Babbitt, MN, to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailing Basin near Hoyt Lakes, MN and to build an ore processing facility at the former LTVSMC site. The proposed project is referred to as the NorthMet Project (Project). The Project description is provided in the March, 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement (Reference (1)) and the NorthMet Project Description (Reference (2)). The impact statement Co-lead Agencies, Minnesota Department of Natural Resources (MDNR), US Army Corps of Engineers (USACE), and USFS, have concluded the Project requires a Supplemental Draft Environmental Impact Statement (SDEIS).

The Final Air Impact Assessment Planning Summary Memo for the SDEIS requires an updated assessment of the cumulative potential effects on visibility in Northeastern Minnesota (Reference (3)).

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

## 2.1 Air Emissions

The Project's controlled potential air emissions are shown in Table 2-1.

**Table 2-1 Project Air Emissions (Controlled Potential to Emit)**

| Project AIR EMISSIONS | Plant Site Stationary Source Emissions (tons/yr) | Mine Site Stationary Source Emissions (tons/yr)(a) | Mobile Source Emissions (tons/yr)(b) |
|---|---|---|---|
| Total $PM_{10}$ Point Source Emissions | 216.4 | 4.27 | 7.76 |
| Total Fugitive $PM_{10}$ Emissions | 305.8 | 454.0 | NA |
| Total Point Source Plus Fugitive $PM_{10}$ Emissions | 522.2 | 458.2 | 7.76 |
| Total $SO_2$ Emissions | 7.0 | 1.9 | 0.51 |
| Total $NO_x$ Emissions | 89.4 | 12.0 | 309.2 |

Source: NorthMet emission calculation spreadsheets last submitted to MPCA March 21, 2012 (Mine Site) and March 5, 2012 (Plant Site). Totals in table may reflect values updated since last submittal, but the complete supporting calculations for the Class I modeling will be provided for review and comment..

(a) Based on Year 13 of Mine operation (higher of two worst-case years evaluated).

(b) Exhaust emissions from mining vehicles, locomotives and Tailings Basin construction equipment. Not listed as "fugitive" because stationary fugitive sources were not included in the Class I impacts analysis.

The emissions data presented in Table 2-1 include all point sources. Emergency generators and other sources not operated during normal, full capacity source operation were not included in the Class I impact analysis as is standard practice (see modeling protocol (Appendix B) for additional details). Fugitive dust emissions were also not included in the Class I analysis as is standard practice (see modeling protocol (Appendix B)). Furthermore, for the source categories associated with the project, fugitive emissions are not included in the determination of the source status with respect to PSD regulations nor are mobile source emissions.

The emissions listed in Table 2-1 represent the worst case over the Project life, which was modeled in the updated increment evaluation. For the updated AQRV modeling, the project was divided into multiple scenarios to represent different time periods of project operation. These scenarios only affect the mobile source emissions. Table 2-2 briefly describes the scenarios and Table 2-3 lists the mobile source emissions associated with each scenario.

**Table 2-2 Mobile Source Emission Scenario Assumptions**

| Scenario | Description | Tailing Basin Mobile Sources | Mine Site Mobile Sources |
|---|---|---|---|
| 1 | Years 1 to 5 | Maximum number of haul trucks (28) – all meet Tier 4 Standards. Auxiliary vehicles emissions based on currently available engine Tier levels. | Seven Tier 2 haul trucks, 1 Tier 4. Other equipment reflects currently available equipment engine Tier levels. Max fuel usage = year 5 + 5% safety factor. |
| 2 | Years 6 to 8 | Maximum haul trucks is 12 – all Tier 4. Other vehicles same as 1. | Four Tier 4 haul trucks, five Tier 2. Other equipment same as 1. Max fuel usage = year 7. |
| 3 | Years 9 to 10 | Maximum haul trucks is 12 – all Tier 4. Other vehicles same as 1. | Same as 2, except one tracked dozer meets final Tier 4 standard. Max fuel usage = year 10. |
| 4 | Years 11 to 20 | Maximum haul trucks is 16 – all Tier 4. Other vehicles same as 1. | All vehicles meet final Tier 4 standards – maximum fuel usage (Year 11). |

**Table 2.3 Mobile Source Scenario Emissions (tons/yr)**

| Mobile Source Emissions | Scenario 1 (1 to 5) | Scenario 2 (6 to 8) | Scenario 3 (9 to 10) | Scenario 4 (11 to 20) |
|---|---|---|---|---|
| Total $PM_{10}$ Emissions | 7.76 | 6.82 | 7.05 | 3.97 |
| Total $SO_2$ Emissions | 0.46 | 0.45 | 0.47 | 0.51 |
| Total $NO_x$ Emissions | 309.2 | 286.8 | 291.4 | 228.2 |

The emission values presented in Tables 2.1 and 2.3 reflect measures taken to reduce visibility impacts in the BWCAW. The measures include the decisions to upgrade the insulation in the existing Crusher and Concentrator Buildings and to purchase low-$NO_x$ space heating equipment such that overall $NO_x$ emissions are reduced by at least 50% below that with all conventional

equipment. A plan for phasing in vehicles that meet Tier 4 emission standards has also been developed and is utilized in Table 2.2 – Mobile Source Emission Scenario Assumptions. These reductions were in addition to those previously adopted such as the use of efficient gen-set locomotives, the recirculation of dust collector exhaust to reduce heating demand, the use of appropriate pollution control equipment and the use of lower emitting fuels where feasible.

# 3.0 Class I Areas Assessment of Potential Impacts to Air Quality Related Values (AQRVs)

## 3.1 Class I Areas

Four Class I areas were identified in the modeling protocol as falling within an approximate 300 km radius and are assessed for potential impacts from the Project emissions using the CALPUFF modeling system. The areas are:

1) BWCAW,
2) Isle Royale National Park,
3) Rainbow Lake Wilderness, and
4) Voyageurs National Park.

The nearest part of the BWCAW is located approximately 34 km (21 miles) northeast of the Hoyt Lakes facility and it extends to 167 km (104 miles) east-northeast of the site. The Rainbow Lake Wilderness is located approximately 142 km (88 miles) southeast of Hoyt Lakes in Wisconsin. Both the BWCAW and the Rainbow Lake Wilderness are managed by the USFS.

Isle Royale National Park is located on Isle Royale in the northern part of Lake Superior (in the state of Michigan) approximately 218 km (135 miles) east and slightly north of the Project. Voyageurs National Park is located just east of International Falls, Minnesota and stretches east along the northern border of Minnesota. The nearest part of Voyageurs National Park is approximately 82 km (51 miles) north of the Project location. Both parks are managed by the National Park Service.

## 3.2 Air Quality Related Values (AQRVs)

AQRVs are features or properties of Class I areas that could be adversely affected by air pollution. The Clean Air Act requires that potential AQRV impacts be reviewed for all major sources near Class I areas. The Project is not a major source, but, in general, the standard procedures for major sources were followed in the assessment of Class I impacts.

Although AQRVs are not well defined in the Act, AQRVs are generally considered by the FLMs to include visibility impairment and acid deposition. In addition, an assessment of the Class I increment has also been prepared based on MPCA guidance.

PolyMet has performed an analysis of projected AQRV impacts from the Project on acid deposition, visibility, and Class I increment. The methodology for these computations of potential impact are as outlined in the FLM Recommendations on Class I Area Analyses (Reference (4)), which also references the following documents:

a) the USFS's "Screening Procedures to Evaluate Effects of Air Pollution on Eastern Wildernesses Cited as Class I Air Quality Areas" for flora and fauna and acid deposition; (Reference (5))
b) the "Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Guidance for Modeling Impacts on Visibility"(Reference (6)), and
c) the "Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Guidance" (Reference (7), Reference (8)).

## 3.3 CALPUFF Modeling System

The CALPUFF Modeling System is the required model for determining visual impacts at long distances from sources. This model was used in accordance with the guidelines found in the *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts* (Reference (6) and the 2010 revisions to Federal Land Managers' Air Quality Related Values Work Group guidance Reference (8)). The Class I Modeling Protocol approved by the FLMs, MPCA and the Co-lead and Cooperating Agencies for the SDEIS is included in Appendix B. The protocol specifies all of the model options and user-selected fields for the analysis.

The CALPUFF system consists of three main components (CALMET, CALPUFF and CALPOST) and a number of pre-processing programs. These pre-processing programs are designed to prepare available meteorological and geophysical data for input into CALMET. Each of these modeling components is described below:

- CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modeling domain. Associated two-dimensional fields such as mixing heights, terrain elevations, land use categories and dispersion properties are also included in the file produced by CALMET.
- CALPUFF is a transport and dispersion model that follows the "puffs" of material emitted from one or more sources as they travel downwind. CALPUFF simulates dispersion and chemical transformations as each puff moves away from the source, using the multi-dimensional grids generated by CALMET.
- CALPUFF produces an output file containing hourly concentrations of pollutants which are processed by CALPOST to yield estimates of ambient air concentrations to determine increment consumptions, estimates of sulfur and nitrogen deposition, and estimates of extinction coefficients and related measures of visibility impairment at selected averaging times and locations.

### 3.3.1 CALMET

Three years (2002-2004) of MM5 prognostic mesoscale meteorological data, surface weather data, precipitation data, and upper air data were used to generate the CALMET data set for use in the CALPUFF model. The CALMET computational grid for the greater domain was 132 grid cells (east-west) by 90 grid cells (north-south) with a grid spacing of 4 km. US Geological Survey (USGS) digital elevation maps (DEMs) and land use land cover (LULC) files required by CALMET were obtained from the WebMET and WebGIS websites hosted by Lakes Environmental and the GeoBase website hosted by Natural Resources Canada.

The CALMET grid used in the cumulative $PM_{10}$ increment analysis described in Section 6 required the use of an expanded CALMET grid to cover the additional sources and with the CALMET grid spacing increased to 12 km to make the model run times practical. This approach is reasonable because the terrain in northern Minnesota is fairly uniform and moving to a 12 km grid will not result in modeling inaccuracies for long-range transport from these more distant sources. A sensitivity run was conducted and confirmed this to be the case.

### 3.3.2 CALPUFF

CALPUFF model input files were set up for each year of CALMET data. Inputs to the CALPUFF modeling system included 3 years of MM5 weather data, 3 years of hourly surface weather data, 3 years of upper air data, 3 years of hourly precipitation data, Project emission rates, source locations, receptor locations, land elevation data, and land use data. Model parameters were set to IWAQM Phase 2 recommended values followed by US Environmental Protection Agency (USEPA) regulatory default values where available, followed by the default values recommended in the model input file. The selection of model parameters is fully detailed in the modeling protocol (Appendix B).

The CALPUFF modeling considered the emission of $SO_2$, $NO_x$, PMC (coarse particulate matter), PMF (fine particulate matter), EC (elemental carbon), SOA (secondary organic aerosols) and sulfates ($SO_4$). The Project emission rates used in the CALPUFF modeling are provided in Table 3-1. Detailed emission rate calculations for each modeled source are included in Appendix A and in the emission inventory spreadsheets.

**Table 3-1 Modeled Project Emission Rates (g/sec)**

| Species | Increment run | AQRV Scenario 1 | AQRV Scenario 2 | AQRV Scenario 3 | AQRV Scenario 4 |
|---|---|---|---|---|---|
| $SO_2$ | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| $NO_x$ | 12.03 | 12.03 | 10.40 | 10.54 | 8.94 |
| PMC | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| PMF | 5.22 | 5.22 | 5.21 | 5.21 | 5.18 |
| EC | 0.15 | 0.15 | 0.14 | 0.14 | 0.10 |
| SOA | 0.21 | 0.21 | 0.20 | 0.20 | 0.18 |
| $SO_4$ | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |

PMC represents the portion of $PM_{10}$ greater than 2.5 µm in diameter; EC was represented by the carbon content of filterable $PM_{10}$; SOA was represented by the organic condensable fraction of the $PM_{10}$; SO4 is represented by the sulfuric acid emissions; PMF is the remainder of the non-carbon filterable and non-organic and non-SO4 portions of the condensable fraction of the PM10. Emitted $PM_{10}$ is thus the summation of PMC, PMF, EC, SOA and SO4.

The CALPUFF modeling also tracked $SO_4$, $NO_3$, and $HNO_3$, which are generated by the chemical transformation of the emitted $SO_2$ and $NO_x$. The IWAQM recommended MESOPUFF II algorithms were selected to describe the rates of transformation. The MESOPUFF II transformation rates are a function of the background ozone and ammonia concentrations. The default CALPUFF libraries were used to characterize the wet and dry deposition of the modeled particulate and gaseous species.

Per guidance included in a May 4, 2012 e-mail from MPCA (Reference (9)), transformation chemistry and the associated secondary particulate formation was not included in the evaluation of $PM_{10}$ increment consumption.

Both dry and wet deposition were modeled for all nine species (PMC, PMF, EC, SOA, $SO_4$ and $NO_3$ were modeled as dry deposition of particles; $NO_x$, $HNO_3$, and $SO_2$ were modeled as dry deposition of gases) to obtain total sulfur and nitrogen deposition.

The CALPUFF modeling used the receptors for the BWCAW, Rainbow Lake Wilderness, Voyageurs National Park, and the Isle Royale National Park obtained from the National Park Service's web site (http://nature.nps.gov/air/Maps/Receptors/).

### 3.3.3 Post-processing

The CALPUFF output of hourly concentration values requires different postprocessing methods to generate the AQRV estimates of deposition, visibility, and increment. The postprocessing used the two program modules: CALPOST and POSTUTIL

POSTUTIL recalculates the hourly concentration values produced by CALPUFF to reflect ammonia scavenging chemistry in the model. The ammonia values used by POSTUTIL are independent of the ammonia value used in the MESOPUFF II chemical transformation algorithm in CALPUFF. A background ammonia concentration of 1 ppb was used. POSTUTIL also is used to sum the individual species contributions of wet and dry deposition to calculate total sulfur and nitrogen deposition.

CALPOST processes the hourly concentration files generated by CALPUFF to develop the estimates of deposition, air pollutant concentrations, and visibility impairment resulting from facility emissions. For visibility calculations, CALPOST uses relative humidity data in

conjunction with the hourly concentration files to calculate 24-hour average light extinction coefficients. Two sets of relative humidity data were used in the postprocessing corresponding to the Method 8 and Method 2 CALPOST visibility processing options. Method 8 follows the visibility calculation procedures in the 2010 revision of the FLAG guidance. Method 8 uses Class I area-specific monthly average relative humidity data provided in the updated guidance. Method 2 (Reference (7)) uses the CALPUFF generated hourly relative humidity data (VISB.DAT) in the visibility calculations, and is included for comparison with prior modeling efforts.

# 4.0 Acid Deposition Impacts Analysis

An evaluation of potential impacts to species (flora and fauna) and ecosystems (terrestrial and aquatic) resulting from Project $SO_2$ and $NO_x$ emissions was conducted according to the methodology outlined in the USFS publication entitled "Screening Procedures to Evaluate Effects of Air Pollution on Eastern Wildernesses Cited as Class I Air Quality Areas" (Reference (5)). The USFS methodology uses a "Green-Yellow-Red" screening procedure in which the acid deposition impact on terrestrial and aquatic ecosystems is judged to be acceptable if ambient air concentrations and/or deposition is not above the respective "Green Line Concentration".

## 4.1 Background Deposition Values

Data characterizing the Class I areas for ambient air concentrations of selected pollutants and for sulfur and nitrogen deposition are provided in Table 4-1. Assumptions and data applications were made for the four Class I areas in order to complete the AQRV analysis. Some of the major assumptions and data applications are listed below. Other assumptions and data applications, particularly estimating dry sulfur and dry nitrogen deposition, are included in the footnotes to Table 4-1.

- Isle Royale: Sulfur and nitrogen deposition data for Isle Royale are limited. The National Atmospheric Deposition Program (NADP) operates a precipitation monitoring site on Isle Royale during the ice-free season and provides seasonal deposition values for sulfur and nitrogen. However, average annual deposition data are needed for the AQRV analysis. Average annual deposition data from the Hovland, Minnesota site, which is located within the Lake Superior basin approximately 22 miles south and west of Isle Royale, were subsequently used to estimate annual average deposition for Isle Royale.

- Rainbow Lake Wilderness: The Rainbow Lake Wilderness is located in northwest Wisconsin. The NADP operates a monitoring site near Spooner, Wisconsin. Wet sulfate and wet nitrate deposition data from the Spooner NADP site were applied to the Rainbow Lake Wilderness.

**Table 4-1 Existing and Estimated Background Values For Selected Class I Areas**

| Characteristic | BWCAW | Isle Royale | Rainbow Lake | Voyageurs Park |
|---|---|---|---|---|
| Mean $SO_2$ Concentration, annual ($\mu g/m^3$) [(a)] | 1.2 | 2.0 | 1.6 | 0.7 |
| Max $SO_2$ Concentration, 3-hour ($\mu g/m^3$) [(b)] | 10.8 | 18 | 14.4 | 6.3 |
| Ozone Concentration, 2nd-high hourly ($ppb_v$) [(c)] | 68 | 68 | 90 | 71 |
| Annual Sulfur Deposition | | | | |
| Wet deposition (kg S/ha/yr) [(d)] | 2.42 | 1.72 | 2.55 | 1.41 |
| Dry deposition (kg S/ha/yr) [(e)] | 0.43 | 0.43 | 0.43 | 0.43 |
| Total deposition(kg S/ha/yr) | 2.85 | 2.15 | 2.98 | 1.84 |
| Annual Nitrogen Deposition | | | | |
| Wet deposition (kg N/ha/yr) [(d)] | 4.07 | 3.17 | 5.20 | 3.19 |
| Dry deposition (kg N/ha/yr) [(e)] | 0.68 | 0.68 | 0.68 | 0.68 |
| Total deposition (kg N/ha/yr) | 4.75 | 3.85 | 5.88 | 3.87 |

(a) Mean annual $SO_2$ concentrations ($\mu g/m^3$):
Annual average $SO_2$ ($\mu g/m^3$) concentrations calculated from data (1991-1993) in Table 1 (Reference (5)):
BWCAW: data from Ely, MN site applied to BWCAW.
Isle Royale National Park: data from the Finland, MN site applied to Isle Royale National Park.
Rainbow Lake Wilderness: data from the Sandstone, MN site applied to Rainbow Lake Wilderness.
Voyageurs National Park: data from Annual Data Summary, Voyageurs National Park 2002, National Park Service, Gaseous Air Pollutant Monitoring Network, Report No. NPS D-139.

(b) Highest 3-hour $SO_2$ set equal to annual average $SO_2$ x 9.0, in accordance with USEPA Guideline (see Table 4-3)

(c) Ozone concentrations:
BWCAW: data from USEPA AirData, Lake County, MN (2003)
Isle Royale National Park: data from USEPA AirData, Lake County, MN (2003)
Rainbow Lake Wilderness: data from USEPA AirData, Polk County, WI (1998)
Voyageurs National Park: data from Annual Data Summary, Voyageurs National Park 2001, National Park Service, Gaseous Air Pollutant Monitoring Network, Report No. NPS D-134.

(d) Annual wet deposition data from NAPD data base (http://nadp.sws.uiuc.edu)
BWCAW: data for Hovland Site, Cook County, MN (1997-2003)
Isle Royale National Park: data for Fernberg Site, Lake County, MN (1997-2003)
Rainbow Lake Wilderness: data for Spooner Site, Washburn County, WI (1997-2003)
Voyageurs National Park: data for Voyageurs National Park, Sullivan Bay, St. Louis County, MN (2000-2003)

(e) Annual dry deposition data from CASTnet data base (http://www.epa.gov/castnet) for Voyageurs National Park. (1996-2002)

## 4.2 Flora and Fauna

Adverse effects to flora (plants) and fauna (animals) are generally accepted to mean any changes in growth, reproduction, mortality, and diversity of native plant and animal species caused by anthropogenic activities. In evaluating potential adverse effects to flora and fauna, lichen species are generally used as a threshold indicator of potential air pollution damage because they are especially susceptible to air pollution and show adverse effects before other plant species and animal species. If pollutant concentrations in a Class I area are sufficiently low that no damage

occurs to native lichens, then it can reasonably be concluded that all other flora and fauna species are protected. The most sensitive lichen species are only present when annual average $SO_2$ concentrations are less than 40 $\mu g/m^3$.[2] Table 4-2 compares the sum of background $SO_2$ concentrations plus modeled ambient air $SO_2$ concentrations to the Project emissions for all AQRV scenarios modeled (i.e., maximum modeling result for all scenarios). As can be seen in Table 4-2, all estimated $SO_2$ ambient air concentrations are substantially lower than 40 $\mu g/m^3$, and they are also well below the Green Line Concentration of 5 $\mu g/m^3$, indicating that there will be no adverse effects from the Project emissions on flora or fauna in the Class I areas.

**Table 4-2 Class I Screening Analysis for Effects on Flora and Fauna from Sulfur Dioxide Total Annual Average Ambient Air Concentrations – All AQRV Scenario Maximum**

| Location | Background Air Concentration [a] ($\mu g/m^3$) | Modeled Project Contribution [b] ($\mu g/m^3$) | Total Projected Air Concentration ($\mu g/m^3$) | Green Line Concentration [c] ($\mu g/m^3$) |
|---|---|---|---|---|
| BWCA Wilderness | 1.2 | 0.001 | 1.2 | 5 |
| Isle Royale National Park | 2.0 | 0.000 | 2.0 | 5 |
| Rainbow Lake Wilderness | 1.6 | 0.000 | 1.6 | 5 |
| Voyageurs National Park | 0.7 | 0.000 | 0.7 | 5 |

[a] Mean annual $SO_2$ concentrations ($\mu g/m^3$):
Annual average $SO_2$ ($\mu g/m^3$) concentrations calculated from data (1991-1993) in Table 1 (Reference (5)):
BWCAW: data from Ely, MN site applied to BWCAW
Isle Royale National Park: data from the Finland, MN site applied to Isle Royale National Park.
Rainbow Lake Wilderness: data from the Sandstone, MN site applied to Rainbow Lake Wilderness.

Voyageurs National Park: data from Annual Data Summary, Voyageurs National Park 2002, National Park Service, Gaseous Air Pollutant
Monitoring Network, Report No. NPS D-139.

[b] Maximum modeled ambient air concentration in a Class I area using the CALPUFF modeling system.

[c] Green line concentration from (Reference (5))

## 4.3 Terrestrial and Aquatic Ecosystems

### 4.3.1 Deposition Thresholds

Adverse effects to terrestrial and aquatic ecosystems are evaluated slightly differently by the National Park Service and the USFS. The National Park Service uses deposition analysis

thresholds (DATs) to evaluate if the incremental impact of the Project for deposition is acceptable, whereas the USFS considers the total concentration or deposition, including background in their Green Line analysis.

For the National Park Service sites (Voyageurs National Park and Isle Royale National Park), the DATs were calculated for total sulfur and total nitrogen. DATs have been developed by the National Park Service and the U.S. Fish and Wildlife Service (Reference (10)) to evaluate the contribution of additional nitrogen (N) or sulfur (S) to deposition within Class I areas. The definition of a DAT is "the additional amount of nitrogen or sulfur deposition within a Class I area, below which estimated impacts from a proposed new or modified source are considered insignificant". The DATs that have been developed are intended to distinguish where deposition increases may result in potentially adverse ecosystem stresses, as well as where the deposition increases are likely to have negligible impact on AQRVs. The National Park Service has calculated the following DATs:

- N = 0.01 kg/ha/yr
- S = 0.01 kg/ha/yr

The DAT is the additional amount of deposition (i.e., deposition threshold) that triggers a management concern, not necessarily the amount that constitutes an adverse impact to the environment. Adverse impact determinations are considered on a case-by-case basis, taking into consideration the best available scientific information to assess existing as well as potential future deposition impacts. The magnitude of the estimated deposition and the sensitivity of the ecosystem are also considered. Site-specific information for each Class I area are also taken into account, including evaluating the potential deposition impacts from a source not just in relation to the DAT, but with other factors as well, such as whether an adverse impact resulting from deposition have been documented, or suspected, in that specific Class I area.

While formulated slightly differently than the National Park Service DATs, the USFS Green Line values for BWCAW and Rainbow Lake account for the soil conditions and lake water chemistry of these wilderness areas. The Green Line values represent the total pollutant loading below which there are no adverse impacts.

### 4.3.2 Terrestrial Impacts

The pollutant values required for the terrestrial impacts evaluation are the Project-related nitrogen and sulfur deposition and $SO_2$ ambient air concentrations. The maximum modeling results across all Project scenarios are provided in Table 4-3. As discussed above, because the USFS considers the total concentration or deposition, including background in their Green Line analysis, comparison for the BWCAW and Rainbow Lake Wilderness should be made between the column titled "Total Concentration or Deposition" and the column titled "Green Line Value or Deposition Analysis Threshold". Similarly, because the National Park Service considers the incremental impact of the Project for deposition (i.e., not including background), deposition comparisons for Isle Royale National Park and Voyageurs National Park should be made between the column titled "Modeled Air Concentration or Calculated Project-Related Deposition" and the column titled "Green Line Value or Deposition Analysis Threshold". The green line values or DATs for terrestrial effects are not exceeded for the Class I areas.

**Table 4-3 Class I Area Screening Analysis Results for Potential Terrestrial Impacts –All AQRV Scenario Maximums**

| Location[b] | Pollutant | Background Data[a] | Model Air Concentration or Calculated Project-Related Deposition[c] | Total Concentration or Deposition | Green Line Value Or Deposition Analysis Threshold[d] [e] |
|---|---|---|---|---|---|
| BWCAW – Ely | Ann. avg. $SO_2$ ($\mu g/m^3$) | 1.2 | 0.001 | 1.2 | 5 $\mu g/m^3$ |
| | 3-hour max. $SO_2$ ($\mu g/m^3$) | 10.8 | 0.105 | 10.9 | 100 $\mu g/m^3$ |
| | Total Sulfur (kg/ha/yr) | 2.85 | 0.000 | 2.9 | 5-7 kg/ha/yr S |
| | Total Nitrogen (kg/ha/yr) | 4.75 | 0.009 | 4.8 | 5-8 kg/ha/yr N |
| Isle Royale National Park | Ann. avg. $SO_2$ ($\mu g/m^3$) | 2.0 | 0.000 | 2.0 | 5 $\mu g/m^3$ |
| | 3-hour max. $SO_2$ ($\mu g/m^3$) | 18 | 0.001 | 18 | 100 $\mu g/m^3$ |
| | Total Sulfur (kg/ha/yr) | 2.15 | 0.000 | 2.2 | 0.01 kg/ha/yr S |
| | Total Nitrogen (kg/ha/yr) | 3.85 | 0.000 | 3.9 | 0.01 kg/ha/yr N |
| Rainbow Lake Wilderness | Ann. avg. $SO_2$ ($\mu g/m^3$) | 1.6 | 0.000 | 1.6 | 5 $\mu g/m^3$ |
| | 3-hour max. $SO_2$ ($\mu g/m^3$) | 14.4 | 0.003 | 14.4 | 100 $\mu g/m^3$ |
| | Total Sulfur (kg/ha/yr) | 2.98 | 0.000 | 3.0 | 5-7 kg/ha/yr S |
| | Total Nitrogen (kg/ha/yr) | 5.88 | 0.000 | 5.9 | 5-8 kg/ha/yr N |
| Voyageurs National Park | Ann. avg. $SO_2$ ($\mu g/m^3$) | 0.7 | 0.000 | 0.7 | 5 $\mu g/m3$ |
| | 3-hour max. $SO_2$ ($\mu g/m^3$) | 6.3 | 0.020 | 6.3 | 100 $\mu g/m3$ |
| | Total Sulfur (kg/ha/yr) | 1.84 | 0.000 | 1.8 | 0.01 kg/ha/yr S |
| | Total Nitrogen (kg/ha/yr) | 3.87 | 0.001 | 3.9 | 0.01 kg/ha/yr N |

[a] Mean annual $SO_2$ concentrations ($\mu g/m^3$):

Annual average $SO_2$ ($\mu g/m^3$) concentrations calculated from data (1991-1993) in Table 1 (Reference (11)):
BWCAW: data from Ely, MN site applied to BWCAW
Isle Royale National Park: data from the Finland, MN site applied to Isle Royale National Park.
Rainbow Lake Wilderness: data from the Sandstone, MN site applied to Rainbow Lake Wilderness.

Voyageurs National Park: data from Annual Data Summary, Voyageurs National Park 2002, National Park Service, Gaseous Air Pollutant Monitoring Network, Report No. NPS D-139.

Highest 3-hour $SO_2$ set equal to annual average $SO_2$ x 9.0, in accordance with USEPA Guideline (Reference (12)).

Annual wet deposition data from NAPD data base (http://nadp.sws.uiuc.edu)
BWCAW: data for Hovland Site, Cook County, MN (1997-2003)
Isle Royale National Park: data for Fernberg Site, Lake County, MN (1997-2003)
Rainbow Lake Wilderness: data for Spooner Site, Washburn County, WI (1997-2003)

| Location[b] | Pollutant | Background Data[a] | Model Air Concentration or Calculated Project-Related Deposition[c] | Total Concentration or Deposition | Green Line Value Or Deposition Analysis Threshold[d] [e] |
|---|---|---|---|---|---|
| Voyageurs National Park: data for Voyageurs National Park, Sullivan Bay, St. Louis County, MN (2000-2003)<br><br>Annual dry deposition data from CASTnet data base (http://www.epa.gov/castnet) for Voyageurs National Park. (1996-2002)<br><br>[b] Highest Modeled air concentration in each Class I area.<br>[c] Model estimated ambient air concentrations using the CALPUFF modeling system.<br>[d] Green line concentration from (Reference (11)). Deposition Analysis Threshold (DAT) is based on National Park Service Guidance for the Eastern U.S.<br>[e] S = sulfur; N = nitrogen. | | | | | |

### 4.3.3 Aquatic Impacts

The pollutant values required for the aquatic impacts evaluation are the Project-related nitrogen and sulfur deposition. The maximum modeling results across all Project scenarios are provided in Table 4-4. As discussed above, because the USFS considers the total deposition, including background in their Green Line analysis, comparison for the BWCAW and Rainbow Lake Wilderness should be made between the column titled "Total Deposition" and the column titled "Green Line Value or Deposition Analysis Threshold". Similarly, because the National Park Service considers the incremental impact of the Project for deposition (i.e., not including background), deposition comparisons for Isle Royale National Park and Voyageurs National Park should be made between the column titled "Estimated Project-Related Deposition" and the column titled "Green Line Value or Deposition Analysis Threshold". The green line values or DATs for aquatic effects are not exceeded for any of the National Park Service Class I areas.

**Table 4-4 Screening Analysis Results for Potential Aquatic Effects –All AQRV Scenario Maximums**

| Location[d] | Pollutant[a] | Background Deposition[b] (kg/ha/yr) | Estimated Project-Related Deposition (kg/ha/yr) | Total Deposition (Project + Background) (kg/ha/yr) | Green Line Value or Deposition Analysis Threshold[c] (kg/ha/yr) |
|---|---|---|---|---|---|
| BWCAW – Ely | Total Sulfur | 2.85 | 0.000 | 2.85 | 7.5 - 8.0 |
| | Total S + 20% of Total N | 3.80 | 0.002 | 3.80 | 9 – 10 |
| Isle Royale National Park | Total Sulfur | 2.15 | 0.000 | 2.15 | 0.01 |
| | Total N | 3.85 | 0.000 | 3.85 | 0.01 |
| Rainbow Lake Wilderness | Total Sulfur | 2.98 | 0.000 | 2.98 | 3.5 - 4.5 |
| | Total S + 20% of Total N | 4.16 | 0.000 | 4.16 | 4.5 – 5.5 |
| Voyageurs National Park | Total Sulfur | 1.84 | 0.000 | 1.84 | 0.01 |
| | Total N | 3.87 | 0.001 | 3.87 | 0.01 |

[a] S = Sulfur; N = Nitrogen.

[b] Annual wet deposition data from NAPD data base (http://nadp.sws.uiuc.edu)
BWCAW: data for Hovland Site, Cook County, MN (1997-2003)
Isle Royale National Park: data for Fernberg Site, Lake County, MN (1997-2003)
Rainbow Lake Wilderness: data for Spooner Site, Washburn County, WI (1997-2003)
Voyageurs National Park: data for Voyageurs National Park, Sullivan Bay, St. Louis County, MN (2000-2003)
Annual dry deposition data from CASTnet data base (http://www.epa.gov/castnet) for Voyageurs National Park. (1996-2002)

[c] Green line concentration from (Reference (5)). Deposition Analysis Thresholds based on National Park Service guidance for the eastern U.S.

[d] Highest modeled deposition used in the assessment.

# 5.0 Visibility Impacts Analysis

The potential visibility impacts associated with the Project were evaluated using CALPUFF based on currently accepted guidance (i.e., Method 8) from the FLMs (Reference (8)). In addition, results are also presented based on the previous version of the FLM guidance (i.e., Method 2) for comparison purposes (Reference (7)). Potential changes in the visibility were expressed in terms of a light extinction coefficient $b_{ext}$. The approach has four major steps.

1) The atmospheric concentrations of visibility-impairing pollutants at receptors in the BWCAW, Voyageurs National Park, and the Isle Royale National Park were estimated by the CALPUFF modeling system.
2) Extinction coefficients were calculated from the model-generated atmospheric concentrations of visibility-impairing pollutants. Extinction coefficient results from both CALPOST Method 8 and Method 2 calculations are presented.
3) The emission-derived extinction coefficients were compared to the existing background extinction coefficients derived from the measured background concentrations of visibility-impairing pollutants at the three Class I areas. Results are compared to 20% best pristine day's background and annual average pristine background.
4) The potential visibility impacts were expressed as changes in the overall extinction coefficient ($\Delta b_{ext}$) and the number of days resulting in a change greater than 5% and 10%.

Three Class I areas were included in the visibility analysis for the Project: the BWCAW (located 34 km from Project facility), Voyageurs National Park (82 km), and Isle Royale National Park (218 km). The Rainbow Lake Wilderness Areas in Wisconsin does not have an AQRV for visibility.

## 5.1 Visibility Thresholds

Visibility impairment is defined as "…. Any humanly perceptible change in visibility (visual range, contrast, coloration) from that which would have existed under natural conditions." (40 CFR 51.301). For this analysis, visibility effects are to be determined by the change in light extinction as calculated in CALPOST. EPA's Prevention of Significant Deterioration (PSD) guidance states; "An 'adverse impact on visibility' means visibility impairment which interferes

with the management, protection, presentation, or enjoyment of a visitor's visual experience of the Federal Class I area."

Current FLM guidance provides the following threshold with regard to individual source visibility impacts (Reference (8)):

"The visibility threshold for concern is not exceeded if the 98th percentile change in light extinction is less than 5% for each year modeled, "

Table 5-1 shows the threshold differences between the different methods.

**Table 5-1 FLAG Comparison**

| | FLAG 2000 | FLAG 2010 |
|---|---|---|
| Maximum Day Over 10% | "...FLMs will likely object to the proposed action." | NA[a] |
| Maximum Day Between 5 and 10% | "...a special decision threshold applies." | NA |
| 98th Percentile Day Less Than 5% (H8H) | NA | "Presumptive no adverse impact" |
| No Days Over 5% | "...generally not trigger a need for a cumulative analysis." | NA |

[a]Not applicable (i.e., the guidance in this column does not use the criteria listed in the first column.

The visibility modeling results consider the Project exclusively.

Flag 2010 (Reference (8)) (Method 8) is the most recent approved guidance from the FLMs. However, previous modeling of the Project used the prior guidance version (Reference (7)) recommending Method 2, so those results are provided Section 5.3 as well for comparison.

## 5.2 Background Visibility Values

Model runs were also conducted for comparison to average natural (pristine) background and to the 20% best pristine days. Annual average chemical speciation data for the average and 20% best pristine days used for CALPUFF input are shown in Table 5-2.

**Table 5-2 Pristine background concentrations**

| Class I Area | Background | Ammonium Sulfate (µg/m3) | Ammonium Nitrate (µg/m3) | Coarse Particulate Matter (µg/m3) | Organic Carbon (µg/m3) | Soil (µg/m3) | Elemental Carbon (µg/m3) | Rayleigh (Mm-1) |
|---|---|---|---|---|---|---|---|---|
| BWCAW | Annual Average (a) | 0.23 | 0.1 | 3.0 | 1.4 | 0.5 | 0.02 | 10 |
| | 20% Best (b) | 0.11 | 0.02 | 0.86 | 0.50 | 0.13 | 0.01 | 11 |
| Voyageurs | Annual Average (a) | 0.23 | 0.1 | 3.0 | 1.4 | 0.5 | 0.02 | 10 |
| | 20% Best (b) | 0.12 | 0.02 | 0.86 | 0.56 | 0.10 | 0.01 | 12 |
| Isle Royale | Annual Average (a) | 0.23 | 0.1 | 3.0 | 1.4 | 0.5 | 0.02 | 10 |
| | 20% Best (b) | 0.10 | 0.02 | 0.79 | 0.34 | 0.09 | 0.01 | 12 |

a) Annual Average background from Table 2-1 of EPA's "Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program" (Reference (13)) Used with CALPOST Method 2

b) 20% Best background from Table V.1-2 in Reference (8). Used with CALPOST Method 8.

## 5.3 Visibility Modeling Results

CALPUFF/CALPOST modeling results for visibility impacts compared to annual average pristine conditions and 20% best pristine days for each Project scenario are presented in Table 5-3 through 5-6. Results are presented for each Class I area. CALPOST visibility processing used Method 8 for 20% best pristine days and used Method 2 for annual average pristine background. Results are presented in Table 5-3.

Method 8 is the method currently approved in guidance from the FLMs. However, previous modeling of the Project used the prior guidance version (Reference (7)) recommending Method 2, so those results are provided for reference as well.

Method 2 may lead to an over-estimation of visibility impacts during periods of higher relative humidity (above 90 percent). These events were often associated with the peak controlling impacts. The current Method 8 uses the monthly average value thus avoiding the problem that impairs Method 2 results.

**Table 5-3 Modeled Visibility Impacts – Scenario 1**

| Proposed Project Year 1 - 5 | | Natural Background | | | | | |
|---|---|---|---|---|---|---|---|
| | | FLAG 2000 Method 2 (hourly RH, average annual background) | | | FLAG 2010 Method 8 (monthly RH, 20% best days background) | | |
| | | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| **BWCAW** | | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | | 11.08 | 7.88 | 4.66 | 9.81 | 6.8 | 6.73 |
| 8th highest $\Delta b_{ext}$ (%) | | 5.08 | 3.33 | 3.41 | 4.86 | 3.92 | 3.85 |
| Days with $\Delta b_{ext} \geq 5\%$ | | 8 | 1 | 0 | 5 | 3 | 2 |
| Days with $\Delta b_{ext} \geq 10\%$ | | 1 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | | - | - | - | 0 | 0 | 0 |
| **Voyageurs** | | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | | 2.28 | 4.5 | 2.76 | 1.7 | 3.18 | 1.9 |
| 8th highest $\Delta b_{ext}$ (%) | | 1.12 | 1.28 | 1.31 | 0.89 | 1.11 | 0.97 |
| Days with $\Delta b_{ext} \geq 5\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | | - | - | - | 0 | 0 | 0 |
| **Isle Royale** | | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | | 1.12 | 1.13 | 1.23 | 1.03 | 0.69 | 0.75 |
| 8th highest $\Delta b_{ext}$ (%) | | 0.41 | 0.25 | 0.38 | 0.44 | 0.21 | 0.23 |
| Days with $\Delta b_{ext} \geq 5\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | | - | - | - | 0 | 0 | 0 |

**Table 5-4 Modeled Visibility Impacts – Scenario 2**

| Proposed Project Year 6-8 | Natural Background | | | | | |
|---|---|---|---|---|---|---|
| | FLAG 2000 Method 2 (hourly RH, average annual background) | | | FLAG 2010 Method 8 (monthly RH, 20% best days background) | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| **BWCAW** | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | 10.88 | 7.75 | 4.56 | 9.63 | 6.69 | 6.59 |
| 8th highest $\Delta b_{ext}$ (%) | 4.86 | 3.11 | 3.27 | 4.74 | 3.83 | 3.8 |
| Days with $\Delta b_{ext} \geq 5\%$ | 7 | 1 | 0 | 4 | 2 | 1 |
| Days with $\Delta b_{ext} \geq 10\%$ | 1 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | - | - | - | 0 | 0 | 0 |
| **Voyageurs** | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | 2.23 | 4.41 | 2.72 | 1.66 | 3.13 | 1.87 |
| 8th highest $\Delta b_{ext}$ (%) | 1.1 | 1.26 | 1.22 | 0.85 | 1.09 | 0.96 |
| Days with $\Delta b_{ext} \geq 5\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | - | - | - | 0 | 0 | 0 |
| **Isle Royale** | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | 1.1 | 1.11 | 1.2 | 1.01 | 0.67 | 0.74 |
| 8th highest $\Delta b_{ext}$ (%) | 0.4 | 0.25 | 0.33 | 0.43 | 0.19 | 0.22 |
| Days with $\Delta b_{ext} \geq 5\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | - | - | - | 0 | 0 | 0 |

**Table 5-5 Modeled Visibility Impacts – Scenario 3**

| Proposed Project Year 9-10 | | Natural Background | | | | | |
|---|---|---|---|---|---|---|---|
| | | FLAG 2000 Method 2 (hourly RH, average annual background) | | | FLAG 2010 Method 8 (monthly RH, 20% best days background) | | |
| | | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| **BWCAW** | | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | | 10.99 | 7.82 | 4.61 | 9.72 | 6.75 | 6.66 |
| 8th highest $\Delta b_{ext}$ (%) | | 4.89 | 3.14 | 3.3 | 4.8 | 3.87 | 3.83 |
| Days with $\Delta b_{ext} \geq 5\%$ | | 7 | 1 | 0 | 4 | 2 | 2 |
| Days with $\Delta b_{ext} \geq 10\%$ | | 1 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | | - | - | - | 0 | 0 | 0 |
| **Voyageurs** | | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | | 2.26 | 4.46 | 2.74 | 1.68 | 3.16 | 1.89 |
| 8th highest $\Delta b_{ext}$ (%) | | 1.11 | 1.28 | 1.23 | 0.86 | 1.09 | 0.97 |
| Days with $\Delta b_{ext} \geq 5\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | | - | - | - | 0 | 0 | 0 |
| **Isle Royale** | | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | | 1.11 | 1.12 | 1.22 | 1.02 | 0.68 | 0.75 |
| 8th highest $\Delta b_{ext}$ (%) | | 0.41 | 0.25 | 0.33 | 0.43 | 0.2 | 0.22 |
| Days with $\Delta b_{ext} \geq 5\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | | - | - | - | 0 | 0 | 0 |

**Table 5-6 Modeled Visibility Impacts – Scenario 4**

| Proposed Project Year 11-20 | Natural Background | | | | | |
|---|---|---|---|---|---|---|
| | FLAG 2000 Method 2 (hourly RH, average annual background) | | | FLAG 2010 Method 8 (monthly RH, 20% best days background) | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| **BWCAW** | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | 9.44 | 6.8 | 3.97 | 8.45 | 5.95 | 5.71 |
| 8th highest $\Delta b_{ext}$ (%) | 4.43 | 2.69 | 2.93 | 4.21 | 3.45 | 3.42 |
| Days with $\Delta b_{ext} \geq 5\%$ | 3 | 1 | 0 | 2 | 2 | 1 |
| Days with $\Delta b_{ext} \geq 10\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | - | - | - | 0 | 0 | 0 |
| **Voyageurs** | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | 1.84 | 3.8 | 2.39 | 1.41 | 2.76 | 1.62 |
| 8th highest $\Delta b_{ext}$ (%) | 0.96 | 1.11 | 1.09 | 0.74 | 0.97 | 0.82 |
| Days with $\Delta b_{ext} \geq 5\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | - | - | - | 0 | 0 | 0 |
| **Isle Royale** | | | | | | |
| Maximum $\Delta b_{ext}$ (%) | 0.93 | 0.93 | 0.99 | 0.88 | 0.55 | 0.62 |
| 8th highest $\Delta b_{ext}$ (%) | 0.35 | 0.21 | 0.29 | 0.36 | 0.17 | 0.19 |
| Days with $\Delta b_{ext} \geq 5\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Days with $\Delta b_{ext} \geq 10\%$ | 0 | 0 | 0 | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 5\%$ | - | - | - | 0 | 0 | 0 |
| 98th %ile days with $\Delta b_{ext} \geq 10\%$ | - | - | - | 0 | 0 | 0 |

When compared to pristine conditions, the Project has no days with a change in extinction greater than 5% at Voyageurs or Isle Royale, for any scenario, using either method.

Using current modeling guidance (Method 8), the 98th percentile day impacts have a change in extinction of less than 5% change at BWCAW for all scenarios. These visibility modeling results meet the current FLM criteria for demonstrating no adverse impacts.

To allow for comparison to previous modeling, the results are also presented using Method 2. BWCAW has zero or one days with greater than a 10% change in extinction and 4 to 9 days greater than 5% using the previous modeling guidance. The results in this report show a significant reduction in the number of days with greater than 5% change in extinction compared

to the modeling results included in the Project Draft Environmental Impact Statement (DEIS) from October of 2009.

## 6.0 Prevention of Significant Deterioration (PSD) Increment Analysis

Air emission permits for major sources require that an air quality analysis be conducted to demonstrate that national ambient air quality standards will not be exceeded and that the Project will not significantly deteriorate air quality from baseline levels beyond what has been set aside for growth. The allowance for growth, in terms of air quality, is defined as the increment of the national ambient air quality standards that are set aside for increases in ambient air concentrations.

The Project is not a major source, but the same method was used for assessing impacts in Class I Areas that is used for major sources.

In the first step in the Class I PSD increment analysis, the modeled ambient air concentrations are compared to SILs[2]. Modeled air concentrations greater than a SIL do not indicate that

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[2] The SILs were proposed by EPA in July, 1996 (61 FR 61 FR 38292), and are used by the FLMs as a benchmark for determining if further analysis is warranted. The Class I SILs were proposed by EPA but have never been finalized. The SILs were established by EPA as a threshold for decision-making with regard to the need for additional analysis. EPA set the SILs at four percent of the Class I area increment. EPA's working assumption is that as long as no individual source contribution exceeds four percent of a Class I increment, it is unlikely that the accumulation of sources over time will exceed that increment and no additional analysis is needed. The SILs proposed by EPA in July, 1996 (61 FR 61 FR 38292), but never finalized, are *de minimis* levels set at four percent of the allowable Class I increment concentration. According to EPA, "where a proposed source contributes less than four percent to the Class I increment, concentrations are sufficiently low so as not to warrant a costly and detailed analysis of the combined effects of the proposed source and all other increment consuming emissions." (61 FR 38292). Even though the

adverse impacts will be associated with a Project's emissions; they simply trigger additional analysis. If the modeled concentrations exceed the SILs, then the applicant is required to conduct a cumulative increment analysis, which accounts for all increment consuming and expanding sources within 300 km of the Class I areas. As discussed in Section 6.1, the modeled Project air emissions exceeded the 24-hour $PM_{10}$ SIL in the BWCAW, which triggered a cumulative increment analysis for $PM_{10}$. The purpose of the cumulative increment analysis is to demonstrate that the addition of the Project along with emission increases and decreases from other facilities that have occurred since the baseline do not exceed the allowed increments.

Two components of the cumulative increment modeling analysis require additional detail beyond that used in the analysis for the AQRVs, and these components are the modeling procedures and the emission inventory. As discussed in Section 3, the modeling domain needed to be expanded to include increment sources within 300 km. Additional post-processing was also required for calculating the net increment consumption. Development of the increment modeling emission inventory is discussed in detail in Section 6.3.

## 6.1 Project Modeling Results Compared to SILs

Table 6-1 shows the maximum modeled pollutant concentrations of the Project emissions compared to the Class I increments and SILs for the three model years of 2002, 2003, and 2004.

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Class I SILs have not been finalized, they were used as guidance for assessing the impacts on the Class I areas.

**Table 6-1 Maximum Modeled Pollutant Concentrations from the Project Compared to Class I PSD Increments**

| | | | | Modeled Results | | | |
|---|---|---|---|---|---|---|---|
| **Pollutant** | **Averaging Period** | **PSD Class I Increment (µg/m3)** | **U.S. EPA SIL (µg/m3)** | **BWCAW (µg/m3)** | **Voyageurs National Park (µg/m3)** | **Isle Royale National Park (µg/m3)** | **Rainbow Lake Area Wilderness (µg/m3)** |
| $SO_2$ | 3-Hour | 25 | 1.0 | 0.106 | 0.020 | 0.001 | 0.003 |
| | 24-Hour | 5 | 0.2 | 0.025 | 0.005 | 0.001 | 0.001 |
| | Annual | 2 | 0.1 | 0.001 | 0.000 | 0.000 | 0.000 |
| $NO_2$ | Annual | 2.5 | 0.1 | 0.037 | 0.005 | 0.002 | 0.002 |
| $PM_{10}$ | 24-Hour | 8 | 0.3 | 0.331 | 0.131 | 0.031 | 0.033 |
| | Annual | 4 | 0.2 | 0.020 | 0.004 | 0.002 | 0.002 |

The maximum modeled concentration from 2002-2004 meteorological data is presented.

While the modeling demonstrates compliance with the promulgated increments by a wide margin, the modeling shows concentrations above the proposed 24-hour SILs for $PM_{10}$ in the BWCAW. Therefore, additional analysis was conducted to evaluate the cumulative impacts to $PM_{10}$ increment in the BWCAW.

## 6.2 Class I Increment Analysis Emission Inventory

A cumulative impacts assessment for $PM_{10}$ in Voyageurs and the BWCAW was obtained from MPCA. This emission inventory was developed to include increment consuming and expanding sources. Current knowledge is that no other major sources within the region have submitted complete permit applications since this inventory was prepared. The emission inventory includes modifications to existing sources, new facilities that have been permitted or submitted permit applications and increases in actual emissions from existing facilities.

The inventory includes major sources within approximately 300 kilometers of Voyageurs and the BWCAW. Selected minor sources near the Class I Areas are also included, as selected by MPCA. The project impacts are below the SIL in Voyageurs, but at the request of MPCA, the cumulative results for Voyageurs are included.

### 6.2.1 Minor Source Baseline Dates

The minor source baseline date (MiSBD) is triggered at the time when a major PSD permit application is submitted and deemed complete. A cumulative increment assessment considers increases and decreases in emissions from sources occurring since the MiSBD to the time of the Project. MiSBDs are typically set on a county by county basis. Voyageurs and the BWCAW border several Minnesota counties and border one county in common. Voyageurs borders Koochiching and St. Louis counties. The BWCAW borders St. Louis, Lake and Cook counties. Based on information from the MPCA these four counties have the following MiSBDs for $PM_{10}$:

**Table 6-2 $PM_{10}$ Minor Source Baseline Dates**

| County | Minor Source Baseline Date | Facility Triggering MiSBD |
|---|---|---|
| Koochiching | 1991 | Boise Cascade |
| St. Louis | 1979 | Potlatch (Cook, MN) |
| Lake | 1999 | Cyprus Northshore Mining |
| Cook | Not applicable | No major modifications |

Source: http://www.pca.state.mn.us/air/modeling.html#psd

### 6.2.2 Area and Mobile Sources

The April, 2006 FLM guidance suggests that area and mobile sources be considered in the cumulative increment assessment. The magnitude of $PM_{10}$ emissions from these sources is quite small in the region around the Class I areas, compared to the major industrial sources. Further, it is likely that these sources have declined since the minor source baseline trigger date. According to the U.S. Census Bureau (censtats.census.gov for 1979 data and www.fedstats.gov for 2004 data), the population in all of the nearby counties except for Cook has decreased since 1979 as shown in Table 6-3. Although there has been a small population increase in Cook County, the overall population in the region has decreased by over 10%.

**Table 6-3 U.S. Census Bureau County Population Data**

| County | 1979 Pop. | 2004 Pop. |
|---|---:|---:|
| Koochiching | 17,500 | 13,900 |
| St. Louis | 221,000 | 198,000 |
| Lake | 12,900 | 11,200 |
| Cook | 4,100 | 5,300 |
| Total | 255,500 | 228,400 |

Based on this information, no increase in emissions from area and mobile sources has likely occurred and therefore, they were not included in the increment assessment. Actual emissions from area and mobile sources have probably decreased but were not included as an increment expanding reduction.

### 6.2.3 New Sources in Inventory

The following recently permitted new sources are included in the emission inventory in addition to the Project:

- Mesabi Nugget
- Keetac Expansion
- Essar Steel

These facilities/projects have been permitted but have not begun operation or have recently commenced operation. The increment consumption for all of these sources was based on permitted emissions, which will be conservative for sources that have commenced operation. The emissions inventory used was prepared by MPCA (February 24, 2012 revision).

## 6.3 Increment Modeling Results

Modeled air concentrations compared to the Class I PSD increment for the Project are presented in Table 6-1. Overall, the CALPUFF modeling indicates that the emissions associated with the Project will not deteriorate the air quality significantly in the four modeled Class I areas, because all modeled concentrations are well below the PSD Class I Increment.

The cumulative Class I increments are evaluated only for those pollutant/averaging period combinations which exceeded the SIL based on Project emissions. If the cumulative increment modeling shows an exceedance of the increment, and if the Project contribution to that exceedance is less than the SIL, then the Project is not considered to significantly contribute to the exceedance (i.e., it is not an exceedance for the Project).

The increment modeling results indicate that the full increment has not been consumed. Considering both increment consuming emission increases and increment expanding emission decreases, the maximum modeled increment consumption in the BWCAW is 1.76 $\mu g/m^3$, and 0.22 $\mu g/m^3$ in Voyageurs for historic projects based on the inventory obtained from MPCA. The analysis modeled all receptors in the BWCAW and Voyageurs, and showed no projected exceedances of increment. Therefore, increment limits will not be exceeded due to the Project.

# 7.0 Summary and Conclusions – Class I Areas and Impacts to Air Quality Related Values (AQRVs) and Increment

Four Class I areas were assessed for potential impacts from the Project emissions: BWCAW, Isle Royale National Park, Rainbow Lake Wilderness, and Voyageurs National Park. The modeling results show that the Project at Hoyt Lakes, Minnesota will not cause significant deterioration of air quality in these areas.

PolyMet has proposed suitable pollution control equipment for all point sources. In addition, PolyMet has agreed to install emission controls in the Crushing Plant and Concentrator consistent with the best controls currently used in the metallic ore processing industries for fine particulates to address specific regulator concerns. The hydrometallurgical process does not use continuously operating combustion sources. Therefore, $NO_x$ emissions are mostly due to heating. Small amounts of $SO_2$ are emitted by the process but controlled potential emissions are below the significant level of 40 tpy.

In order to reduce modeled impacts from natural gas fired space heaters, PolyMet has committed to upgrade the insulation in the existing Crusher and Concentrator Buildings and to purchase low-$NO_x$ space heating equipment such that overall $NO_x$ emissions are reduced by at least 50% below that with conventional equipment.

The mine vehicles and locomotives were also included in the emission inventory for the Class I modeling. The equipment utilized for the Project mining operation will meet the applicable standard for the current model year at the time of purchase. The emissions from the mine vehicles for the four scenarios modeled have been calculated based on reasonable assumptions on when Tier 4 vehicles in different size categories will be available and when vehicles in the fleet would be replaced or upgraded.. Maximum modeled fuel consumption was also adjusted for various periods of mine operation to reflect changes in the mine configuration over time.

The Class I modeling also includes the construction equipment used at the Tailings Basin. PolyMet plans to hire a contractor to complete the construction activities at the Tailings Basin. The emissions from the Tailings Basin construction fleet are based on the currently available

equipment configurations, which are at Tier 3 and Tier 4 emissions levels The level of activity (i.e., number of haul trucks) for each modeled scenario is based on the maximum within the scenario timeframe.

PolyMet and their contractors will also not use any fuel with greater than 15 ppm sulfur in the mine vehicles, locomotives and Tailings Basin construction equipment.

Modeled impacts were compared to PSD Class I increment values and AQRVs; flora and fauna impacts, deposition, and visibility impacts. The CALPUFF Modeling System was used to assess impacts.

$PM_{10}$ increment modeling was conducted and the results show that increment consumption has not exceeded the allowable value.

No adverse impact on flora and fauna is expected. Deposition values were below the "Green Line Values" set by the USFS and National Park Service. Therefore, no adverse impact on terrestrial and aquatic ecosystems is expected.

When compared to pristine conditions, the Project has no days with a change in extinction greater than 5% at Voyageurs or Isle Royale, for any scenario, using either method.

Using current modeling guidance (Method 8), 98th percentile day has a change in extinction of less than 5% at the BWCAW for all scenarios. These visibility modeling results meet the current FLM criteria for demonstrating no adverse impacts.

# 8.0 References

1. **Minnesota Department of Natural Resources, US Army Corps of Engineers, US Forest Service.** Draft Alternative Summary, NorthMet Project Environmental Impact Statement. March 4, 2011.

2. **PolyMet Mining, Inc.** NorthMet Project - Project Description (v3). 2011.

3. **Minnesota Department of Natural Resources, US Army Corps of Engineers, US Forest Service.** Air Impact Assessment Planning Summary Memo NorthMet Supplemental EIS. May 6, 2011.

4. **Wickman, Trent, Air Resource Specialist, Superior National Forest, and Duluth, Minnesota.** Federal Land Manager (FLM) Recommendations on Class I Area Analyses.

5. **Adams, et al.** Screening Procedures to Evaluate Effects of Air Pollution on Eastern Wildernesses Cited as Class I Air Quality Area. *USDA, Forest Service, Northeast Forest Experiment Station, General Technical Report NE-151.* September 1991.

6. **U.S. EPA Office of Air Quality Planning and Standards.** Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. December 1998. PA-454/R-98-019.

7. **Federal Land Managers' Air Quality Related Values Workgroup (FLAG).** Phase I Report. December 2000.

8. —. Phase I Report Revised. November 10, 2010.

9. **Baumann, Suzanne (MPCA).** *Email to Kevin Pylka of PolyMet Mining Inc and Pat Sheehy of Barr Engineering Co.* [Electronic Mail communication] May 4, 2012.

10. **National Park Service.** Guidance on Nitrogen and Sulfur Deposition Analysis Thresholds. [Online] http://www2.nature.nps.gov/air/Pubs/pdf/flag/nsDATGuidance.pdf.

11. **Pratt, et al.** Estimation of dry deposition of inorganics using filter pack data and inferred deposition velocity. *Environmental Science and Technology.* 1996. 30:2168-2177.

12. **U.S. EPA Office of Air Quality Planning and Standard.** EPA Guideline for Air Quality Maintenance Planning and Analysis. October 1977. Vol. 10 (revised). EPA-450/4-77-001.

13. **U.S. EPA Office of Air Quality Planning and Standards.** Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program. September 2003. EPA-454/B-03-005.

14. **MDNR, US Army Corps of Engineers, US Forest Service.** Draft Alternative Summary, NorthMet Project Environmental Impact Statement. March 4, 2011.

# Appendices

# Appendix A

## Modeled Emission Rates

| Stack ID No. | UTM: Zone 15 (NAD83) | | LCC: 47N 93W (30,60N) | | Base Elevation | Exit Height from Base | | | Inside Diameter | | Exit Flow Velocity | Exit Temperature | | Emission Rates | | | | | | | | | | Speciated Modeling Rates | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | NOx | | PM10 | | PM2.5 | | SO2 | | SO4 | | | PMC | PMF | SOA | EC | SO2 | SO4 | NOX | |
| | Easting | Northing | X | Y | | | | | | | | | | Hourly | Annual | Hourly | Annual | Hourly | Annual | Hourly | Annual | Hourly | Annual | | | | | | | | | |
| | (m) | (m) | (m) | (m) | (m) | (ft) | (m) | Basis | (ft) | (m) | (m/s) | (F) | (K) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | Notes |
| SV 003 | 564854.90 | 5272663.30 | 62693.53 | 65229.63 | 523.0 | 130.0 | 39.6 | | 6.5 | 1.98 | 24.341 | 77 | 298.15 | | | 0.429 | 0.429 | 0.429 | 0.429 | | | | | | | 0.429 | | | | | | | 1 |
| SV 004 | 564852.30 | 5272633.60 | 62691.00 | 65200.92 | 523.6 | 130.0 | 39.6 | | 6.5 | 1.98 | 24.341 | 77 | 298.15 | | | 0.429 | 0.429 | 0.429 | 0.429 | | | | | | | 0.429 | | | | | | | 1 |
| SV 401 | 564853.91 | 5272660.23 | 62692.57 | 65226.66 | 523.1 | 130.0 | 39.6 | | 3.2 | 0.98 | 19.139 | 77 | 298.15 | | | 0.082 | 0.082 | 0.082 | 0.082 | | | | | | | 0.082 | | | | | | | 1 |
| SV 005 | 564832.70 | 5272690.10 | 62672.08 | 65255.54 | 522.2 | 128.0 | 39.0 | | 2.2 | 0.67 | 29.400 | 77 | 298.15 | | | 0.059 | 0.059 | 0.059 | 0.059 | | | | | | | 0.059 | | | | | | | 1 |
| SV 402 | 564852.00 | 5272662.70 | 62690.72 | 65229.05 | 523.0 | 68.0 | 20.7 | | 2.7 | 0.82 | 19.520 | 77 | 298.15 | | | 0.059 | 0.059 | 0.059 | 0.059 | | | | | | | 0.059 | | | | | | | 1 |
| SV 403 | 564854.06 | 5272627.85 | 62692.70 | 65195.36 | 523.7 | 130.0 | 39.6 | | 3.2 | 0.98 | 19.139 | 77 | 298.15 | | | 0.082 | 0.082 | 0.082 | 0.082 | | | | | | | 0.082 | | | | | | | 1 |
| SV 404 | 564848.90 | 5272627.80 | 62687.72 | 65195.32 | 523.6 | 128.0 | 39.0 | | 2.7 | 0.82 | 19.520 | 77 | 298.15 | | | 0.059 | 0.059 | 0.059 | 0.059 | | | | | | | 0.059 | | | | | | | 1 |
| SV 008 | 564851.40 | 5272629.10 | 62690.13 | 65196.57 | 523.6 | 130.0 | 39.6 | | 3.8 | 1.16 | 17.648 | 77 | 298.15 | | | 0.106 | 0.106 | 0.106 | 0.106 | | | | | | | 0.106 | | | | | | | 1 |
| SV 009 | 564834.50 | 5272690.00 | 62673.82 | 65255.45 | 522.2 | 68.0 | 20.7 | | 2.5 | 0.76 | 18.007 | 77 | 298.15 | | | 0.047 | 0.047 | 0.047 | 0.047 | | | | | | | 0.047 | | | | | | | 1 |
| SV 405 | 564813.89 | 5272416.06 | 62653.81 | 64990.65 | 531.1 | 52.0 | 15.8 | | 2.2 | 0.67 | 18.442 | 77 | 298.15 | | | 0.037 | 0.037 | 0.037 | 0.037 | | | | | | | 0.037 | | | | | | | 1 |
| SV 406 | 564805.83 | 5272416.37 | 62646.01 | 64990.95 | 530.2 | 52.0 | 15.8 | | 2.2 | 0.67 | 18.442 | 77 | 298.15 | | | 0.037 | 0.037 | 0.037 | 0.037 | | | | | | | 0.037 | | | | | | | 1 |
| SV 012 | 564811.80 | 5272231.90 | 62651.72 | 64812.64 | 528.4 | 151.0 | 46.0 | | 4.0 | 1.22 | 20.940 | 77 | 298.15 | | | 0.140 | 0.140 | 0.140 | 0.140 | | | | | | | 0.140 | | | | | | | 1 |
| SV 407 | 564802.56 | 5272309.88 | 62642.82 | 64888.02 | 530.0 | 150.0 | 45.7 | | 4.0 | 1.22 | 20.940 | 77 | 298.15 | | | 0.140 | 0.140 | 0.140 | 0.140 | | | | | | | 0.140 | | | | | | | 1 |
| SV 013 | 564818.40 | 5272308.90 | 62658.13 | 64887.07 | 531.2 | 150.0 | 45.7 | | 6.0 | 1.83 | 27.920 | 77 | 298.15 | | | 0.420 | 0.420 | 0.420 | 0.420 | | | | | | | 0.420 | | | | | | | 1 |
| SV 014 | 564807.30 | 5272310.00 | 62647.40 | 64888.13 | 530.4 | 150.0 | 45.7 | | 6.5 | 1.98 | 18.983 | 77 | 298.15 | | | 0.335 | 0.335 | 0.335 | 0.335 | | | | | | | 0.335 | | | | | | | 1 |
| SV 408 | 564688.70 | 5272325.60 | 62532.76 | 64903.25 | 519.4 | 63.0 | 19.2 | | 2.3 | 0.70 | 18.830 | 77 | 298.15 | | | 0.042 | 0.042 | 0.042 | 0.042 | | | | | | | 0.042 | | | | | | | 1 |
| SV 016 | 564686.90 | 5272304.80 | 62531.01 | 64883.15 | 519.2 | 63.0 | 19.2 | | 2.3 | 0.70 | 18.830 | 77 | 298.15 | | | 0.042 | 0.042 | 0.042 | 0.042 | | | | | | | 0.042 | | | | | | | 1 |
| SV 413 | 564688.20 | 5272361.80 | 62532.29 | 64938.24 | 518.4 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 414 | 564690.77 | 5272389.51 | 62534.78 | 64965.03 | 518.5 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 415 | 564693.81 | 5272417.71 | 62537.73 | 64992.29 | 518.4 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 416 | 564696.25 | 5272451.62 | 62540.10 | 65025.06 | 518.1 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 417 | 564698.39 | 5272476.82 | 62542.17 | 65049.43 | 519.0 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 418 | 564700.82 | 5272499.03 | 62544.53 | 65070.89 | 519.6 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 419 | 564703.56 | 5272526.63 | 62547.19 | 65097.57 | 519.9 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 420 | 564704.00 | 5272536.80 | 62547.62 | 65107.40 | 520.5 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 421 | 564680.64 | 5272279.05 | 62524.96 | 64858.26 | 518.2 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 422 | 564677.95 | 5272247.04 | 62522.34 | 64827.32 | 518.2 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 423 | 564675.92 | 5272218.34 | 62520.37 | 64799.57 | 518.3 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 424 | 564672.90 | 5272188.90 | 62517.44 | 64771.12 | 518.0 | 63.0 | 19.2 | | 3.0 | 0.91 | 19.692 | 77 | 298.15 | | | 0.074 | 0.074 | 0.074 | 0.074 | | | | | | | 0.074 | | | | | | | 1 |
| SV 409 | 564801.23 | 5272257.62 | 62641.51 | 64837.50 | 528.6 | 144.4 | 44.0 | | 4.0 | 1.22 | 18.757 | 77 | 298.15 | | | 0.125 | 0.125 | 0.125 | 0.125 | | | | | | | 0.125 | | | | | | | 1 |
| SV 410 | 564813.70 | 5272256.76 | 62653.56 | 64836.67 | 529.4 | 144.4 | 44.0 | | 4.0 | 1.22 | 18.757 | 77 | 298.15 | | | 0.125 | 0.125 | 0.125 | 0.125 | | | | | | | 0.125 | | | | | | | 1 |
| SV 2532 | 564631.39 | 5271702.87 | 62477.16 | 64301.31 | 484.7 | 193.6 | 59.0 | | 3.4 | 1.04 | 19.652 | 202.5 | 367.87 | 0.039 | 0.039 | 1.091 | 1.091 | 1.091 | 1.091 | 0.030 | 0.030 | 0.124 | 0.124 | | | 1.091 | | | 0.030 | 0.124 | 0.039 | | 1 |
| SV 8003 | 564623.56 | 5271627.52 | 62469.56 | 64228.48 | 483.4 | 125.0 | 38.1 | | 0.7 | 0.20 | 17.174 | 75.8 | 297.48 | | | 0.017 | 0.017 | 0.017 | 0.017 | 0.055 | 0.055 | 0.017 | 0.017 | | | 0.017 | | | 0.055 | 0.017 | | | 1 |
| SV 221 | 564560.56 | 5272350.65 | 62408.90 | 64927.51 | 491.9 | 10.0 | 3.0 | | 0.3 | 0.10 | 11.879 | 120 | 322.04 | | | 0.044 | 0.044 | 0.031 | 0.031 | | | | | | 0.013 | 0.031 | | | | | | | 1 |
| SV 322 | 564528.38 | 5271685.49 | 62377.58 | 64284.56 | 483.5 | 30.4 | 9.3 | | 0.9 | 0.27 | 16.705 | 77 | 298.15 | | | 0.010 | 0.010 | 0.010 | 0.010 | | | | | | | 0.010 | | | | | | | 1 |
| SV 301 | 564623.72 | 5271703.14 | 62469.74 | 64301.59 | 484.7 | 193.6 | 59.0 | | 2.4 | 0.73 | 15.034 | 302 | 423.15 | 0.602 | 0.602 | 0.046 | 0.046 | 0.046 | 0.046 | 0.004 | 0.004 | | | | 0.000 | 0.001 | 0.033 | 0.011 | 0.004 | | 0.602 | 2, 3, 4, 5 |
| SV 323 | 564418.84 | 5271687.96 | 62271.69 | 64286.97 | 475.1 | 15.4 | 4.7 | | 3.1 | 0.95 | 16.718 | 77 | 298.15 | | | 0.006 | 0.006 | 0.006 | 0.006 | | | | | | | 0.006 | | | | | | | 1 |
| SV 331 | 564495.76 | 5271666.50 | 62346.04 | 64266.20 | 482.7 | 90.0 | 27.4 | | 1.0 | 0.30 | 16.817 | 77 | 298.15 | | | 0.014 | 0.014 | 0.014 | 0.014 | | | | | | | 0.014 | | | | | | | 1 |
| SV 332 | 564494.97 | 5271656.42 | 62345.27 | 64256.46 | 482.6 | 90.0 | 27.4 | | 1.0 | 0.30 | 16.817 | 77 | 298.15 | | | 0.014 | 0.014 | 0.014 | 0.014 | | | | | | | 0.014 | | | | | | | 1 |
| SV 333 | 564523.73 | 5271680.29 | 62373.08 | 64279.53 | 483.4 | 35.0 | 10.7 | | 0.8 | 0.24 | 16.582 | 77 | 298.15 | | | 0.017 | 0.017 | 0.017 | 0.017 | | | | | | | 0.017 | | | | | | | 1 |
| SV 334 | 564523.67 | 5271676.84 | 62373.02 | 64276.19 | 483.3 | 35.0 | 10.7 | | 0.8 | 0.24 | 16.582 | 77 | 298.15 | | | 0.017 | 0.017 | 0.017 | 0.017 | | | | | | | 0.017 | | | | | | | 1 |
| SV 327 | 564519.23 | 5272116.22 | 62368.87 | 64700.92 | 491.6 | 40.0 | 12.2 | | 28.0 | 8.53 | 1.403 | 98.3 | 309.98 | | | 0.002 | 0.002 | 0.002 | 0.002 | | | | | | | 0.002 | | | | | | | 1 |
| SV 327 | 564537.65 | 5272115.01 | 62386.68 | 64699.74 | 491.6 | 40.0 | 12.2 | | 28.0 | 8.53 | 1.403 | 98.3 | 309.98 | | | 0.002 | 0.002 | 0.002 | 0.002 | | | | | | | 0.002 | | | | | | | 1 |
| SV 327 | 564567.95 | 5272112.59 | 62415.97 | 64697.39 | 491.6 | 40.0 | 12.2 | | 28.0 | 8.53 | 1.403 | 98.3 | 309.98 | | | 0.002 | 0.002 | 0.002 | 0.002 | | | | | | | 0.002 | | | | | | | 1 |
| SV 327 | 564590.53 | 5272110.19 | 62437.79 | 64695.06 | 491.6 | 40.0 | 12.2 | | 28.0 | 8.53 | 1.403 | 98.3 | 309.98 | | | 0.002 | 0.002 | 0.002 | 0.002 | | | | | | | 0.002 | | | | | | | 1 |
| SV 328 | 564519.29 | 5272063.72 | 62368.91 | 64650.17 | 492.5 | 57.4 | 17.5 | | 0.5 | 0.15 | 15.756 | 300 | 422.04 | 0.025 | 0.025 | 0.002 | 0.002 | 0.002 | 0.002 | 0.000 | 0.000 | | | | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | | 0.025 | 2, 3, 4, 5 |
| SV 427 | 563910.16 | 5270773.32 | 61779.69 | 63403.02 | 460.1 | 46.0 | 14.0 | | 0.5 | 0.15 | 14.230 | 300 | 422.04 | 0.038 | 0.038 | 0.002 | 0.002 | 0.002 | 0.002 | 0.000 | 0.000 | | | | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | | 0.038 | 2, 6, 7 |
| SV 428 | 565064.24 | 5272746.78 | 62895.91 | 65310.26 | 502.2 | 12.0 | 3.7 | | 0.9 | 0.27 | 18.366 | 250 | 394.26 | | | | | | | | | | | | | | | | | | | 2, 3, 4, 5 |
| WWTP (Mine) | 577530.29 | 5273579.95 | 73540.20 | 65667.40 | 484.2 | 56.4 | 17.2 | | Space Heater Stack | 0.5 | 0.15 | 7.340 | 350.33 | 450.00 | 0.036 | 0.036 | 0.052 | 0.052 | 0.032 | 0.032 | 0.004 | 0.004 | | | 0.000 | 0.000 | 0.037 | 0.015 | 0.004 | | 0.036 | 2, 6, 7 |

| | UTM: Zone 15 (NAD83) | | LCC: 47N 93W (30,60N) | | Elevation | | Release Height | | | Sigma Y | Sigma Z | | | | NOx | | PM10 | | PM2.5 | | SO2 | | SO4 | | Heating | PMC | PMF | SOA | EC | SO2 | SO4 | NOX | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Volume Sources** | Easting (m) | Northing (m) | X (m) | Y (m) | (m) | | (m) | | | (m) | (m) | | | | Hourly | Annual | Hourly | Annual | Hourly | Annual | Hourly | Annual | Hourly | Annual | PMF | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | (g/s) | Notes |
| CoarseCrush | 564824.77 | 5272640.14 | 62,664.4 | 65,207.3 | 523.1 | | 38.4 | | | 10.0 | 0.9 | | | | 0.0629 | 0.0629 | 0.0097 | 0.0097 | 0.0097 | 0.0097 | 0.0008 | 0.0008 | | | 0.0097 | 0.0000 | 0.0003 | 0.0070 | 0.0024 | 0.0008 | | 0.0629 | 2, 3, 4, 5 |
| DH | 564812.91 | 5272426.47 | 62,652.9 | 65,000.7 | 530.6 | | 15.1 | | | 5.3 | 0.9 | | | | 0.0103 | 0.0103 | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.0001 | 0.0001 | | | 0.0016 | 0.0000 | 0.0000 | 0.0011 | 0.0004 | 0.0001 | | 0.0103 | 2, 3, 4, 5 |
| FineCrush | 564798.39 | 5272222.94 | 62,638.8 | 64,804.0 | 527.5 | | 44.5 | | | 9.8 | 0.9 | | | | 0.1033 | 0.1033 | 0.0427 | 0.0427 | 0.0427 | 0.0427 | 0.0012 | 0.0012 | | | 0.0157 | 0.0000 | 0.0274 | 0.0114 | 0.0039 | 0.0012 | | 0.1033 | 2, 3, 4, 5 |
| Conc B V | 564637.11 | 5272166.58 | 62,482.8 | 64,749.6 | 507.3 | | 53.9 | | | 20.2 | 0.9 | | | | 0.1022 | 0.1022 | 0.1006 | 0.1006 | 0.1005 | 0.1005 | 0.0012 | 0.0012 | | | 0.0311 | 0.0001 | 0.0702 | 0.0225 | 0.0078 | 0.0012 | | 0.1022 | 2, 3, 4, 5 |
| Flot V | 564593.36 | 5272365.42 | 62,440.6 | 64,941.8 | 492.5 | | 30.3 | | | 10.7 | 0.9 | | | | 0.0190 | 0.0190 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0002 | 0.0002 | | | 0.0029 | 0.0000 | 0.0001 | 0.0021 | 0.0007 | 0.0002 | | 0.0190 | 2, 3, 4, 5 |
| Conc Dewa V | 564577.48 | 5271652.37 | 62,425.0 | 64,252.5 | 483.6 | | 15.6 | | | 8.6 | 0.9 | | | | 0.0056 | 0.0056 | 0.0009 | 0.0009 | 0.0009 | 0.0009 | 0.0001 | 0.0001 | | | 0.0009 | 0.0000 | 0.0000 | 0.0006 | 0.0002 | 0.0001 | | 0.0056 | 2, 3, 4, 5 |
| Conc LO V | 564569.81 | 5271562.67 | 62,417.6 | 64,165.8 | 482.6 | | 11.1 | | | 8.6 | 0.9 | | | | 0.0022 | 0.0022 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0000 | 0.0000 | | | 0.0003 | 0.0000 | 0.0000 | 0.0002 | 0.0001 | 0.0000 | | 0.0022 | 2, 3, 4, 5 |
| Rebuild V | 564975.95 | 5272116.18 | 62,810.4 | 64,700.7 | 523.4 | | 11.1 | | | 7.7 | 0.9 | | | | 0.0439 | 0.0439 | 0.0067 | 0.0067 | 0.0067 | 0.0067 | 0.0005 | 0.0005 | | | 0.0067 | | 0.0002 | 0.0048 | 0.0017 | 0.0005 | | 0.0439 | 2, 3, 4, 5 |
| Main WH V | 564720.58 | 5272100.04 | 62,563.5 | 64,685.2 | 522.6 | | 13.8 | | | 4.7 | 0.9 | | | | 0.0165 | 0.0165 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0002 | 0.0002 | | | 0.0025 | | 0.0001 | 0.0018 | 0.0006 | 0.0002 | | 0.0165 | 2, 3, 4, 5 |
| Hydromet V | 564617.68 | 5271571.96 | 62,463.9 | 64,174.8 | 482.6 | | 25.4 | | | 9.3 | 0.9 | | | | 0.0416 | 0.0416 | 0.0063 | 0.0063 | 0.0063 | 0.0063 | 0.0005 | 0.0005 | | | 0.0063 | 0.0000 | 0.0002 | 0.0046 | 0.0016 | 0.0005 | | 0.0416 | 2, 3, 4, 5 |
| Gen Shop V | 564918.87 | 5272034.44 | 62,755.2 | 64,621.7 | 522.7 | | 17.5 | | | 14.9 | 0.9 | | | | 0.1854 | 0.1854 | 0.0282 | 0.0282 | 0.0282 | 0.0282 | 0.0022 | 0.0022 | | | 0.0282 | 0.0000 | 0.0007 | 0.0204 | 0.0070 | 0.0022 | | 0.1854 | 2, 3, 4, 5 |
| TBWWTPBV | 565057.89 | 5272764.77 | 62,889.8 | 65,327.6 | 498.7 | | 10.1 | | | 3.0 | 0.9 | | | | 0.0498 | 0.0498 | 0.0076 | 0.0076 | 0.0076 | 0.0076 | 0.0006 | 0.0006 | | | 0.0076 | | 0.0002 | 0.0055 | 0.0019 | 0.0006 | | 0.0498 | 2, 3, 4, 5 |
| Reagent V | 564614.26 | 5271549.75 | 62,460.5 | 64,153.3 | 482.5 | | 19.9 | | | 5.6 | 0.9 | | | | 0.0128 | 0.0128 | 0.0373 | 0.0373 | 0.0235 | 0.0235 | 0.2028 | 0.2028 | 0.0003 | 0.0003 | 0.0019 | 0.0138 | 0.0213 | 0.0014 | 0.0005 | 0.2028 | 0.0003 | 0.0128 | 2, 3, 4, 5 |
| Spares WH V | 564712.69 | 5272010.04 | 62,555.8 | 64,598.2 | 522.4 | | 8.6 | | | 4.7 | 0.9 | | | | 0.0134 | 0.0134 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0002 | 0.0002 | | | 0.0020 | 0.0000 | 0.0001 | 0.0015 | 0.0005 | 0.0002 | | 0.0134 | 2, 3, 4, 5 |
| Heat Pl V | 564541.19 | 5271689.93 | 62,390.0 | 64,288.8 | 483.8 | | 19.6 | | | 3.6 | 0.9 | | | | 0.0257 | 0.0257 | 0.0727 | 0.0727 | 0.0434 | 0.0434 | 0.0003 | 0.0003 | | | 0.0039 | 0.0293 | 0.0396 | 0.0028 | 0.0010 | 0.0003 | | 0.0257 | 2, 3, 4, 5 |
| Area1BV | 562275.82 | 5271257.34 | 60,200.0 | 63,871.4 | 510.7 | | 16.2 | | | 9.5 | 0.9 | | | | 0.1928 | 0.1928 | 0.0104 | 0.0104 | 0.0104 | 0.0104 | 0.0003 | 0.0003 | | | 0.0104 | 0.0000 | 0.0000 | 0.0074 | 0.0030 | 0.0003 | | 0.1928 | 2, 6, 7 |
| Area2BV | 566643.74 | 5272131.09 | 64,422.5 | 64,714.6 | 510.8 | | 16.2 | | | 7.4 | 0.9 | | | | 0.1790 | 0.1790 | 0.0096 | 0.0096 | 0.0096 | 0.0096 | 0.0003 | 0.0003 | | | 0.0096 | 0.0000 | 0.0000 | 0.0069 | 0.0028 | 0.0003 | | 0.1790 | 2, 6, 7 |
| MDS 602 | [A] | [A] | 75,076.0 | 66,186.0 | 486.6 | | 4.7 | | Mobile Diesels - Ore Haul Locomotives (Mine) [B] | 291.6 | 2.2 | | | | 0.3926 | 0.3926 | 0.0158 | 0.0158 | 0.0158 | 0.0158 | 0.0007 | 0.0007 | | | | 0.0000 | 0.0057 | 0.0033 | 0.0069 | 0.0007 | | 0.3926 | 2, 8, 9 |
| MDS 603 | [A] | [A] | 62,669.0 | 65,277.0 | 479.2 | | 4.7 | | Mobile Diesels - Ore Haul Locomotives (Plant) [B] | 97.6 | 2.2 | | | | 0.3926 | 0.3926 | 0.0158 | 0.0158 | 0.0158 | 0.0158 | 0.0007 | 0.0007 | | | | 0.0000 | 0.0057 | 0.0033 | 0.0069 | 0.0007 | | 0.3926 | 2, 8, 9 |
| MDS 604 | [A] | [A] | 62,886.0 | 64,746.0 | 479.7 | | 4.7 | | Mobile Diesels - Switcher Locomotive | 1,127.7 | 2.2 | | | | 0.0873 | 0.0873 | 0.0035 | 0.0035 | 0.0035 | 0.0035 | 0.0002 | 0.0002 | | | | 0.0000 | 0.0013 | 0.0007 | 0.0015 | 0.0002 | | 0.0873 | 2, 8, 9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Year 1-5** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MDS 601 | [A] | [A] | 74,865.0 | 67,272.0 | 488.8 | | 6.6 | | Mobile Diesels - Mine Site Haul Truck and other equip. | 3,369.6 | 3.1 | | | | 6.5308 | 6.5308 | 0.1492 | 0.1492 | 0.1492 | 0.1492 | 0.0085 | 0.0085 | | | | | 0.0534 | 0.0312 | 0.0647 | 0.0085 | | 6.5308 | 2, 8, 9 |
| MDS 605 | 566377.41 | 5274058.62 | 64,165.7 | 66,577.9 | 498.0 | | 6.6 | | Mobile Diesels - Tailings Basin Construction Vehicles | 207.8 | 3.1 | | | | 2.7162 | 2.7162 | 0.0335 | 0.0335 | 0.0335 | 0.0335 | 0.0057 | 0.0057 | | | | | 0.0120 | 0.0070 | 0.0145 | 0.0057 | | 2.7162 | 2, 8, 9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Year 6-8** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MDS 601 | [A] | [A] | 74,865.0 | 67,272.0 | 488.8 | | 6.6 | | Mobile Diesels - Mine Site Haul Truck and other equip. | 3,369.6 | 3.1 | | | | 6.3044 | 6.3044 | 0.1260 | 0.1260 | 0.1260 | 0.1260 | 0.0093 | 0.0093 | | | | | 0.0450 | 0.0263 | 0.0546 | 0.0093 | | 6.3044 | 2, 8, 9 |
| MDS 605 | 566377.41 | 5274058.62 | 64,165.7 | 66,577.9 | 498.0 | | 6.6 | | Mobile Diesels - Tailings Basin Construction Vehicles | 207.8 | 3.1 | | | | 1.3190 | 1.3190 | 0.0206 | 0.0206 | 0.0206 | 0.0206 | 0.0028 | 0.0028 | | | | | 0.0074 | 0.0043 | 0.0089 | 0.0028 | | 1.3190 | 2, 8, 9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Year 9-10** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MDS 601 | [A] | [A] | 74,865.0 | 67,272.0 | 488.8 | | 6.6 | | Mobile Diesels - Mine Site Haul Truck and other equip. | 3,369.6 | 3.1 | | | | 6.4392 | 6.4392 | 0.1325 | 0.1325 | 0.1325 | 0.1325 | 0.0098 | 0.0098 | | | | | 0.0474 | 0.0277 | 0.0574 | 0.0098 | | 6.4392 | 2, 8, 9 |
| MDS 605 | 566377.41 | 5274058.62 | 64,165.7 | 66,577.9 | 498.0 | | 6.6 | | Mobile Diesels - Tailings Basin Construction Vehicles | 207.8 | 3.1 | | | | 1.3190 | 1.3190 | 0.0206 | 0.0206 | 0.0206 | 0.0206 | 0.0028 | 0.0028 | | | | | 0.0074 | 0.0043 | 0.0089 | 0.0028 | | 1.3190 | 2, 8, 9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Year 11-20** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MDS 601 | [A] | [A] | 74,865.0 | 67,272.0 | 488.8 | | 6.6 | | Mobile Diesels - Mine Site Haul Truck and other equip. | 3,369.6 | 3.1 | | | | 4.4893 | 4.4893 | 0.0420 | 0.0420 | 0.0420 | 0.0420 | 0.0108 | 0.0108 | | | | | 0.0150 | 0.0088 | 0.0182 | 0.0108 | | 4.4893 | 2, 8, 9 |
| MDS 605 | 566377.41 | 5274058.62 | 64,165.7 | 66,577.9 | 498.0 | | 6.6 | | Mobile Diesels - Tailings Basin Construction Vehicles | 207.8 | 3.1 | | | | 1.6683 | 1.6683 | 0.0238 | 0.0238 | 0.0238 | 0.0238 | 0.0035 | 0.0035 | | | | | 0.0085 | 0.0050 | 0.0103 | 0.0035 | | 1.6683 | 2, 8, 9 |

Speciation Notes:

1) Fraction of PM10 as PMF is set based on PM2.5 rate (PM2.5 rate = PMF rate), PMC is equal to PM10 - PMF.

2) Fraction of PM10 as PMF is set based on PM2.5 rate (PM2.5 = PMF + SOA + EC +SO4), PMC is equal to PM10 - PMF -EC -SOA -SO4.

3) Emission factor from AP-42 Table 1.4-2 is 7.6 (total PM)/$10^6$ scf natural gas
5.5 VOC's
% of Total Particulate assumed to be SOA = 5.5 lb VOCs/mmscf / 7.6 lb PM/mmscf = 72.4%

4) Assume all filterable PM emissions from natural gas combustion are EC
AP-42 'Natural Gas Combustion' Table 1.4-2; Total PM Emission factor is 7.6 lb and filterable is 1.9 lb:
EC, percent of PM10: 1.9 / 7.6 = 25.0%

5) SO2 emissions from natural gas fired sources are negligible, therefore SO4 emissions are assumed to be zero.
All natural gas particulate is assumed to be PMF

6) Assume all filterable PM emissions from propane combustion are EC
AP-42 'Liquified Petroleum Gas Combustion' Table 1.5-1 (07/2008); Total PM Emission factor is 0.7 lb/10^3 gallon and filterable is 0.2 lb/10^3 gallon:
EC, percent of PM10: 0.2 / 0.7 = 28.6%

Assume condensible PM emissions from propane combustion are SOA
SOA, percent of PM10: 0.5/0.7 = 71.4%

7) SO2 emissions from propane fired sources are negligible, therefore SO4 emissions are assumed to be zero.
All propane particulate is assumed to be PMF (no PMC emissions)

8) Heavy Duty Diesel speciated emissions from US EPA SPECIATE 3.2, profile number 32202 (added 1/5/89)
EC, percent of (PM10-SOA-SO4) 54.8
Assume SOA equals organic carbon speciation SOA, percent of PM10 20.9

All diesel particulate is assumed to be PMF (no PMC emissions)

9) The diesel sources are assumed to have no SO4 concentrations because the exhaust temperatures are higher than the temperatures at which the conversion of SO3 to H2SO4 vapor occurs.

General Notes
[A] These sources not included in Class II modeling, so UTM coordinates have not been determined. Coordinates in columns D and E are used for Class I modeling.
[B] Ore haul locomotive emissions are divided in half between the Plant Site and the Mine Site.

# Appendix B

## Class I Modeling Protocol

# *Class I Area Air Dispersion Modeling Protocol*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining, Inc.***

***May 2011***

BARR

# Class I Area Air Dispersion Modeling Protocol

## May 2011

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# Section 1: Introduction

## 1.1 Background

PolyMet Mining, Inc. (PolyMet) proposes to reactivate and modify portions of the former LTV Steel Mining Company (LTVSMC) Taconite Processing Plant in Hoyt Lakes, Minnesota for the processing of ore from the NorthMet deposit located approximately eight miles east of the Plant Site. The proposed project is referred to as the NorthMet Project (Project).

This protocol addresses the dispersion modeling procedures that will be followed for the Class I Area air quality analysis to be conducted in support of the Supplemental Draft Environmental Impact Statement (SDEIS) being prepared for the Project. Other analyses required for the SDEIS (e.g., pollution control equipment evaluations, Class II Area analysis) are not addressed in this protocol, but the results of these analyses will be available for the Federal Land Managers (FLMs) to review.

PolyMet is proposing to permit the Project as a synthetic minor source for federal Prevention of Significant Deterioration (PSD) purposes. However, in general, the same procedures that would be used for assessing Class I Area impacts from a PSD major project will be used to provide information to aid in preparation of the SDEIS.

This protocol is being provided as a stand-alone document for review and it will be integrated into the Air Data Package after approval.

## 1.2 Project Description

A comprehensive description and analysis of all aspects of the Project are provided in the NorthMet EIS Draft Alternative Summary Revised March 4, 2011 and NorthMet Project Description Version 2 submitted April 15, 2011. The Project is well defined at this point, but some design details and specific equipment selections still need to be finalized. Where there is uncertainty in the Project an attempt will be made to make conservative assumptions, such that modeled impacts based on the final Project details will be equivalent or less than those evaluated in the SDEIS .

## 1.3 Purpose of Protocol

The purpose of this protocol is to establish procedures to be used in evaluating the Project's impact on nearby Class I areas (Figure 1) for the SDEIS. Class I areas are overseen by FLMs from several organizations:

- The National Park Service (NPS): Isle Royale National Park and Voyageurs National Park.
- The U.S. Forest Service (USFS): Rainbow Lake Wilderness Area and the Boundary Waters Canoe Area Wilderness.

Given the proximity of the Project to Class I Areas (Figure 1) an assessment of impacts in the Class I Areas was required for the Draft Environmental Impact Statement (DEIS) prepared for the Project and published in October of 2009. The previous modeling will now be updated to reflect changes to the Project and changes to applicable modeling guidance.

The original modeling protocol prepared for the Project DEIS, as well as the protocols of subsequent projects in the region were used as a guide in preparing this protocol. CALMET specific settings were based on the latest guidance provided by the FLMs: "EPA-FLM Recommended CALMET Input File Values" (August 20, 2009).

The protocol contains separate sections for the main components of the CALPUFF modeling system: Section 2 presents how the CALMET input files will be developed; Section 3 presents the model options for CALPUFF execution; Section 4 describes the post-processing that will be conducted for determining the impacts to the Class I areas and Section 5 describes how the results will be reported.

# Section 2: CALMET Settings

The CALMET meteorological model requires input from several meteorological and geophysical data preprocessors prior to model execution. This section describes the data sources, preprocessing methodology and CALMET model settings that will be used for the Project.

The CALMET input files will include SURF.DAT, GEO.DAT, PRECIP.DAT, MM4/MM5 data files and upper air data files, for the years 2002, 2003 and 2004. Compilation of these input files will be done with the currently approved preprocessors from the CALPUFF software suite (CALPUFF v5.8, June 23, 2007 release). Some compilation will occur through the CALPUFF View program by Lakes Environmental.

## 2.1 Meteorological Data Preprocessing

The meteorological data for CALMET consists of three years (2002, 2003 and 2004) of MM5 prognostic mesoscale meteorological data with surface, upper air and precipitation data from several stations in and around the modeling domain. Figure 1 shows the surface, upper air and precipitation stations that will be included in the modeling.

### 2.1.1 Surface Data

Surface data will be obtained from the National Climatic Data Center (NCDC). Initial preprocessing will be performed on the surface files with Russell Lee's program, NCDC_CNV (rflee.com). This program converts the files into SAMSON format, which is compatible with the SMERGE preprocessor. Once all files are in a compatible format, SMERGE will be run to combine the individual surface data files into yearly SURF.DAT files. These SURF.DAT files will then be ready for input to CALMET.

### 2.1.2 Upper Air Data

Upper air data files will be obtained from the NOAA/ERSL RAOBS website (esrl.noaa.gov/raobs/). These files will be processed within the Lakes Environmental CALPUFF View interface using READ62. Quality processing will be done after the READ62 process using the FIX program within the CALPUFF View interface. FIX incorporates station substitution, extrapolation, spatial substitution and temporal substitution to complete the data files. Extrapolation and station substitution will be favored when possible. After preprocessing with READ62 and FIX, the upper air data files (one per station per year) will be ready for input to CALMET.

### 2.1.3 Precipitation Data

The PRECIP.DAT file required by CALMET contains all of the precipitation observations for the modeling domain. The PRECIP.DAT file will be created within the CALPUFF View program. Precipitation data files will be obtained from the NCDC. The files will then be processed within CALPUFF View by the PMERGE preprocessor, yielding the PRECIP.DAT file.

## 2.2 Geophysical Data Preprocessing – GEO.DAT

Land use data files and elevation data files are required to develop the GEO.DAT geophysical data file required by CALMET. The MAKEGEO preprocessor will be used to combine a land use data file (LU.DAT) with a terrain elevation file (TERREL.DAT) to create the GEO.DAT file.

### 2.2.1 Land Use Data

Because CTG land use data files are not available for Canadian portions of the modeling domain, the land use will be set using the North American Land Cover Characteristics database. The CTGCOMP preprocessor will combine the land use files into the LU.DAT file required by the MAKEGEO preprocessor.

### 2.2.2 Terrain Data

Elevation data files will be created from the appropriate digital elevation model (DEM) files. The DEM files will be obtained from the WebGIS website hosted by Lakes Environmental as well as the GeoBase website hosted by Environment Canada. The DEM files will be of 1:250,000 resolution. The TERREL preprocessor will create the TERREL.DAT file required by the MAKEGEO preprocessor.

## 2.3 CALMET Control File Input Groups

Each CALMET input group is detailed separately. A preliminary version of the CALMET control file is included as Appendix A.

### 2.3.1 Input Group 1 – General Run Control Parameters

Run start date and length will vary by which year is being modeled. These will include all available dates from 2002, 2003 and 2004. One month data lengths will be used.

The run type will be set to 1, for computation of wind fields and micrometeorological variables (IRTYPE = 1). The special data fields for CALGRID will be calculated (LCALGRID = T). Initial setup of the

model will be performed with ITEST = 1 with the final runs including the computational phase (ITEST = 2). The check for conformity with regulatory values will be used (MREG = 1).

### 2.3.2 Input Group 2 – Map Projection and Grid Control Parameters

The Lambert Conformal coordinate system (LCC) will be used for the model as summarized in Table 1. The projection origin will be 47N, 93W, with false easting and northing of 0. The matching parallels of latitude will be 30N and 60N. The datum region used will be the WGS-84 GRS 80 Spheroid, Global coverage.

The rectangular grid defining the domain will be 528 by 360 km with a grid spacing of 4 km. The reference grid coordinate for the southwest corner of the grid will be (-140,-100) km. The vertical grid will consist of 10 layers, with face heights of 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000 and 4000 meters.

### 2.3.3 Input Group 3 – Output Options

All variables in input group 3 except NZPRN will be set to their default values in conformance with EPA-FLM guidance (NZPRN = 0).

### 2.3.4 Input Group 4 – Meteorological Data Options

The modeling will incorporate meteorological data from surface stations, precipitation stations, upper air stations and MM4/MM5 data sets (NOOBS=0). The number of stations available for use varies slightly by year modeled. For this analysis, there will be approximately 88 surface stations (NSSTA=88), 99 precipitation stations (NPSTA=99) and 4 upper air stations. No cloud data will be used. The default file formats will be used for meteorological inputs.

### 2.3.5 Input Group 5 – Wind Field Options and Parameters

The wind field options will be set to their default values with the following exceptions:

| Model Parameter | Model Input Value |
|---|---|
| Extrapolation of surface winds will be allowed at all surface stations. | [RMIN2 = -1 ] |
| Prognostic wind fields will be used for the initial guess field. These data will come from the MM5 data sets. | [IPROG = 14 (MM5) ] |
| The maximum radius of influence (ROI) settings will be 100 km over land in the surface layer, 200 km over land aloft, 200 km over water and 15 km for terrain features. | RMAX1 = 100 RMAX2 = 200 RMAX3 = 200<br>TERRAD = 15 |

| Model Parameter | Model Input Value |
|---|---|
| The relative weighting of the first guess field versus surface observations will be 50 km. | R1 = 50 |
| The relative weighting of the first guess field versus aloft observations will be 100 km. | R2 = 100 |
| The relative weighting of the prognostic wind field data will be 0 km. | RPROG = 0 |
| The surface meteorological station used for surface temperature will be the Hibbing, MN station. | ISURFT = Hibbing, MN |
| The upper air station used for domain-scale lapse rate will be International Falls, MN. | IUPT = International Falls, MN |

### 2.3.6 Input Group 6 – Mixing Height, Temperature and Precipitation Parameters

The parameters for input group six will be set to the default values with the following exceptions:

| Model Parameter | Model Input Value |
|---|---|
| The over water temperature interpolation scheme requires at least one over water meteorological file, with complete coverage of the modeled time period. Continuous over water data are not available for Lake Superior, as Great Lakes monitoring buoys are removed from the lake for the winter season. The over water interpolation scheme will not be used. | JWAT1 = 55<br>JWAT2 = 55 |
| Maul-Carson mixing height will be used for land cells only. Offshore and Coastal Dispersion Model (OCD) mixing height will be used over water. | IMIXH = -1 |
| The threshold buoyancy flux required to sustain convective mixing height growth over land will be 0. | THRESHL = 0.0 |
| Over water surface fluxes will use the original deltaT method. | ICOARE = 0 |

### 2.3.7 Input Group 7 – Surface Meteorological Station Parameters

Surface weather observations will be obtained from several locations around and in the modeling domain as shown in Figure 1.

### 2.3.8 Input Group 8 – Upper Air Meteorological Station Parameters

Upper air observations will be obtained from stations at International Falls, MN; Minneapolis, MN; Gaylord, MI; and Green Bay, WI. Upper air station locations are shown in Figure 1.

### 2.3.9 Input Group 9 – Precipitation Station Parameters

Precipitation observations will be obtained from many locations around and in the modeling domain as shown in Figure 1.

# Section 3: CALPUFF Settings

The CALPUFF model grid will be the same as that used for CALMET. A preliminary CALPUFF control file is included in Appendix B.

## 3.1 Input Group 1 – General Run Control Parameters

The CALPUFF runs will be made with restart files active, writing a restart file throughout the run. This will allow resumption of processing in the event of an error. The restart file includes all puffs that are on the grid at the end of the run. The restarted run will be able to begin with the grid in the exact condition it was in when the previous run left off.

## 3.2 Input Group 2 – Technical Options

All variables in Input Group 2 will be set to their default values with one exception: the chemical mechanism flag will be set to compute transformation internally (MCHEM = 1).

## 3.3 Input Group 3 – Species List[1]

Species modeled in CALPUFF will be $SO_4$, $SO_2$, $NO_3$, $HNO_3$, $NO_x$, $PM_{10}$, PMF, PMC, EC and OC (as SOA). The species $SO_2$, $SO_4$, $NO_x$, $PM_{10}$, PMF, PMC, EC and SOA will be modeled as emitted. $NO_3$ and $HNO_3$ will be included as non-emitted species, as they result from chemical transformations when $SO_2$ and $NO_x$ emissions are processed by the model. Dry particle deposition will be modeled for $SO_4$, $NO_3$, $PM_{10}$, PMF, PMC, EC and SOA. Dry gas deposition will be modeled for the species $SO_2$, $HNO_3$ and $NO_x$. OC will be represented in the CALPUFF and CALPOST modeling as SOA. The extinction coefficient of SOA will be set to 4 in CALPOST to reflect that it represents OC.

## 3.4 Input Group 4 – Map Projection and Grid Control Parameters

The map projection will be the same as for CALMET as discussed in Section 2.3.2 above. Grid corner indices are shown in Table 1.

[1] $SO_4$ – sulfate; $SO_2$ – sulfur dioxide; $NO_x$ – nitrogen oxides; $PM_{10}$ – particulate matter with an aerodynamic diameter of <10 µm; PMF – fine particulate matter (d < 2.5 µm); PMC – coarse particulate matter (2.5 µm <d<10 µm); EC – elemental carbon; OC – organic carbon; SOA – secondary organic aerosol; $NO_3$ – nitrate; $HNO_3$ – nitric acid.

## 3.5 Input Group 5 – Output Options

Variables for Input Group five will be set to their default values.

## 3.6 Input Group 6 – Subgrid Scale Complex Terrain Inputs

No complex terrain features will be modeled. The variables of this section will be set to their default values.

## 3.7 Input Group 7 – Chemical Parameters for Dry Deposition of Gases

The dry deposition parameters for $NO_x$, $SO_2$ and $HNO_3$ will be set in this section as given in Appendix B.

## 3.8 Input Group 8 – Size Parameters for Dry Deposition of Particles

The size parameters for $NO_3$, $SO_4$, $PM_{10}$, PMF, PMC, EC and OC will be set in this section as given in Appendix B.

## 3.9 Input Group 9 – Miscellaneous Dry Deposition Parameters

The miscellaneous dry deposition parameters will be set to their default values as given in Appendix B.

## 3.10 Input Group 10 – Wet Deposition Parameters

Wet deposition parameters for $SO_2$, $SO_4$, $NO_3$, $HNO_3$, $PM_{10}$, PMC, PMF, EC and OC will be set in this section as given in Appendix B.

## 3.11 Input Group 11 – Chemistry Parameters

Most parameters in Input Group 11 will be set to their defaults. An OZONE.DAT file containing data from several representative stations will be included. The OZONE.DAT file used will be based on monitoring stations throughout the modeling domain. The default ozone concentration will be set to 40 ppm, to reflect the average conditions in the domain. This concentration will be used when all observation stations have no data. Initial modeling will set the monthly ammonia concentration to 1 ppb for all months, to give a conservative estimate of background ammonia levels. Refinement of background ammonia levels may be necessary as modeling progresses. A monthly background level of 1 ppb will also be used for $H_2O_2$ concentrations.

## 3.12 Input Group 12 – Miscellaneous Dispersion and Computational Parameters

Variables pertaining to the use of a single meteorological station will not be used. Default values will be used for the variables in this group.

## 3.13 Input Group 13 – Point Source Parameters

Emission rates and stack parameters used in the modeling will be based on the most current emission inventory at the time the modeling is performed. Portions of a draft emission inventory have been submitted to the MPCA for review and the remaining sections will be submitted in the near future. The emission rates and stack parameters used in the modeling will be detailed in the Class I modeling report.

Backup generators and fire pumps will not be included in the modeling because they will only be occasionally operated for a short amount of time for testing, except in emergency situations. During such emergencies, emission generating activities at the plant would be stopped or significantly curtailed.

For speciation of pollutants the analysis will use a combination of information from AP-42, stack test data, process flow simulations and other available data sources. PM handling sources will be speciated into PMC and PMF. Combustion $PM_{10}$ emissions will be divided into PMC, PMF, OC, SOA, $SO_4$ and EC. Speciation is expected to utilize the same methodology as the prior PolyMet modeling effort. Final speciation data will be provided with the modeling report. Sulfuric acid mist will be modeled as $SO_4$. Changes may be made to the speciation calculations as the modeling is completed.

## 3.14 Input Group 14 – Area Source Parameters

No area sources will be modeled. This input group will not contain any variables for input to the model

## 3.15 Input Group 15 – Line Source Parameters

No line sources will be modeled. This input group will not contain any variables for input to the model

## 3.16 Input Group 16 – Volume Source Parameters

Fugitive sources at the facility will not be modeled. Given the nature of the sources (low release height, no upward momentum) emissions would not be expected to reach the Class I Areas. These fugitive sources include: dust generated from traffic on unpaved roads, outdoor conveyor transfer points, other

outdoor handling such as transfer to stockpiles, rail loading operations, truck unloading operations and truck hauling on paved roads.

Several volume sources will be modeled to represent the exhaust emissions from haul trucks, trains, etc. used for mining operations and the transportation of ore to the Plant Site. Non-road haul trucks used for construction of dams at the Tailings Basin will be added to the SDEIS modeling to reflect the current design and proposed operation of the Tailings Basin. Volume sources will be located covering the general operating areas of the diesel equipment.

## 3.17 Input Group 17 – Non-Gridded (Discrete) Receptor Information

Discrete receptors for each Class I area were obtained from the NPS web site using the NPS Convert Class One Areas DotNet utility. The receptors for Voyageurs National Park, Isle Royale National Park, Rainbow Lake Wilderness and the Boundary Waters Canoe Area Wilderness will encompass the areas shown in Figure 1. The coordinates of these receptors can be found in Appendix B. The receptors included in the modeling consist of the four Class I areas in the region. Figure 1 is a map with the modeling domain, Class I areas, meteorological station locations and source locations.

# Section 4: CALPOST analysis

CALPOST analysis will be conducted for fine particulate matter (PMF), coarse particulate matter (PMC), particulate matter with diameters under 10 microns ($PM_{10}$), sulfur dioxide ($SO_2$), sulfate ($SO_4$), nitrate ($NO_3$), nitric acid ($HNO_3$), nitrous oxides ($NO_x$), elemental carbon (EC) and organic carbon (OC). CALPOST will convert the hourly concentration files generated by CALPUFF and monthly average relative humidity data into 24-hour time-averaged extinction coefficients.

Multiple CALPOST runs will be conducted to calculate the Project impacts on each Class I area. Values for visibility, acid deposition, foliar damage and increment consumption will be calculated. Visibility runs will be run independently for each Class I area to maintain clarity of results. The 24-hour time-averaged extinction coefficients generated by CALPOST will be compared to 20% best natural conditions (using Method 8) as part of the visibility analysis. Appendix C contains a sample CALPOST control file.

# Section 5: Reporting

The Class I dispersion modeling analysis will be made available for review by the Lead and Cooperating Agencies, along with the MPCA who, as a Participating Agency and as the permitting authority, will be assessing air quality impacts for the Project. The analysis will demonstrate attainment of the Class I Area increments for all appropriate pollutants and averaging times. $PM_{10}$, $SO_2$ and $NO_x$ will all be modeled to support the visibility analysis. A comparison to the SILs and Class I increment standard will be made for the increase in emissions associated with the Project and an analysis of cumulative increment consumption will be made for pollutants and averaging times for which the model results are above the SIL.

A summary of the Class I analysis with the appropriate detailed model outputs will be submitted to the FLMs. Electronic copies of the modeling input and output files will be included for technical review by the FLMs. Modeling results may be submitted to the FLMs for comment prior to final submission to the agencies identified in the previous paragraph. Evaluation of visibility impacts, acid deposition, direct foliar damage and increment consumption will be reported. These will be compared with their applicable standards, as detailed below.

## 5.1 Visibility

Visibility calculations will be performed with CALPOST. A comparison with background conditions will be made to determine the percent change in extinction coefficient over 24-hour averaging periods. Modeled visibility impacts will be compared to the hypothetical natural background conditions (20% best days background extinction coefficients) as developed by the FLMs[2].

## 5.2 Deposition

Acid deposition rates associated with the emissions from the Project will be evaluated. Different evaluation criteria exist for the Class I areas managed by the NPS and United States Fish and Wildlife Service (USFWS) versus those managed by the USFS. The Deposition Analysis Threshold (DAT) for Isle Royale National Park and Voyageurs National Park is 0.01 kg/ha/yr for the total N and total S deposition. A DAT is "the additional amount of N or S deposition within a

[2] Federal Land Managers Air Quality Related Values Workgroup. 2008. *Phase I Report (Revised).* U.S. Forest Service – Air Quality Program, National Park Service – Air Resources Division, U.S. Fish and Wildlife Service – Air Quality Branch. June 27, 2008 Draft. Appendix V-1.

Class I area, below which estimated impacts from a proposed new or modified source are considered insignificant"[3] The threshold of potential impact for Boundary Waters Canoe Area Wilderness and Rainbow Lakes Wilderness will be defined by the "green line" terrestrial and aquatic deposition rates. The "green line" deposition rates are the loading levels below which no adverse impact is expected.[4] Table 2 contains the "green line" deposition rates. Table 4 lists the background values that will be added to the modeling results for comparison to the "green line" values.

## 5.3 Direct Foliar Damage

The green line deposition thresholds mentioned above also have values for atmospheric concentration of $SO_2$ and ozone. The green line concentrations of $SO_2$ are 100 and 5 $\mu g/m^3$ for 3-hour and annual averaged concentrations, respectively. The green line ozone concentration during the growing season is 80 $\mu g/m^3$ for the second highest hourly concentration. The modeling proposed will generate the values needed for $SO_2$ concentration, but will not produce ozone concentrations. Background values that will be added to the model results for comparison to green line concentrations are listed in Table 4.

## 5.4 Increment

The modeled concentrations of $SO_2$, $PM_{10}$ and $NO_2$ will be compared to both the Class I PSD increment[5] and the EPA Significant Impact Level (SIL)[6] concentrations. These values are detailed in Table 3. In evaluating $PM_{10}$ concentration, the model-generated $PM_{10}$ concentration will include the contribution of $SO_4$ (ammonium sulfate) and $NO_3$ (ammonium nitrate) to the total $PM_{10}$ concentration. Only emissions from the Project will be included in the evaluation of the SILs. Table 3 contains the regulatory concentration standards. If modeled concentrations exceed the SILs, a cumulative PSD increment modeling assessment will be performed. Cumulative increment model setup parameters will be consistent with those from the single source modeling above, with grid spacing increased to 12km to maintain manageable runtimes.

---

[3] National Park Service and U.S. Fish and Wildlife Service. 2002. *Guidance on Nitrogen and Sulfur Deposition Analysis Thresholds.* 7 pg. (www2.nature.nps.gov/air/Permits/flag/FlagInfo).

[4] Adams M. G., *et. al.* 1991. *Screening Procedure to Evaluate Effects of Air Pollution on Eastern Region Wildernesses Cited as Class I Air Quality Areas.* USDA, Forest Service, Northeastern Forest Experimental Station, General Technical Report NE-151.

[5] 40 CFR 52.21

[6] EPA. 1996. Prevention of Significant Deterioration (PSD) and Nonattainment New Sources Review (NSR). *Federal Register*: July 23, 1996, Volume 61, Number 142. Proposed Rules. Pp 38249-38344.

In the time since the DEIS modeling was completed, EPA has promulgated a Class I increment for $PM_{2.5}$. However, the minor source baseline date has not yet been triggered for this pollutant in the Project area. Therefore, the Project, as a synthetic minor source, does not consume $PM_{2.5}$ increment and an evaluation is not proposed for this pollutant.

# Tables

**Table 1 Modeling Projection Parameters**

| **Lambert Conformal Conic (LCC) Projection** | |
|---|---|
| Projection Origin | |
| Latitude | Longitude |
| 47.00N | 93.00W |
| | |
| False Easting | False Northing |
| 0 | 0 |
| | |
| Parallels of Latitude | |
| Parallel Latitude 1 | Parallel Latitude 2 |
| 30.00N | 60.00N |
| | |
| Datum | WGS-G |
| | |
| Grid dimensions | |
| Number of X grid cells | Number of Y grid cells |
| 132 | 90 |
| | |
| Grid Spacing | 4 km |
| | |
| Grid Corner Reference | |
| X coordinate | Y coordinate |
| -140 | -100 |

**Table 2 Terrestrial and Aquatic Green-Line Deposition Rates**

| Ecosystem | Pollutant | Green-Line Deposition Rate (kg/ha/yr) |
|---|---|---|
| Terrestrial | Total Sulfur (S) | 5.0 – 7.0 |
| | Total Nitrogen (N) | 5.0 – 8.0 |
| Aquatic | Total S | 7.5 – 8.0 |
| | Total S + 20% Total N | 9.0 – 10.0 |

**Table 3 Regulatory Concentration Standards**
**Concentrations**
**(µg/m3)**

| Pollutant | Averaging Period | PSD Increment – Class I Areas[2] | EPA SIL – Class I Areas[3] |
|---|---|---|---|
| PM 10 | Annual<br>24-Hour | 4<br>8[1] | 0.2<br>0.3 |
| $SO_2$ | Annual<br>24-Hour<br>3-Hour | 2<br>5[1]<br>25[1] | 0.1<br>0.2<br>1 |
| $NO_2$ | Annual | 2.5 | 0.1 |

[1] Not to be exceeded more than once per year

[2] 40 CFR 52.21

[3] EPA. 1996. Prevention of Significant Deterioration (PSD) and Nonattainment New Sources Review (NSR). *Federal Register*: July 23, 1996, Volume 61, Number 142. Proposed Rules. Pp 38249-38344.

**Table 4 Background Values**

| Parameter | Averaging Period | Background Level (kg/hectare/yr) | Data Source |
|---|---|---|---|
| BWCAW Sulfur Deposition | Annual | 2.9 | Wet deposition data from NAPD data base – Hovland site; Dry from Castnet database for Voyageurs |
| BWCAW Nitrogen Deposition | Annual | 4.8 | |
| BWCAW Sulfur + 20% Nitrogen Dep. | Annual | 3.8 | Calculated from above data |
| Rainbow Lakes Sulfur Deposition | Annual | 3.0 | Wet deposition data from NAPD data base – Spooner site; Dry from Castnet database for Voyageurs |
| Rainbow Lakes Nitrogen Deposition | Annual | 5.9 | |
| Rainbow Lakes Sulfur + 20% Nitrogen Dep. | Annual | 4.2 | Calculated from above data |
| BWCAW $SO_2$ Concentration | Annual | 1.2 | 1991-1993 data from Ely site |
| | 3-hour | 10.8 | Calculated from above per EPA guidance |
| Isle Royale $SO_2$ Concentration | Annual | 2.0 | 1991-1993 data from Finland site |
| | 3-hr | 18 | Calculated from above per EPA guidance |
| Rainbow Lakes $SO_2$ Concentration | Annual | 1.6 | 1991-1993 data from Sandstone site |
| | 3-hr | 14.4 | Calculated from above per EPA guidance |
| Voyageurs $SO_2$ Concentration | Annual | 0.7 | 1991-1993 data from Sullivan Bay site |
| | 3-hr | 6.3 | Calculated from above per EPA guidance |

# Figures

Barr Footer: Date: 5/17/2011 3:37:03 PM File: I:\Client\PolyMet\Maps\AirModel\Class I Area Air Dispersion Modeling Protocol\Figure 1 Modeling Area 17MAY2011.mxd User: ajs

Project Site
4 km Modeling Domain
Class I Areas
Upper Air Stations
Precipitation Stations
Surface Stations
Ozone Stations

Miles
0 50 100

Kilometers
0 100 200

Figure 1
CLASS I MODELING REGION
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN

# Appendices

***See Electronic Media Included for all of the following:***

**Appendix A  CALMET Input Control File**
**Appendix B  CALPUFF Input Control File**
**Appendix C  CALPOST Input Control Files**

**Attachment D**

**Mine Site Class II Air Quality Dispersion Modeling Protocol**

# Mine Site Class II Air Quality Dispersion Modeling Protocol

**Version 2**

**March 2012**

**NorthMet Project**

**PolyMet Mining Incorporated**

**Hoyt Lakes, MN**

This document provides the Class II dispersion modeling protocol for the Mine Site in the format requested by the Minnesota Pollution Control Agency (MPCA). This includes MPCA form AQDMP-01, five attachments and eight figures. The attachments and figures are listed below.

## Attachments (name references corresponding section of the AQDMP-01 form):

Attachment B - Class II Modeling Surface Meteorology – Minimum Wind Speed for Modeling
Attachment C – Non-Default Modeling Options
Attachment H – $PM_{2.5}$ and $PM_{10}$ SIL Analysis
Attachment J – Nearby Sources (Previously submitted as a standalone document on January 6, 2012)
Attachment K – Anticipated Outputs (OU Pathway)

## Figures:

Figure 1 – Significant Impact Analysis Receptor Grid
Figure 2 – 24 Hour $PM_{2.5}$ SIL Results
Figure 3 – Annual $PM_{2.5}$ SIL Results
Figure 4 – 24 Hour $PM_{10}$ SIL Results
Figure 5 – Annual $PM_{10}$ SIL Results
Figure 6 – EIS Cumulative NAAQS/Increment Receptor Grid
Figure 7 – Year 11 Source Layout
Figure 8 – Year 13 Source Layout

In addition to this document, requested electronic files will be provided via the Project Air FTP Site.

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

# AQDMP-01

## Air Quality Dispersion Modeling Protocol (AQDMP)

Protocol Form for Criteria Pollutant Modeling

*Doc Type: Air Dispersion Modeling*

**Guidance Information on Page 13**

**Instructions:** Permit applicants required to conduct air dispersion modeling should submit two paper copies of the completed Air Quality Dispersion Modeling Protocol form (AQDMP-01), the Air Quality Dispersion Modeling Protocol Spreadsheet (AQDMPS-01), and all accompanying files to:

Air Quality Permit Document Coordinator
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Applicants may also submit an electronic version in addition to the two paper copies.

Electronic copies of the forms and accompanying files should be sent to: AirModeling.PCA@state.mn.us.

## Facility Information

AQ file no.: _____ AQ facility/permit ID no.: _____ Today's date (mm/dd/yyyy): 1/16/2012

Three-letter modeling facility ID (ex., XEK = Xcel Energy Allen S. King, MEC = Mankato Energy Center, etc.): PMM

Facility name: PolyMet Mining Inc.

Facility street address: 6500 County Road 666

City: Hoyt Lakes County: St. Louis

State: MN Zip code: 55750 Elevation at facility: 493 m

Facility contact: Kevin Pylka Protocol prepared by: Jennifer Koenen, Barr Engineering Co

Facility contact phone: (218) 471 - 2162 Preparer phone: (952) 832 - 2682

Facility contact e-mail address: kpylka@polymetmining.com Preparer e-mail address: jkoenen@barr.com

Latitude, Longitude of facility (Decimal degrees to **four** decimal places): 47.6141 N, 91.9690 W

UTM coordinates of facility (NAD83, zone 15 extended **ONLY**): x = 577,480.00 m East, y = 5,273,931.00 m North

### Files to accompany protocol

*Use the checkboxes to indicate that the following **required** files are included with the completed protocol form.*
*Please **do not use** spaces or special characters in the file names and pathways.*

- ☒ 1. Sample AERMOD input files for **each** modeled criteria pollutant (*.inp, *.adi, *.ami)
  ***Note:** Input file should include receptor grid and building downwash (if applicable)
- ☒ 2. BPIPPRM input file (*.bpi)
- ☒ 3. Elevation files for input into AERMAP (*.tif (NED files), *.dem(s))
- ☒ 4. Background data files with concentrations for each applicable pollutant (annual, seasonal, monthly, daily, etc.)
- ☐ 5. AQDMPS-01 spreadsheet
- ☒ 6. **Optional**, but recommended, files and supporting documents – Please list below:
  ***Examples include***: sample AERMOD output files (with "CO RUNORNOT NOT"), SMS Spreadsheet, images and figures, SIL analysis and/or paved roads fugitive dust modeling output files, etc.

  Figure 1 SIL Receptor Grid; Figure 2 24 Hour PM2.5 SIL Results; Figure 3 Annual PM2.5 SIL Results; Figure 4 24 Hour PM10 SIL Results; Figure 5 Annual PM10 SIL Results; Figure 6 EIS Cumulative NAAQS/Increment Receptor Grid; Figure 7 Year 11 Source Layout; Figure 8 Year 20 Source Layout; PolyMet_Minesite_EI.xls (alternative to AQDMPS-01.xls);

## Section A. Purpose for Air Dispersion Modeling and Related Information

1. What is the purpose for conducting the ambient air dispersion modeling? (check all that apply)
   ☐ Permit requirement ☐ EAW ☒ EIS ☐ SIP ☐ PSD
   ☐ Other – please explain: _____
   a. If EAW and/or EIS are selected, please specify the regulatory trigger for modeling (ex., air emissions increase of 250 TPY, 25 MW operating capacity or design, petition, voluntary, etc. – see Minn. R. ch. 4410 for more information) and the name of MPCA EAW staff consulted with (N/A if not applicable or if no EAW staff were consulted):
      Mandatory EIS per MN Rules 4410.4400 Subpart 8b construction of a new facility for mining metallic minerals. Modeling scope agreed upon through process established by state and federal co-lead agencies.
      MPCA EAW staff name(s): Suzanne Baumann Date of consultation (mm/dd/yyyy): _____
      ***Note**: If EAW and/or EIS are to be performed and air modeling will be conducted, cumulative effects will need to be addressed, as per the CARD decision. Please then select "NAAQS/MAAQS" in question 8 (A.8). Contact the Environmental Review Unit Supervisor (currently Craig Affeldt) for any questions regarding applicability and requirements.
2. Were MPCA air dispersion modeling staff consulted while completing this form? ☒ Yes ☐ No
   a. If yes, please provide the following consultation information:
      MPCA modeling staff name(s): Ruth Roberson Date of consultation (mm/dd/yyyy): 12/30/2011
      Topic of consultation:
      Discussion focused on what to put for model version since the release of the new version of AERMOD was after this form was developed and the new version is not on the drop down menu.
3. What type of air emission permit does this facility currently hold?
   ☒ No current permit ☐ Federal (Title V/Part 70) ☐ State ☐ State Registration ☐ Capped ☐ General
   ☐ Other: _____
4. Will you be applying for a permit or a permit amendment for the project? ☒ Yes ☐ No
5. Please provide a project title and a description of the proposed project:
   a. Project title (10 words or less): NorthMet Project - PolyMet Mine
   b. Project description (50 words or less):
      PolyMet plans to construct and operate a mine (subject of this protocol), to reactivate portions of the LTV Steel Mining Company facility and to build a hydrometallurgical concentrate processing facility at the former LTVSMC site. More detail is available in the NorthMet Project Description Version 3 Submitted September 13, 2011
6. Is the proposed project subject to PSD? ☐ Yes ☒ No
   a. If yes, list pollutants: _____
   b. Is this facility considered a major source for PSD: ☐ Yes ☒ No
7. Has the PSD minor source baseline been set for: St. Louis County? ☒ Yes ☐ No
   a. If yes, for which pollutant(s) and the year(s) it was set (check all that apply)?
      ☒ $NO_2$ 1991 ☒ $PM_{10}$ 1979 ☐ *$PM_{2.5}$* _____ ☒ $SO_2$ 1986
      PSD major source baseline *($PM_{2.5}$ trigger date will be on Oct. 20, 2011, 1 year after F.R. publication date.)*
      ☒ $NO_2$ 1988 ☒ $PM_{10}$ 1975 ☒ *$PM_{2.5}$* 2010 ☒ $SO_2$ 1975
8. What type of analysis will be conducted? (check all that apply)
   ☒ NAAQS/MAAQS ☒ PSD Class II Increments ☒ PSD Class I Increments ☒ SIL Analysis ☐ Screening
   ☒ Other: AERA
9. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section B. EPA Pre-Processors and EPA Post-Processors

1. Will AERMAP be used? ☒ Yes ☐ No
   If no, please explain: _____
   a. What version of AERMAP is proposed to be used: AERMAP version 11103
      If other, please explain: _____
   b. What type of elevation data will be used:

☒ NED 1/3 arc second ☐ NED 1 arc second ☐ DEM 7.5 min ☐ DEM 1.0 degree

☐ Other - Please describe: _____

*All UTM coordinates must be in NAD83, Zone 15 Extended (**not** NAD27).*

2. Will BPIP-PRIME version 04274 be used? ☒ Yes ☐ No

   If no, please explain: _____

   *Tiering of buildings must follow MPCA's modeling guidance from section 6 of the Oct. 2004 "MPCA Air Dispersion Modeling Guidance For Minnesota Title V Modeling Requirements And Federal Prevention of Significant Deterioration (PSD) Requirements (Version 2.2)."*

3. Will MPCA pre-processed AERMET data be used? ☒ Yes ☐ No If yes, proceed to question 4.

   **Note –** MPCA's pre-processed meteorological data with AERMET incorporates the following details:

   - *AERSURFACE version 08009 is used to determine surface characteristics using 1992 LULC data.*
   - *Yearly-averaged moisture conditions (wet, dry, or average) based on historical ranks are accounted for in AERSURFACE to aid in the determination of Bowen ratio values.*
   - *Default 1.0 km radius for surface roughness and 10 km by 10 km domain for albedo and Bowen ratio used in AERSURFACE*

   a. If **no**, will on-site meteorological data be processed and used? ☐ Yes ☐ No

      **If no, skip to question 4 and provide additional information in question 5.*

   b. If **yes** to question a, please answer the following questions.

      i. Will AERSURFACE be used to determine surface characteristics around the meteorological tower? *(Default is "Yes")* ☐ Yes ☐ No

      ii. What version of AERSURFACE is proposed to be used: [Select from list] _____

      iii. What LULC data will be used? [Select from list] _____

      If other, please explain: _____

      iv. Will yearly-averaged moisture conditions (wet, dry, or average) based on historical ranks be accounted for in AERSURFACE (for the Bowen Ratio)? *(Default is "Yes")* ☐ Yes ☐ No

      v. Will the default 1.0 km radius for surface roughness, and 10 km by 10 km domain for albedo and Bowen ratio be used? *(Default is "Yes")* ☐ Yes ☐ No

      If no, please explain: _____

4. Are any **EPA** post-processors (such as LEADPOST) proposed to be used in the analysis? ☐ Yes ☒ No

   a. If yes, what post-processor(s) and version(s):

5. Are any user-developed pre-processors or post-processors proposed to be used in the analysis? ☒ Yes ☐ No

   a. If yes, what pre-processors or post-processors, and describe their functions:

      A post-processor may be developed to set the surface wind speeds less than 0.5 m/s to calms in the MPCA processsed surface file (.sfc).

6. Additional information for this section that was not included above (if not applicable, place N/A in field):

   Attachment B included with this protocol describes the method used for post-processing the MPCA processed surface meteorology to assign wind speeds less than 0.5 m/s as calm.

## Section C. Model Selection and Options (Key CO Pathway Inputs)

1. Identify the air dispersion model and version proposed to be used in the analysis: Other

   a. If other, please list: version 11353

2. What criteria pollutants are required and will be modeled (check all that apply)?

   ☐ CO ☒ $NO_2$ ☒ $PM_{2.5}$ ☒ $PM_{10}$ ☒ $SO_2$ ☐ Pb ☐ $H_2S$ ☐ Other: _____

   *Please refer to **Tables App.1 and App.2 in the Appendix** for averaging times and form of standard for each criteria pollutant(s). Refer to the most recent version of the EPA's AERMOD User's Guide for correct pollutant IDs to use. Use EPA's most recent modeling guidance' methods for $PM_{2.5}$.*

3. What model options (CO pathway keywords) are proposed to be used in the analysis for the source under review (check all

that apply)? (See Tables B-1 and B-2 of the "*AERMOD User's Guide, Addendum for Version 11103*")

☒ Regulatory Default - list pollutants: SO2 ☒ Non-Default - List pollutants: NO2, PM10, PM2.5

☒ Concentration ☒ Rural ☐ Urban ☒ ELEV ☐ FLAT

☐ Other(s) not listed: _____

a. If Urban, please specify population area, population, and surface roughness radius:
Population area: _____ Population: _____ Surface roughness height: 1.0 km

b. If Non-Regulatory Default, please specify non-default options: OLM (1 hour NO2), Half-Life (PM10), and Secondary Formation of Combustion Sources (PM2.5) (see Attachment C)

4. Will alternative air dispersion models and/or methods, as specified by Appendix W, be applied (e.g., parallel version(s) of model, PVMRM, OLM, secondary formation, etc.)? ☒ Yes ☐ No

If yes, please explain: The 1 hour NO2 SIL analysis assumes OLM and the options selected are included in question 5 below. Attachment C describes the proposed PM2.5 modeling methodology to account for secondary formation from the combustion sources at the mine site.

a. If yes, will approval be required by MPCA and/or EPA Region V air modeling staff? ☒ Yes ☐ No
If yes, please select: ☒ MPCA (State-only action) ☒ EPA Region V (PSD/SIP action)
If no, please explain: _____

5. If $NO_2$ is required to be analyzed for the one-hour and annual NAAQS, what tier methodology(s) is proposed?

☐ N/A, $NO_2$ not required (skip to question 6)

☐ Tier 1 (100% $NO_x$ to $NO_2$ conversion, most conservative)

☐ Tier 2 (Default ambient ratio of 0.80, or an appropriate ratio value)

☒ Tier 3 (OLM, requires justification and approval by MPCA and/or EPA Region 5)

☐ Tier 3 (PVMRM, requires justification and approval by MPCA and/or EPA Region 5)

a. If Tier 2, please provide the ambient ratio proposed (**default** = 0.80): 0.80

b. If Tier 3 is anticipated to demonstrate compliance in the modeling analysis (OLM or PVMRM), please provide the following details now to expedite MPCA's review:
   i. In-stack ratio of $NO_2/NO_x$ (NO2STACK) (**default=0.50**): 0.50
   ii. Equilibrium ratio (NO2EQUIL) (**default=0.90**): 0.90

c. If Tier 3 is anticipated, please provide details below regarding **MPCA-generated** ozone values (in **µg/m$^3$**)
*(Please check all option(s) proposed to be used):*
☒ MPCA-generated $O_3$ values will be used
☐ MPCA-generated values will NOT be used (proceed to question d)
   i. ☐ CO OZONEFIL (hourly):
      *1.* O3FileName: _____
      *2.* File creation date: _____
      *3.* FORTRAN subroutine: _____
   ii. ☐ CO O3VALUES O3flag: SEASON OZONUNIT: ☐ PPB ☐ PPM ☒ UG/M3
   **Note**: MPCA O3flag uses SEASON as a default, as well as OZONUNIT set to UG/M3.
      *1.* Please input the O3values (i=1,n) for the O3flag specified above (C.5.c.ii):
      ***Example***: For "CO O3VALUES SEASON", n=4 values (winter #, spring #, summer #, fall #)
      _____

d. If Tier 3 is anticipated, please provide details below regarding **user-generated** ozone values
*(Please check all option(s) proposed to be used):*
☐ User-generated $O_3$ values will be used
☐ User-generated values will NOT be used (proceed to question e)
   i. ☐ CO OZONEFIL (hourly):
      1. O3FileName: _____
      2. O3Units: ☐ UG/M3 ☐ PPM ☐ PPB
      3. O3Format: _____
   ii. ☐ CO O3VALUES O3flag: _____ OZONUNIT: ☐ PPB ☐ PPM ☐ UG/M3
   **Note**: O3flag can be defined as ANNUAL, SEASON, MONTH, etc. PPB is the AERMOD default for OZONUNIT. See Table B-2, Appendix B, of the "AERMOD User's Guide, Addendum for Version 11103".

1. Please input the O3values (i=1,n) for the O3flag specified above (C.5.d.ii):
   ***Example***: For "CO O3VALUES SEASON", n=4 values (winter #, spring #, summer #, fall #)

iii. ☐ CO OZONEVAL (monitored value): _____ O3Units: ☐ UG/M3 ☐ PPB ☐ PPM
   **Note**: UG/M3 is the AERMOD default for OZONEVAL O3units.

e. Is EPA approval needed for the modeling protocol (e.g., Tier 3 $NO_2$)? *Tier 3 $NO_2$ methodologies that require approval by Region 5 modeling staff need to have said approval before submission of this form and attach approval.*
   ☒ Yes – PSD/SIP permit action ☐ No – State-only action

6. Are the following criteria from Appendix W, section 3.2.2, paragraph (e), met in this protocol? ☒ Yes ☐ No
   If no, please explain: _____

*e. "Finally, for condition (3) in paragraph (b) of this subsection…an alternative refined model may be used provided that:*
   i. *The model has received a scientific peer review;*
   ii. *The model can be demonstrated to be applicable to the problem on a theoretical basis;*
   iii. *The data bases which are necessary to perform the analysis are available and adequate;*
   iv. *Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and*
   v. *A protocol on methods and procedures to be followed has been established."*

7. Additional information for this section that was not included above (including justification for non-default options, additional CO pathway keywords not mentioned above, or additional values listed in 5a or 5b):
   Attachment C included with this protocol describes the Half-Life method used for the PM10 modeling and the off-set emission rate method used to account for secondary formation of PM2.5 from combustion sources.

## Section D. Emission Source Characterizations and Parameters (Key SO Pathway Inputs)

Include and list the facility's modeling parameters for all source types in the *MPCA's Modeling Parameters Spreadsheet* (Form AQDMPS-01). For background sources listed within SO Pathway, please see Section I.

1. Please indicate which of the following source characterizations are present at your facility and will be included for modeling analysis (check all that apply ):
   *"Yes" = Source-type present and will model; "N/A" = Source-type not present; "No" = Source-type present but will not model.*

a. **Point sources**:
   ☒ Yes ☐ N/A ☐ No-please explain: _____

i. Are any of the point sources capped and/or horizontal stacks (see guidance in section 6.1, AERMOD Implementation Guide (03/19/2009)) and, if yes, accounted for in the following?
   ☒ No ☐ Yes – exit velocity(s) = 0.001 m/s ☐ Yes – Non-Default POINTCAP and /or POINTHOR*
   **Please provide justification for use of non-default option in question b, below.*

ii. Additional information for this subsection (if not applicable, place N/A in field):
   There are 3 point sources located at the PolyMet mine site: backup generator, interim generator to move electrical equipment, and a lime silo. The generators are not part of regular operations and are considered intermittant use sources. The lime silo is part of regular operations and is a non-combustion source of PM10 and PM2.5. These stacks are only modeled for PM10 and PM2.5 since intermittant use sources are not required in the 1 hour SO2 and NO2 demonstrations.

b. **Volume sources**:
   ☒ Yes ☐ N/A ☐ No-please explain: _____
   **Tip**: Please refer to Figure App.1 in the appendix on calculating the lateral and vertical dimensions.

i. Will there be any volume source(s) overlapping or within 1.0 meters of any receptors?
   ☒ No ☐ Yes*
   ** Volume source should then be converted to an area source of commensurate size (per section 6.2 of EPA's AERMOD Implementation Guide (03/19/2009)) or be further refined.*

ii. Additional information for this subsection (if not applicable, place N/A in field):
   The mine site volume sources represent the fugitive dust from the unpaved roads and stockpile handling. There is also a space heater vented out of the wastewater treatment building that is represented as a volume source.

c. **Area sources** (includes AREACIRC and AREAPOLY):

☐ Yes ☒ N/A ☐ No-please explain: _____

i. Additional information for this subsection (if not applicable, place N/A in field):

d. **Open pit sources**:

☒ Yes ☐ N/A ☐ No-please explain: _____

i. Additional information for this subsection (if not applicable, place N/A in field):

There are two open pit sources at the PolyMet mine site and they will each be represented as an OPENPIT source.

2. Are fugitive emissions emitted from the source, and if yes, will they be accounted for in the modeling analysis? (Examples of fugitive emissions include but are not limited to: traffic on paved and/or unpaved roads, stockpiles of various materials, wind erosion, loadout, unloading, etc.)

(Yes = fugitive emissions are emitted AND will be included in modeling analysis; N/A = no fugitive emissions are emitted; No = fugitive emissions are emitted and will NOT be included in modeling analysis)

☒ Yes ☐ N/A ☐ No-please explain*: _____

** Please provide justification for excluding any fugitive emission sources within the modeling.*

a. If yes, please list the facilities' fugitive sources: material handling, unpaved road traffic, crushing/screening

***Note**: If modeling for paved road fugitive dust, please read and complete Section E.*

b. Will the Standardized Mobile Source (SMS) Spreadsheet be used to determine emissions due to paved and/or unpaved roads (unpaved spreadsheets under development)? ☐ Yes ☒ No

3. Will all insignificant activities emitted from the source for $PM_{10}$ (with emissions over 0.1 lb/hr), $PM_{2.5}$ (with emissions over 0.02 lb/hr), or other pollutants be accounted for in the modeling?

☒ Yes ☐ N/A ☐ No-please explain*: _____

** Please provide justification for excluding any insignificant activities within the modeling.*

*Scale for other pollutants. For example, (0.1 lb/hr) / (150 µg/m$^3$) = (X lb/hr) / (35 µg/m$^3$), where X = 0.02 lb/hr.*

*Refer to guidance in section 10 of the Oct. 2004 "MPCA Air Dispersion Modeling Guidance For Minnesota Title V Modeling Requirements And Federal Prevention of Significant Deterioration (PSD) Requirements (Version 2.2)"*

4. Are intermittent emissions sources present at the facility? ☒ Yes ☐ No – Skip to question 5.

a. If yes, please provide detail on the types and operations of the intermittent emission source(s) (include the source IDs, any regular uses, testing frequencies, emergency uses, peaking vs. non-peaking units, etc.):

SV326 is the wastewater treatment facility backup generator and will be modeled for the 24 hour and annual PM10 and PM2.5 NAAQS/Increment assuming 8,760 hours of operation. SV337 is an portable generator that is used to move electrical equipment and will be modeled for the 24 hour and annual PM10 and PM2.5 NAAQS/Increment assuming 8,760 hours of operation. If these very conservative assumptions produce unacceptable results, the maximum operating hours per day will be used in the modeling or worst case short term emissions for the entire Mine Site will be determined.

b. If yes to question 4, will intermittent emission sources be included in the modeling analysis?

☒ Yes – please list the source ID(s): SV326, SV337

☐ No – please explain: _____

5. Does your facility have alternative operating scenarios? ☒ Yes ☐ No

a. If yes, will multiple operating scenarios be modeled?

☒ Yes - # of scenarios to be modeled: 2 ☐ No – most conservative scenario will be modeled

b. If yes to 5a above, please describe the operating scenarios and the differences between them:

There will be two main phases of Mine Site operation: 1) temporary stockpile phase and 2) in-pit disposal/stockpile reclaimation phase. The change in mining phase is scheduled to occur during Year 11 of mine operation – in this year the East Pit will be mined out and newly mined wasterock will be placed in the East Pit and rock from the temporary stockpiles will begin to be relocated to the pit. A worst case year for each phase was determined as described in the emission inventory spreadsheet and the two worst case years will be modeled. The two mining phases are not consistent with the definition of alternative operating scenario for permitting purposes, but this question was the most applicable place on the protocol form to discuss the modeling scenarios.

**Note**: If multiple scenarios will be modeled, please list the scenarios in the AQDMPS-01 spreadsheet.

6. Will emission factors/scalars (SO EMISFACT) be used to demonstrate compliance in the air dispersion modeling analysis?
☐ Yes ☒ No

a. If yes, describe for which sources and the types of emission factors/scalars that will be applied:

7. Will hourly emission file(s) be used for this analysis (HOUREMIS)? ☒ Yes* ☐ No
   **If yes, please provide the hourly emission file(s) with the submittal of this form and list file in question 6 under the "Files To Accompany Protocol" section.*
8. Please list the anticipated source groups (SRCGROUP) that will be used in the modeling analysis:
   ***Tip**: For NAAQS modeling, please include for source groups:
   "SO SRCGROUP ALL BACKGROUND", "SO SRCGROUP BKG BACKGROUND", "SO SRCGROUP FAR 1-99999999".
   NAAQS, Increment, PMM, Nearby, NAAQSnoMN, NAAQSnoPMP, NAAQSnoNSM, INCnoMN, INCnoPMP
9. Will $NO_2/NO_x$ ratios be used for OLM or PVMRM options? ☐ N/A ☒ Yes ☐ No
10. Will "OLMGROUP ALL" be used for the OLM option? ☐ N/A ☒ Yes ☐ No
11. Will all applicable PSD increment consuming and/or expanding sources be modeled for your source?
    ☒ Yes ☐ No-please explain (SIL-only, NAAQS-only, etc.): _____
12. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section E. Paved Roads Fugitive Dust

Current MPCA policy regarding modeling of paved road fugitive dust emissions, in support of air quality permitting or environmental review, recommends that:

> New facilities or facilities undergoing physical expansions will not be required to model paved road fugitive dust emissions if a facilities' predicted ambient impacts for $PM_{10}$ and $PM_{2.5}$ are less than a specified percent of the NAAQS and/or PSD Class II Increment. Physical expansions do not include increases in emission limits.

This policy does not apply to modeling that supports permitting in maintenance areas or the development of State Implementation Plans. Exceptions to the policy can and will occur. Please see the MPCA air modeling webpage for policy.

If paved road fugitive dust emissions are proposed to be included in your modeling analysis and you did **not** answer "Neither" to question 1b, MPCA guidance recommends that the source in question first model its' facility (**without** including paved road fugitive dust emissions) plus nearby sources plus background (i.e., FAC w/o paved roads + nearby source impacts + background impacts). Results then can be recorded using Table E-01 below for $PM_{10}$ and $PM_{2.5}$. If your facility has multiple paved roads operating scenarios, results recorded in Table E-01 must reflect the most conservative scenario.

1. Does your facility have paved road fugitive dust emissions for $PM_{10}$ and $PM_{2.5}$?
   ☐ Yes ☒ No – Please continue to the next section (F)
   a. Will your facility include paved road fugitive dust emissions in the modeling analysis? ☐ Yes ☐ No
   b. Is your facility either a new facility or an existing facility undergoing a physical expansion?
      ☐ New facility ☐ Existing w/ phys. expan. ☐ Neither*
      ** If neither, policy does not apply. Please answer questions 2 – 5, and proceed to the next section (F) **without** filling in Table E-01.*
   c. If yes to question 1 and no to question 1a, please provide justification for not including paved road fugitives:
      _____
2. How many vehicles per day drive on and off your facility's property? (Provide the maximum number from all scenarios.)
   Employee traffic and parking: _____ Third-party truck traffic: _____
3. Does your facility have multiple operating scenarios for traffic on your property (i.e., seasonal traffic changes)?
   ☐ Yes ☐ No
   a. If yes, please provide additional details for the operating scenarios, such as changes in traffic counts, types of vehicles, silt loadings, cleaning frequencies, etc.
      _____
4. Will you be using the most recent version of the MPCA's Standardized Mobile Source (SMS) spreadsheet to determine paved road fugitive dust emissions and source parameters?
   ☐ Yes* ☐ No **If yes, please submit SMS with this modeling protocol form and indicate on the cover page of this form.*

5. Additional information for this section that was not included above or below (if not applicable, place N/A in field):

***Note:*** *Modeling output files must be submitted, if completing Table E-01.*

**Table E-01** (Use max modeled concentrations from all operating scenarios)

| | Averaging Period | NAAQS (µg/m$^3$) | Modeled NAAQS Impact Concentrations w/ Background and Nearby Sources(µg/m$^3$) | % of NAAQS/MAAQS | PSD Class II Increments (µg/m$^3$) | Modeled Class II Increment Impact Concentrations (µg/m$^3$) | % of Class II Increments |
|---|---|---|---|---|---|---|---|
| $PM_{10}$ | 24-hour | 150 | | 0.00% | 30 | | 0.00% |
| | Annual | 50 | | 0.00% | 17 | | 0.00% |
| $PM_{2.5}$ | 24-hour | 35 | | 0.00% | 9 | | 0.00% |
| | Annual | 15 | | 0.00% | 4 | | 0.00% |

Table E-02 indicates the resultant category(s) for your facility, based on the % of the standard(s) for $PM_{10}$ and $PM_{2.5}$ (see results in columns "% of NAAQS" and "% of Class II Increments" in Table E-01 above). This uses the highest % from all averaging periods for each pollutant and standard. The category descriptions are provided in Table E-03. Answers to question 2 above will help determine permit conditions if modeled concentrations result in a category 2 designation.

**Table E-02**

| | NAAQS | | | | PSD Class II Increments | | | |
|---|---|---|---|---|---|---|---|---|
| | ***NAAQS/MAAQS Result(s) w/ Background and Nearby Sources (%)*** | **Cat. 1** | **Cat. 2** | **Cat. 3** | ***PSD Class II Result(s) (%)*** | **Cat. 1** | **Cat. 2** | **Cat. 3** |
| $PM_{10}$ | 0.00% | *# < 60%* | *60% < # < 95%* | *95% < #* | 0.00% | *# < 35%* | *35% < # < 75%* | *75% < #* |
| $PM_{2.5}$ | 0.00% | *# < 80%* | *80% < # < 95%* | *95% < #* | 0.00% | *# < 40%* | *40% < # < 80%* | *80% < #* |

**Table E-03**

| | |
|---|---|
| Cat 1: | Paved road fugitive emissions not required to be modeled, and no paved road fugitive dust permit conditions. Requirements in Minn. Rule 7011.150 apply. |
| Cat 2: | Paved road fugitive emissions not required to be modeled, with paved road fugitive dust permit conditions determined by levels of traffic at the facility. |
| Cat 3: | Paved road fugitive emissions **are** required to be modeled, with site-specific paved road fugitive dust permit conditions. Re-modeling and/or addition of paved road fugitive emissions source group required. |

## Section F. Receptors (RE Pathway)

Please refer to guidance from Table 4 and 5 of the October 2004 "*MPCA Air Dispersion Modeling Guidance For Minnesota Title V Modeling Requirements And Federal Prevention of Significant Deterioration (PSD) Requirements (Version 2.2)"*, as well as federal guidance.

1. What type of receptor grid will be used? Discrete Cartesian
   a. If other, or a combination, please describe:
   b. Will grid be converted to discrete Cartesian? ☐ Yes ☐ No ☒ N/A – already discrete Cartesian
2. How many receptors in total will be included in the receptor grid? 5,678 receptors
3. What will be the grid dimensions? (Ex., radius of 10 km, 5 km by 5 km, etc.) 39 km X 34 km
4. What is the proposed spacing of receptors for…?
   a. Inside the property boundary(s): see 6 meters
   b. On the fenceline(s): see 6 meters
   c. On the property line(s): see 6 meters
   d. Beyond the property line(s): see 6 meters

5. Will FLAGPOLE receptors be included in the receptor grid?

   (N/A = No high-rise structures w/ ambient air within 3 miles of source; No = High-rise structures w/ ambient air exist within 3 miles of source, but will not include in receptor grid.)

   ☐ Yes ☐ N/A ☒ No – Please continue to the next question (6)

6. Additional information for this section that was not included above (if not applicable, place N/A in field):

   The EIS Class II Cumulative NAAQS and Increment mine site receptor grid assumes a 100 meter space grid around the ambient air boundary with a 25 meter spaced area south of the unloading area where initial modeling showed maximum impacts. From the boundary out 1km the receptors are spaced 100 meters, except in the area of maximum impacts, which was spaced at 50 meters. From 1 km out to 5 km the receptors were spaced every 500 meters. From 5km to the maximum extent of the grid, 15km, the receptors were spaced every kilometer. Source groups will be utilized in the modeling analysis to ignore impacts from a nearby facility on receptors located within their ambient air boundary. Figure 6 shows the proposed EIS Class II receptor grid and the onsite receptors that will ignore impacts from the nearby facility.

## Section G. Meteorological Data (ME Pathway)

**Note:** If modeling with more than one meteorological data set (i.e., portable facility), please list in question 8 the information requested in questions 1-4 for the additional data sets.

1. What meteorological surface station is proposed for use? Please indicate the station name, the state the surface station is located in, and the three letter call sign\identifier. (Ex.: Minneapolis/St. Paul Int'l Arpt; MN; MSP) Or check the box to indicate that on-site surface meteorological data will be used instead of NWS surface meteorological data.

   Surface station name: Hibbing Airport State: MN Three-letter call sign/identifier: HIB

   ☐ Onsite surface data

2. What meteorological upper air station is proposed for use? Please indicate the station name, the state the surface station is located in, and the three letter call sign\identifier. (Ex.: Chanhassen; MN; MPX)

   Upper air station name: International Falls State: MN Three-letter call sign/identifier: INL

3. What consecutive 5- year period will be used? 2006 to 2010

4. Were the proposed AERMET files pre-processed by MPCA staff?

   ☒ Yes ☐ No

   a. If yes, please provide the name of the met data zip file that was received or obtained from the MPCA and the date it was obtained:

      Name: HIBINL5Y_20062010 .zip Date (mm/dd/yyyy): 05/05/2011

   b. Please indicate what version of AERMET will be used: AERMET version 11059

      If other, please explain:

5. Will on-site meteorological data be used, instead of NWS meteorological data processed by MPCA staff?

   ☐ Yes ☒ No

   **Note:** If site-specific meteorological data will be collected and used, please follow the federal guidance (EPA's), as specified in section 8.3 and section 8.3.3.2 (QA/QC) of 40 CFR Part 51 dated 11/09/2005 (Appendix W).

   a. If site-specific surface meteorological data will be collected and used, where will the **location** of the meteorological tower be set (city and state, coordinates, etc.)?

      N/A

   b. If site-specific meteorological data will be collected and used, what **year** of data is proposed to be used?

      N/A

6. What justification(s) applies for the proposed surface and upper air stations identified above? (Check all that apply)

   ☐ Similar surface characteristics as meteorological tower ☐ Similar land use characteristics

   ☐ Similar wind patterns/characteristics ☐ Proximity to surface and/or upper air station(s)

   ☒ Other – Please describe: Nearest Surface Station with available minute data.

   a. Please provide additional detail for your justifications:

7. Will wind speed categories be used?

   ☐ Yes ☒ No – Skip to question 8.

   a. If yes, please list the user-specified wind speed categories for the ME WINDCATS pathway:

b. If yes, please list the user-specified wind speed emission factors for the SO EMISFACT WSPEED pathway:

8. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section H. SIL Analysis and Results

1. Will a SIL analysis be conducted in conjunction with this project, in order to determine if a cumulative analysis is required?
   ☐ N/A – Proceed to the next section (I)
   ☐ No – Will not model against SILs and instead proceed directly to conducting a cumulative analysis
   ☒ Yes – List for which pollutants: SO2, NO2, PM10, PM2.5
2. Extent of SIL receptor grid: 15 km
3. If a preliminary SIL analysis has been conducted for this project, it is optional but highly recommended that results be provided (in the Table H-01 below), as well as including corresponding model output files.

**Table H-01, Class II Significant Impact Levels Modeling Results for:**

| Pollutant | Averaging Time | Modeled Impacts (H1H) ($\mu g/m^3$) | SILs ($\mu g/m^3$) *As of 10/26/2010 | % of SIL | Exceed SIL? | Radius of Impact (If exceeds SIL) |
|---|---|---|---|---|---|---|
| $SO_2$ | *1-hr* | 0.74 | 7.83 | 2.00% | No - Complete | km |
| | *3-hr* | 0.54 | 25 | 3.00% | | |
| | *24-hr* | 0.13 | 5 | 1.00% | | |
| | *Annual* | 0.01 | 1 | 600.00% | | |
| $PM_{10}$ | *24-hr* | 30.00 | 5 | 630.00% | Yes - Refined Modeling | 10 km |
| | *Annual* | 6.30 | 1 | 833.30% | | |
| $PM_{2.5}$ | *24-hr* | 10.00 | 1.2 | 733.00% | Yes - Refined Modeling | 15 km |
| | *Annual* | 2.2 | 0.3 | 71.01% | | |
| $NO_x$ | *1-hr* | 5.34 | 7.52 | 10.00% | No - Complete | km |
| | *Annual* | 0.10 | 1 | 0.00% | | |
| CO | *1-hr* | | 2000 | 0.00% | (blank) | km |
| | *8-hr* | | 500 | 14t00.00% | | |

4. Additional information for this section that was not included above (if not applicable, place N/A in field):
   See Attachment H for additional discussion. Class II SIL modeling files are included with this protocol as an attachment.

## Section I. Background Values

Please refer to pages 35-39 (Section 2.4) and Table B-4 of the "*AERMOD User's Guide, Addendum for Version 11103*" for guidance as well as the latest version of the MPCA's Air Dispersion Modeling Guidance for Title V and PSD.
***Contact MPCA air dispersion modeling staff for MPCA-generated products.**

1. Are background concentrations required for your analysis?
   ***Tip**: If "NAAQS/MAAQS" was selected in question A.8, the answer is "Yes".
   ☒ Yes – List pollutants required for: PM10, PM2.5
   ☐ No – Please explain and proceed to question 3 (e.g., SIL analysis-only, etc.):

   **Note**: All MPCA and user-generated background concentrations, including uniform and temporally varying concentrations, will need to be specified in the input file(s).
2. **Will MPCA-generated background concentrations (in $\mu g/m^3$) be used?**
   ☒ No ☐ Yes – List pollutants to be used for:

If yes, check MPCA-generated background concentrations option(s) to be used (check all that apply):

a. ☐ SO BACKGRND BGflag *Default for BGflag (question I.2.a.iii) for MPCA-generated is "SEASON"*
   i. File name(s): _____
   ii. File creation date(s): _____
   iii. BGflag(s) – List all that apply: _____
b. ☐ SO BACKGRND HOURLY
   i. File name(s): _____
   ii. File creation date(s): _____
   iii. FORTRAN subroutine: _____

**Tip**: Please include MPCA-generated background concentrations as an external file in the modeling input file. Ex., "SO INCLUDED BGflag filename" or "SO BACKGRND HOURLY hourlyfilename"

3. **Will user-generated background concentrations be used?**

☐ No ☒ Yes – List pollutants to be used for: PM10 and PM2.5

a. If yes, please provide a description below of the user-generated background concentration(s) and any considerations given to the methodology:

The Virginia, MN monitor is a site representative of the Iron Range and has been used as a background site for recent PSD permits at Northern Minnesota Taconite mining facilities. The 3 year average of the high 2nd second high 24 hour PM10 and PM2.5 values for 2008-2010 will be added directly to the modeled 24 hour concentrations (PM10 = 36; PM2.5 = 16.5). The maximum annual average monitored PM10 and PM2.5 concentrations from 2008-2010 will be added directly to the modeled annual concentrations (PM10 = 14; PM2.5 = 5.8).

b. Background data sources (check all that apply): ☒ MPCA website ☐ EPA website
   ☐ Other – explain: _____
c. Examined monitors out to a distance of: km
d. Monitors excluded and reasons why: _____

e. Facility characteristics:
   i. Facility land use (industrial, residential, agricultural, cropland, mixed, etc.): _____
   ii. Facility setting: ☐ Urban ☐ Suburban ☒ Rural
f. Ambient air monitor(s) characteristics:
   i. Monitor land use (industrial, residential, agricultural, cropland, mixed, etc.): _____
   ii. Monitor setting: ☐ Urban ☐ Suburban ☒ Rural
g. Form of background value(s) (maximum, 98th percentile, etc.): 24 hour - 3 year average High 2nd High (2008-2010)
   Annual - Maximum annual average for 2008-2010
h. Please check user-generated background concentrations option(s) to be used (check all that apply):
   ☐ SO BACKGRND BGflag *(BGflag can be defined as ANNUAL, SEASON, MONTH, etc. See Table B-4, Appendix B, of the AERMOD User's Guide Addendum)*
   i. File name(s): See number 4.
   ii. File creation date(s): _____
   iii. BGflag(s) – List all that apply: _____
   ☐ SO BACKGRND HOURLY
   i. File name(s): _____

4. Additional information for this section that was not included above (if not applicable, place N/A in field):

The annual background concentration will be applied to the modeled concentration outside of the AERMOD run, so no background data file was created.

## Section J. Nearby Sources

***Contact MPCA air dispersion modeling staff for MPCA-generated products.**

1. Will any nearby sources be modeled explicitly for the analysis?
   ☐ N/A ☐ No ☒ Yes – List pollutants required for: PM10, PM2.5
2. **Will MPCA-generated nearby sources be used for any of the criteria pollutants?**

☐ N/A ☒ No ☐ Yes – List pollutants to be used for: _____

*If yes, check MPCA-generated nearby sources option(s) to be used (check all that apply):*

a. ☐ First-approximation representative (FAR) data

i. File name(s): _____

ii. Creation date(s): _____

iii. Distance(s) (DMAX) (km): CO: 50 $NO_2$: 50 $PM_{10}$: 50 $PM_{2.5}$: 50 $SO_2$: 50

iv. Scalar(s) (SMAX): CO: $NO_2$: $PM_{10}$: $PM_{2.5}$: $SO_2$:

iv. Coefficients for Coef. * D test(s): CO: $NO_2$: $PM_{10}$: $PM_{2.5}$: $SO_2$:

**Tip:** Please include MPCA-generated nearby sources as an external file in the modeling input file. Ex., "SO INCLUDED filename". Do not change the MPCA-generated source ID's (SrcID) of the nearby sources, or alter the files in any way without MPCA approval (ex., replacing FAR data with refined data).

b. ☐ Refined nearby source modeling

i. ☐ FAR sources replaced with refined modeling data (if checked, please list FAR ID's & FAC ID's)

ii. ☐ Other refined nearby sources (if checked, please list FAC ID's)

3. **Will user-generated nearby sources be used for any of the criteria pollutants?**

☐ N/A ☐ No ☒ Yes – List pollutants to be used for: PM10 and PM2.5

*If yes, please explain:*

The majority of emissions from the NorthMet mine site are mechanically generated fugitive dust which has maximum impacts in the extreme near-field and do not extend far beyond the ambient air boundary. In the previous DEIS, this was taken into account and the immediately nearby facilities, Northshore Peter Mitchell Mine, NorthMet plant site, and Mesabi Nugget Phase I were accounted for explicitly in the modeling analysis. These same sources will be included explicitly in the PolyMet mine site Class II PM10 and PM2.5 NAAQS and PM10 Increment analyses.

4. Additional information for this section that was not included above (if not applicable, place N/A in field):

See Attachment J for a description of the proposed nearby source inputs.

## Section K. Anticipated Outputs (OU Pathway)

*Please refer to Tables B-11 and B-12 of the "*AERMOD User's Guide, Addendum for Version 11103*".

1. Please list the plot file(s) (*.plt) that will be generated for each pollutant and averaging time combination (OU PLOTFILE) (Required for all modeled criteria pollutants):

See #9.

**Note**: Plot files with combined averaging times for the same pollutant, and extensions such as ***.grf**, should be separated into individual *.plt files. For example, $PM_{10}$ should have at least two individual plot files: one for the 24-hour averaging period for source group ALL and a second for the annual averaging period for source group ALL. Group ALL should include BACKGRND if conducting NAAQS modeling (e.g., "SO SRCGROUP ALL BACKGRND").

2. Please list the keyword and parameters that will be used in the modeling output files for the keyword RECTABLE (Required) (Ex., "NO2 = OU RECTABLE ALLAVE 1-8", "SO2 = OU RECTABLE ALLAVE 1-4"):

See #9.

3. Please list the keyword and parameters that will be used in the modeling output files for the keyword MAXTABLE (OU MAXTABLE Aveper Maxnum) (Maxnum=80) (Required):

Not being used at this time.

4. Will source contribution (OU EVENTOUT SOCONT) or hourly contribution (OU EVENTOUT DETAIL) files be generated for event output files? (Required for $PM_{10}$ and CO):

☒ SOCONT ☒ DETAIL ☐ N/A (not modeling for $PM_{10}$ and/or CO)

5. Please specify the parameters for use with OU MAXDCONT (for use with 1-hour $NO_2$, 1-hour $SO_2$, and 24-hour $PM_{2.5}$ only): (Required)

☐ 1-hour $NO_2$ – GrpID: Upper Rank: LowerRank or ThreshValue: FileName:

☐ 1-hour $SO_2$ – GrpID: Upper Rank: LowerRank or ThreshValue: FileName:

☒ 24-hour $PM_{2.5}$ – GrpID: TBD Upper Rank: TBD LowerRank or ThreshValue: TBD FileName: TBD

6. Will output files of daily maximum 1-hour values for each processed day (OU MAXDAILY) be generated for this analysis (for 1-hour $NO_2$ and 1-hour $SO_2$ only)? (Optional)

☒ No ☐ Yes – for: ☐ 1-hour $NO_2$ and/or ☐ 1-hour $SO_2$

7. Will output files of daily maximum 1-hour values by year, for each processed year (OU MXDYBYYR) be generated for this analysis (for 1-hour $NO_2$ and 1-hour $SO_2$ only)? (Optional)

   ☒ No ☐ Yes – for: ☐ 1-hour $NO_2$ and/or ☐ 1-hour $SO_2$

8. Other outputs to be generated (please specify the keyword and the parameter options):

9. Additional information for this section that was not included above (if not applicable, place N/A in field):

   See Attachment K.

## Appendix

**Figure App.1**

TABLE 3-1.

SUMMARY OF SUGGESTED PROCEDURES FOR ESTIMATING INITIAL LATERAL DIMENSIONS $\sigma_{yo}$ AND INITIAL VERTICAL DIMENSIONS $\sigma_{zo}$ FOR VOLUME AND LINE SOURCES

| Type of Source | Procedure for Obtaining Initial Dimension |
|---|---|
| (a) Initial Lateral Dimensions ($\sigma_{yo}$) | |
| Single Volume Source | $\sigma_{yo}$ = length of side divided by 4.3 |
| Line Source Represented by Adjacent Volume Sources (see Figure 1-8(a) in EPA, 1995) | $\sigma_{yo}$ = length of side divided by 2.15 |
| Line Source Represented by Separated Volume Sources (see Figure 1-8(b) in EPA, 1995) | $\sigma_{yo}$ = center to center distance divided by 2.15 |
| (b) Initial Vertical Dimensions ($\sigma_{zo}$) | |
| Surface-Based Source ($h_e$ = 0) | $\sigma_{zo}$ = vertical dimension of source divided by 2.15 |
| Elevated Source ($h_e$ > 0) on or Adjacent to a Building | $\sigma_{zo}$ = building height divided by 2.15 |
| Elevated Source ($h_e$ > 0) not on or Adjacent to a Building | $\sigma_{zo}$ = vertical dimension of source divided by 4.3 |

**Table App.1 – Modeled Form of the NAAQS/MAAQS by Averaging Periods**

| Pollutant | 1-hour | 3-hour | 8-hour | 24-hour | Monthly | Annual |
|---|---|---|---|---|---|---|
| ***CO*** | H2H | - | H2H | - | - | - |
| ***$NO_2$*** | 98$^{th}$ percentile of the daily max. 1-hour values | - | - | - | - | H1H |
| ***Pb*** | - | - | - | - | H1H | - |
| ***$PM_{10}$*** | - | - | - | H6H of the multiyear values | - | H1H |
| ***$PM_{2.5}$*** | - | - | - | 98$^{th}$ percentile of daily max. 24-hour values | - | H1H |
| ***$SO_2$*** | 99$^{th}$ percentile of the daily max. 1-hour values | H2H | - | H2H | - | H1H |

**Table App.2 – Modeled Form of PSD Increment by Averaging Periods**

| Pollutant | 1-hour | 3-hour | 24-hour | Annual |
|---|---|---|---|---|
| ***$NO_2$*** | - | - | - | H1H |
| ***$PM_{10}$*** | - | - | H2H | H1H |
| ***$PM_{2.5}$*** | - | - | H2H* | H1H |
| ***$SO_2$*** | - | H2H | H2H | H1H |

***Criteria pollutants modeled for SIL analyses should be modeled as H1H's.***

## Helpful Webpages, Documents/Guidance, and Modeling Tips

Please consult the following webpages and documents for the most current modeling guidance and recommendations when filling out this form:

- U.S. EPA's Support Center for Regulatory Atmospheric Modeling: http://www.epa.gov/scram001/
  **Please check the SCRAM webpage regularly for the most recent updates to guidance, models, and standards; especially, for modeling guidance related to: 24-hour $PM_{2.5}$, 1-hour $NO_2$, and 1-hour $SO_2$ NAAQS.**
- U.S. EPA's 40 CFR Part 51 Appendix W: http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf
- U.S. EPA's AERMOD Implementation Guide: http://www.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf
- U.S. EPA's AirData: http://www.epa.gov/air/data/index.html
- MPCA's Air Dispersion Modeling: http://www.pca.state.mn.us/nwqh421
- MPCA's Ambient Air Monitoring Network Plan: http://www.pca.state.mn.us/mvri439
- MPCA's Environmental Review: http://www.pca.state.mn.us/xggx692
- USGS' National Map Seamless Viewer (NED data): http://seamless.usgs.gov/website/seamless/viewer.htm

For questions on this form, or data requests from MPCA air dispersion modeling staff, please send an e-mail to: AirModeling.PCA@state.mn.us. Please be sure to include with your questions or requests: the form ID (ADQMP-01), facility name and permit #, and contact information.

Questions can also be asked by calling one of the MPCA's air dispersion modeler's (phone numbers are listed on the MPCA's Air Dispersion Modeling webpage, link above).

***Tip*:** Please be sure to use UTM Coordinates, NAD83, Zone 15 Extended for all locational data.

***Tip*:** For NAAQS modeling, please include the following source groups:

- SO SRCGROUP ALL BACKGROUND
- SO SRCGROUP BKG BACKGROUND
- SO SRCGROUP FAR 1-99999999
- SO SRCGROUP FAC [FAC sources)

**Under-Development by MPCA Staff**:

Procedures and data involving the following subject areas are under-development and therefore, MPCA air dispersion modeling staff should be contacted (via the email address above) to discuss data files, methods, and/or procedures for:

- Standardized Mobile Source (SMS) Spreadsheet
- Background concentration data
- Nearby sources
- Pre-processed AERMET meteorological data files
- Ozone data generated for Tier 3 $NO_2$ modeling

**Acronyms**

| | |
|---|---|
| $\mu g/m^3$ | Micrograms per cubic meter |
| AERMAP | AERMOD Terrain Preprocessor |
| AERMET | AERMOD Meteorological Preprocessor |
| AERMINUTE | AERMOD 1-Minute ASOS Wind Data Processor |
| AERMOD | AMS/EPA Regulatory Model |
| AERSURFACE | AERMOD Surface Characteristic Tool |
| AQ | Air Quality |
| AQDMP-01 | Air Quality Dispersion Modeling Protocol form |
| AQDMPS-01 | Air Quality Dispersion Modeling Protocol Spreadsheet |
| BPIP-PRIME | Building Profile Input Program for PRIME |
| CO | Carbon Monoxide |
| DEM | Digital Elevation Model |
| EAW | Environmental Assessment Worksheet |
| EIS | Environmental Impact Statement |
| EPA | U.S. Environmental Protection Agency |
| FAC | 3-letter facility ID |
| FAR | First-Approximation Representative |
| H1H | High-first-high value |
| H2H | High-second-high value |
| H6H | High-sixth-high value |
| $H_2S$ | Hydrogen Sulfide |
| km | Kilometer |
| LULC | Land Use Land Cover |
| MAAQS | Minnesota State Ambient Air Quality Standard |
| MPCA | Minnesota Pollution Control Agency |
| NAAQS | National Ambient Air Quality Standard |
| NAD | North American Datum of 1983 |
| NED | National Elevation Dataset |
| $NO_2$ | Nitrogen Dioxide |
| NWS | National Weather Service |
| OLM | Ozone Limiting Method |
| Pb | Lead |
| $PM_{10}$ | Particulate Matter less than 10 um in size |
| $PM_{2.5}$ | Particulate Matter less than 2.5 um in size |
| POINTCAP | Capped-release point source (AERMOD beta, non-default) |
| POINTHOR | Horizontal-release point source (AERMOD beta, non-default) |
| PPB | Parts Per Billion |
| PPM | Parts Per Million |
| PRIME | Plume Rise Model Enhancements |
| PSD | Prevention of Significant Deterioration Program |
| PVMRM | Plume Volume Molar Ratio Method |
| SCRAM | Support Center for Regulatory Atmospheric Modeling |
| SIL | Significant Impact Level |
| $SO_2$ | Sulfur Dioxide |
| SIP | State Implementation Plan |
| SMS | Standardized Mobile Source |
| UG/M3 | Micrograms per cubic meter ($\mu g/m^3$) |
| UTM | Universal Transverse Mercator |

## Attachment B - CLASS II MODELING SURFACE METEOROLOGY – Minimum Wind Speed for Modeling

This document contains a proposal to modify the current meteorological data set used in the Class II modeling to change wind speeds below 0.5 m/s to 0 m/s (calm). A proposal to use an alternate meteorological data set was submitted on August 5, 2011. This proposal was rejected by EPA as described in a document distributed via e-mail on November 28, 2011. During discussion of this proposal, EPA indicated that an alternative proposal for treating calm winds would likely be acceptable. This document describes such a proposal submitted on October 28, 2011. EPA has not completed the formal approval process to date, but it is anticipated based on discussion during weekly NorthMet air group meetings that EPA intends to approve this proposal.

**Issue:** The current meteorological data set being used for the Northmet Project Class II Air Dispersion Modeling Analysis is the 2006 – 2010 Hibbing, Minnesota airport surface data set processed using AERMINUTE for the AERMOD dispersion model. AERMINUTE processes an airport's ASOS (Automated Surface Observing System) data (which are two-minute averages stored at one minute intervals) to calculate hourly average meteorological data fields required for AERMOD. The minimum wind speed calculated by AERMINUTE for the Hibbing data set is 0.28 m/s. Our proposal is to revise the data set so the minimum wind speed is 0.5 m/s. This revision will make the AERMINUTE data set consistent with the minimum wind speed required for an on-site meteorological data set (Table 5-2 in Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005).

**Discussion:** The MPCA processed and provided the Hibbing, MN 2006 – 2010 AERMINUTE meteorological data set. We are proposing to substitute all wind speeds in this data set which are less than 0.5 m/s with 0 m/s. AERMOD interprets wind speeds of 0 m/s as calm. AERMOD does not calculate pollutant dispersion for calm hours. This substitution will change 997 hours (2.3% of total) in the data set. There are 43,800 hours in the data set.

The minimum recorded wind speed for an ASOS station is 2 knots (1.02 m/s) . The AERMINUTE program substitutes one-half the reporting limit (1 knot = 0.51 m/s) in its calculation of hourly averages (see excerpt below). The proposed change to the minimum wind speed in the meteorological data set is therefore both consistent with AERMINUTE data usage and the requirements of an on-site meteorological data set.

From Section 3.3 of AERMINUTE User's Instructions

If the record's date is inside the processing date range, the 2-minute average wind speed and direction are processed as:

- If the wind speed is less than 2 knots:
  - If the station is not part of the IFW group, or the station is part of the IFW group and the date and time of the record is before the station's IFW commission date, the 2-minute wind is considered to be "calm" and the wind speed is set to half the instrument threshold, i.e., 0.51 m/s (1 knot), consistent with guidance for processing site-specific wind data. The wind speed will be used in calculating the hourly average wind speed but the direction is considered to be invalid and will not be used in calculating the hourly wind direction.
  - If the station is part of the IFW group and the record's date is on or after the station's IFW commission date, the minute is flagged as non-calm and the speeds are converted from knots to m/s, since the threshold for sonic anemometers is effectively zero. The wind speed and wind direction are used in hourly averages.
- If the wind speed is 2 knots or greater, regardless of IFW group status and date, the 2-minute wind speed is converted from knots to m/s. The wind speed and wind direction are used in hourly averages.

## Attachment C – Non-Default Modeling Options

### I. $PM_{10}$ Particulate Deposition

$PM_{10}$ modeling conducted to date has used the OPENPIT option for the mining pit areas. The OPENPIT option requires particle size data (particle size category, mass fraction, density) as model inputs. The particle size data required by the OPENPIT option are also necessary model inputs for modeling sources including deposition. However, it was noted in preliminary modeling for the NorthMet Draft Environmental Impact Statement (DEIS) that in using the OPENPIT option along with particulate deposition for the remaining sources, the AERMOD model produced results that were not consistent with expected concentration patterns and were therefore unrealistic. Specifically, the model showed maximum concentrations from the pit at far receptors in a bull's eye pattern. Both the OPENPIT algorithm and the particulate deposition algorithm in the model are complex. While the internal calculations of the model are not readily apparent, the inconsistency of the results indicated that the model was not producing reliable results for particulate deposition and OPENPIT sources.

To address this issue, an alternative approach to accounting for particulate deposition was proposed and approved for the DEIS modeling. The same approach will be used for the modeling for the Supplemental Draft Environmental Impact Statement (SDEIS). In this alternative approach, particulate deposition is represented by the Decay Term (D). As stated in the model user's guide: "The Decay Term in Equation (1-1) is a simple method of accounting for pollutant removal by physical or chemical processes."

The decay term is calculated as a half-life as follows:

$$D = \exp [ - \psi \ x / u_s ]$$

Where: $\psi$ = decay coefficient ($s^{-1}$)
$x$ = downwind distance (m)
$u_s$= wind speed (corrected for release height)

and $\psi = 0.693 / T_{1/2}$

$T_{1/2}$ = pollutant half life (s)

Example :
$T_{1/2}$= 900 s
$x$ = 1000 m
$u_s$ = 4 m/s

$$D = \exp [ - (0.693/900) 1000 / 4 ]$$
$$= 0.825$$

In this case, 17.5% of the plume would be removed for a receptor at 1 km distance from the source. The model applies the Decay Term after conducting the other dispersion calculations.

The pollutant half life ($T_{1/2}$) is used to represent the various physical mechanisms which remove particulate mass from the plume. Deposition occurs from gravitational settling, removal by vegetation, particle agglomeration, and other mechanisms. The pollutant half life was estimated using the gravitational settling velocity (Stoke's Law) term as described in the model user's guide, as follows.

$$v_g = (\rho - \rho_{air}) g d_p^2 c_2 / [ 18 \mu ] * S_{CF} \qquad \text{(Equation 1-84)}$$

Where:
- $v_g$ = gravitational settling velocity (cm/s)
- $\rho$ = particle density (g/cm$^3$) = 2.7 for haul roads (crushed ore)
- $\rho_{air}$ = air density (= 1.2 x $10^{-3}$ g/cm$^3$)
- $d_p$ = particle diameter (μm) = 7.4 for mass-mean particle size
- $c_2$ = units conversion constant (1 x $10^{-8}$ cm$^2$/μm$^2$)
- $\mu$ = viscosity of air (1.81 x $10^{-4}$ g/cm/s)
- $S_{CF}$ = slip correction factor (see Equation 1-85; for a 7.4 μm particle $S_{CF}$ = 1.02)
- $g$ = acceleration due to gravity (981 cm/s$^2$

For the particle characteristics given above (7.4 μm diameter, 2.7 g/cm3 density), the gravitational settling term $v_g$ = 0.455 cm/s.

To calculate the pollutant half life, it was assumed that the time required for a 7.4 μm particle to settle from an average release height of 5 m would approximate the time-dependent component of deposition. For a 5 m release height, the settling time is T = 5 m x 100 cm/m / 0.455 cm/s = 1,100 s.

The calculation of pollutant half life and use of the decay coefficient to represent deposition was used in Midwest Research Institute's report prepared for the MPCA entitled: Iron Range Air Quality Analysis (June 1979). The MRI report also provided detailed emission inventories and modeling analysis (including model calibration) which were required for EPA approval of Minnesota's State Implementation Plan (SIP). During the late 1970s, the Iron Range was in nonattainment for TSP, and the 1979 modeling analysis was part of determining the actual attainment status and identifying mitigation measures and future attainment status. An important component of the modeling analysis was to adequately address particulate deposition so that the model results could be directly compared

to monitoring data. To account for particle deposition, the 1979 modeling assumed a particle density of 3 g/cm$^3$, a particle diameter of 12.25 µm, and a release height of 5 m, for a half life of 370 s.

The proposed pollutant half life of 1,100 s is 3 times greater than was assumed in the MRI study, with the greatest difference in the half life resulting from the smaller particle diameter used in this analysis. The 1979 analysis also assumed that particles less than 5 µm did not settle out. For this analysis, we propose to model particles less than 2.5 µm as though they do not deposit. For the mining fugitive dust sources, $PM_{2.5}$ accounts for 10% of the total $PM_{10}$. Therefore, the modeled emission rate will be scaled by a factor of 1.1 to account for the $PM_{2.5}$ portion of the $PM_{10}$ that would not be predicted to settle out.

**Reference:**

Midwest Research Institute, 1979. *Iron Range Air Quality Analysis*. Draft Final Report. MRI Project No. 4532-L(2). June 5, 1979. Prepared for Minnesota Pollution Control Agency.

USEPA, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models. Volume II – Description of Model Algorithms. USEPA – OAQPS. RTP, NC. September 1995.

USEPA, 2004. AERMOD Deposition Algorithms – Science Document (Revised Draft). March 19, 2004. http://www.epa.gov/scram001/dispersion_prefrec.htm#aermod.

**Determination of the mass mean particle diameter of 7.4 µm**

A size distribution curve representative of mechanically generated particulates is shown in Figure 2 on the Particle Size Categories page appended at the end of this discussion or can be accessed at the following website. http://www.epa.gov/air/oaqps/eog/bces/module3/category/category.htm (http://www.epa.gov/eogapti1/module3/category/category.htm).

This Figure 2 shows the frequency % particle by mass for three types of atmospheric particulates (ultrafine, fine, and coarse - supercoarse). The Particle Formation page http://www.epa.gov/air/oaqps/eog/bces/module3/formation/formate.htm (http://www.epa.gov/eogapti1/module3/formation/formate.htm) goes into some detail over the mechanisms associated with formation of the three classes of atmospheric particulates shown in Figure 2. As described on the Particle Formation page, physical attrition (mechanically generated) particles are shown to be primarily greater than $PM_{10}$ and correspond to the coarse - supercoarse curve on Figure 2.

The mass mean particle diameter used in the proposed decay coefficient reflects mechanically generated particulate. EPA's size spectrum shown in Figure 2 was used to apportion the particulate matter between 3 and 10 microns and develop the mass mean particle diameter. Figure 2 is generic in that it is representative of atmospheric particulates and is not specific to any industry or source type. Using Figure 2 for this calculation was recommended by MPCA on a previous project. Interpolation of the coarse - supercoarse curve for the coarse particle size range (between 2.5 and 10 microns which is representative of the fugitive $PM_{10}$ modeling) of Figure 2 leads to a mass mean diameter of 7.4 microns as shown below in Table 1 and Figures 3 and 4:

**Table 1 – $PM_{10}$ Mass Percent from EPA Figure 2**

| Particle Size | Frequency % Particles by Mass [1] | Normalized Mass % | Cumulative Normalized Mass % |
|---|---|---|---|
| 3 | 0.6 | 2.7% | 2.7% |
| 4 | 1.2 | 5.3% | 8.0% |
| 5 | 1.8 | 8.0% | 16.0% |
| 6 | 2.7 | 12.0% | 28.0% |
| 7 | 3.4 | 15.1% | 43.1% |
| 8 | 3.8 | 16.9% | 60.0% |
| 9 | 4 | 17.8% | 77.8% |
| 10 | 5 | 22.2% | 100.0% |

Figure 3 shows the cumulative mass % (normalized to 100%) derived from EPA's Figure 2. Note that Figure 3 did not use a mathematical representation of EPA's Figure 2 as one was not provided in EPA's references. Instead, Figure 3 was obtained by selecting the particle size and reading the mass % off of the Y-axis in Figure 2. The total mass % was normalized to 100% as shown in Table 1 above. Figure 4 shows the linear interpolation for the cumulative mass percent between the 7 and 8 μm particle sizes in Figure 3. As shown in Figure 4, the 50% cumulative mass percent intersects the 7.4 μm particle size.

[1] Interpolated from Figure 2 for the midpoint of the category (e.g., 10 micron frequency % is midpoint between 9 and 10 microns).

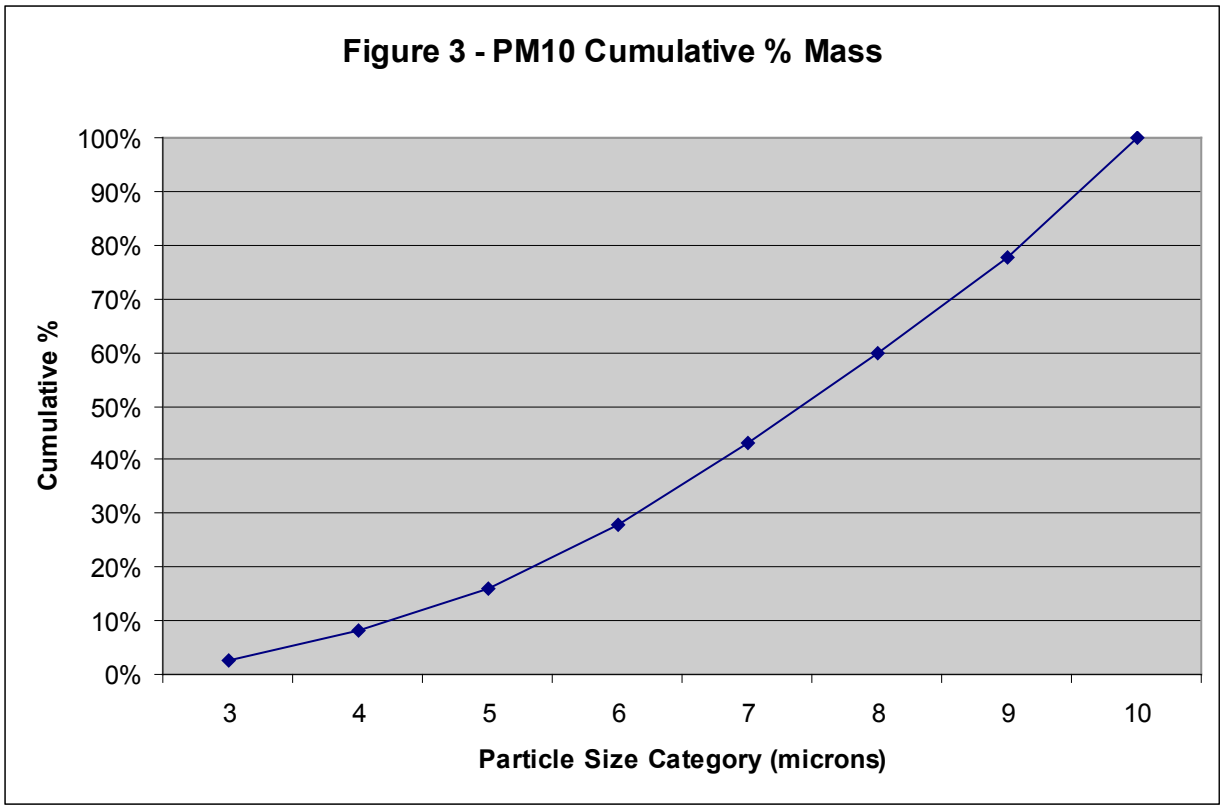



Figure 3 is derived from EPA's Figure 2 for the coarse particle size distribution curve.

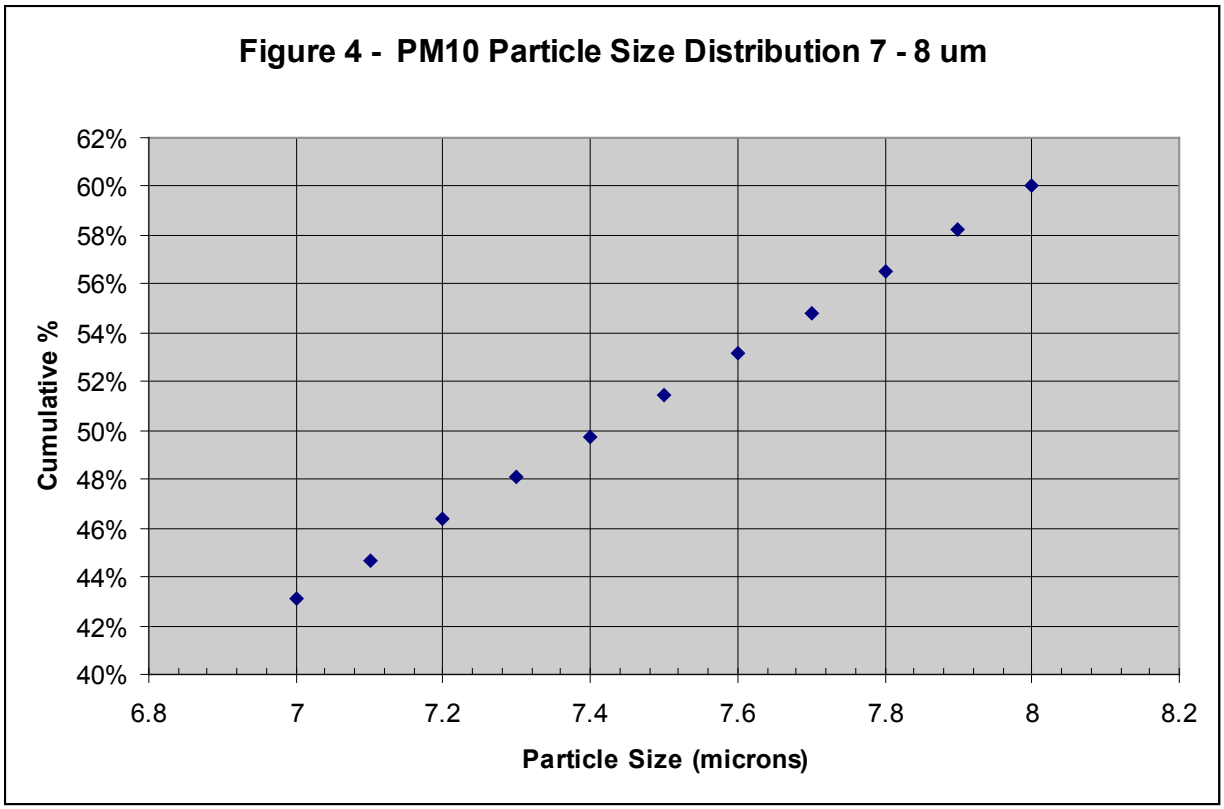



Figure 4 shows the linear interpolation between the 7 and 8 µm particle size categories from Figure 3 to determine the 7.4 µm mass mean particle size.

# Basic Concepts in Environmental Sciences

# Module 3: Characteristics of Particles - Particle Size Categories

**EPA Particle Size Terminology**

Since the range of particle sizes of concern for air emission evaluation is quite broad it is beneficial to divide this range into smaller categories. Defining different size categories is useful since particles of different sizes behave differently in the atmosphere and the respiratory system.

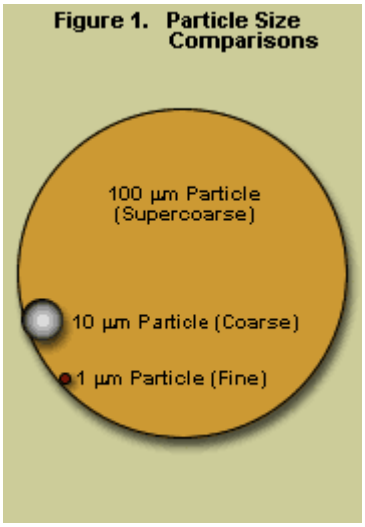
The EPA has defined four terms for categorizing particles of different sizes. Table 1 displays the EPA terminology along with the corresponding particle sizes.

**Table 1. EPA Terminology for Particle Sizes**

| EPA Description | Particle Size |
|---|---|
| Supercoarse | $d_{pa} > 10\ \mu m$ |
| Coarse | $2.5\ \mu m < d_{pa} \leq 10\ \mu m$ |
| Fine | $0.1\ \mu m < d_{pa} \leq 2.5\ \mu m$ |
| Ultrafine | $d_{pa} \leq 0.1\ \mu m$ |

Figure 1 provides a visual comparison of the size of a fine particle (1.0 $\mu m$), coarse particle (10 $\mu m$), and a supercoarse particle (100 $\mu m$). There is a substantial difference in size between these particles, all of which are considered moderate-to-large in air pollution control.

**Figure 1. Particle Size Comparisons**



**Regulated Particulate Matter Categories**

In addition to the terminology provided in Table 1 the EPA also categorizes particles as follows:

Total Suspended Particulate Matter (TSP)

$PM_{10}$

$PM_{2.5}$

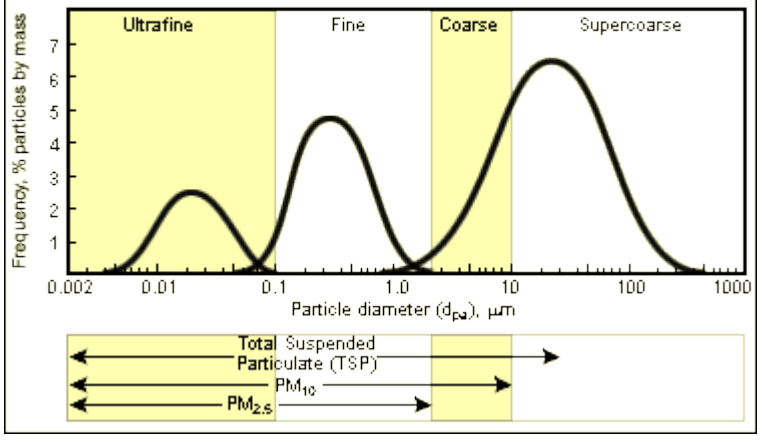
Particles less than 0.1 μm

Condensable Particulate Matter

These particle categories are important because particulate matter is regulated and tested for under these categories. The National Ambient Air Quality Standard for $PM_{2.5}$ was remanded by a District of Columbia court in May of 1999 and is under litigation as of the writing of these modules (December 1999). Air quality standards are presented in these modules as they were promulgated by the EPA, with no presumptions made regarding the outcome of the pending litigation.

Figure 2 displays a typical size distribution of atmospheric particulate matter that combines the two classification schemes discussed above.

**Figure 2. Ambient Particulate Matter Size Distributions**



**Total Suspended Particulate Matter**

Particles ranging in size from 0.1 micrometer to about 30 micrometer in diameter are referred to as **total suspended particulate matter (TSP)**. TSP includes a broad range of particle sizes including fine, coarse, and supercoarse particles.

---

**$PM_{10}$**

The U.S. EPA defines $PM_{10}$ as particulate matter with a diameter of 10 micrometers collected with 50% efficiency by a $PM_{10}$ sampling collection device. However, for convenience in these modules, the term $PM_{10}$ will be used to include all particles having an aerodynamic diameter of less than or equal to 10 micrometers.

$PM_{10}$ is regulated as a specific type of "pollutant" because this size range is considered respirable. In other words, particles less than approximately 10 micrometers can penetrate into the lower respiratory tract. The particle size range between 0.1 and 10 micrometers is especially important in air pollution studies. A major fraction of the particulate matter generated in some industrial sources is in this size range. $PM_{10}$ is discussed in more detail in Module 6.

## Attachment C – Non-Default Modeling Options

### II. $PM_{10}$ Half-Life Modeling Analysis

The AERMOD model is setup that when the half-life option is selected it is applied to every source in the input file and does not allow the user to specify which sources it can be applied to (similar to the urban source option). The purpose of modeling $PM_{10}$ with half-life is to account for the deposition of particulate matter from mechanically generated fugitive dust sources. There are currently four sources included in the Mine Site modeling analysis that are not considered mechanically generated. They are the emergency generator stacks (SV326, SV337), the lime silo (SV425), and the Wastewater Treatment Facility space heater (WWTSH). In order to model all of the $PM_{10}$ Mine Site sources together, the LAKES AERMOD-View Multi-Chem utility will be used to combine the post-files of the mechanically generated half-life sources and the non-half-life sources together by each hour and receptor to determined the combined 24 hour and annual $PM_{10}$ NAAQS and Increment concentration results.

The LAKES Multi-Chem utility allows the user to model multiple emission rates for the same input file by splitting out a single AERMOD input file into individual source, unitized model runs. Each source is modeled individually at 1 g/s with an output plot file and post file for the maximum 1hour concentration. Multi-Chem then post-processes the individual source files, combining them together by hour and receptor and multiplying each source's individual concentration results by an emission rate specified in a text file input to the software. Using this utility creates a significant amount of data files due to a post file created for every individual source. Since the format of the post-files is the same whether for a single source or a combination of sources, PolyMet is proposing to use the Multi-Chem post-processing capabilities, but not for individual source, unitized post file runs.

The $PM_{10}$ modeling for the Mine Site will be divided into two separate modeling files. The first file will model the non-half life sources listed in the paragraph above in regulatory default mode using the hourly $PM_{10}$ emission rates calculated in the emission inventory. The input file will be setup to model the 1 hour concentration and output the maximum 1 hour high $1^{st}$ high concentration plot file and post file. The second file will model the mechanically generated fugitive dust sources using the half-life option using the hourly $PM_{10}$ emission rates calculated in the emission inventory multiplied by 1.1 to account for the 10% of the $PM_{10}$ that is made up of $PM_{2.5}$ and is not subject to deposition. The output will be the maximum 1 hour high $1^{st}$ high concentration plot file and post file similar to the first input file. Using the Multi-Chem post-processing utility, these post files will be combined

on an hour by hour basis for each receptor. Because the actual modeled hourly $PM_{10}$ emission rates will be accounted for in the post files, the emission rate text file that is required for the Multi-Chem utility will list the emission rates for the two post-files as 1 g/s. In this way, the half-life and non-half-life sources will be combined in time and space and the 24 hour $PM_{10}$ high $2^{nd}$ high plot file can be produced for determining the Increment results and the high $1^{st}$ high through high $6^{th}$ high plot files can be produced for determining the NAAQS results. Using this method provides the option of modeling half-life for specific sources without the necessity of creating individual input files and an overwhelming number of post files.

## Attachment C – Non-Default Modeling Options

### III. $PM_{2.5}$ Secondary Formation

This section describes the proposed 24-hour $PM_{2.5}$ NAAQS modeling methodology to account for secondary formation of $PM_{2.5}$ due to the space heater and emergency generator combustion sources. The modeling analysis will use the off-set ratio method described in the National Association of Clean Air Agencies (NACAA) Report[2] published January 7, 2011. The method multiplies the direct $PM_{2.5}$ emissions of combustion sources with an offset ratio to reflect the $PM_{2.5}$ created from secondary formation. The offset ratio represents the amount of $NO_X$ or $SO_2$ that contributes to $PM_{2.5}$ concentrations through secondary formation. This value is called the total equivalent primary $PM_{2.5}$ emission rate. The equation (Primary $PM_{2.5}$ [TPY] + [$SO_2$ TPY]/15 + [$NO_X$ TPY]/77) was used to calculate the total equivalent $PM_{2.5}$ emission rates for each of the combustion sources.

The combustion sources used the hourly $SO_2$ and $NO_X$ emission rates converted to TPY to calculate the total equivalent $PM_{2.5}$ emissions. The offset ratios for $NO_X$ and $SO_2$ used in this equation are from the NAACA document and were developed in that report for a source located in Northern Minnesota.

The majority of $PM_{2.5}$ emissions at the Mine Site are mechanically generated; the three combustion sources make up only 0.4% of the total direct $PM_{2.5}$ emissions. Therefore, secondary particulate formation is not expected to contribute significantly to the maximum modeled $PM_{2.5}$ concentration.

[2] "$PM_{2.5}$ Modeling Implementation for Projects Subject to National Ambient Air Quality Demonstration Requirements Pursuant to New Source Review", NACAA $PM_{2.5}$ Modeling Implementation Workgroup

## Attachment H – $PM_{2.5}$ and $PM_{10}$ SIL Analysis

Based on previous discussions and agreement with MPCA, the nearby sources of concern for cumulative $PM_{2.5}$ and $PM_{10}$ modeling are: 1) the Northshore Mining Peter Mitchell Mine, 2)Mesabi Nugget, and the activities at the former LTVSMC site that will remain under the control of Cliff Erie, referred to as the Cliffs Erie Pellet Yard. Additional information on these facilities is provided in Attachment J.

To provide support for the selected nearby facilities, and to provide additional information for the protocol, Significant Impact Level (SIL) runs were completed for $PM_{2.5}$ and $PM_{10}$ with a receptor grid that extended out to 15 kilometers from the property boundary for the Mine Site. As expected, the results are above the SIL for both pollutants and the maximum impacts occur at the property boundary. The modeled concentration also declines rapidly as the distance from the property boundary increases. This was expected because about 99% of the direct $PM_{2.5}$ and $PM_{10}$ emissions are from mechanically generated fugitive emission sources, which typically produce maximum modeled concentrations close to the emission source.

### $PM_{2.5}$ SIL Modeling Results

Figures 2 and 3 present the results of the SIL runs for $PM_{2.5}$ for the 24-hour and annual averaging periods respectively. Figure 3 shows that the annual concentration is below the SIL at 15 km. Figure 2 shows that the 24-hour concentration drops below 2 $\mu g/m^3$ at 15 kilometers, compared to a result of 10.2 $\mu g/m^3$ at the boundary. The concentration is below the SIL within 15 kilometers to the north, towards the Northshore facility. Results are above the SIL to the west of the Plant Site, but the Mine Site impacts will be included in the cumulative modeling completed separately for the Plant Site on the Plant Site receptor grid. Therefore, the combined impacts of the Mine Site with the nearby sources will be evaluated beyond the SIL receptor grid shown. Furthermore, the Mesabi Nugget EIS cumulative $PM_{10}$ and $PM_{2.5}$ modeling completed in 2009 included the PolyMet Mine Site and demonstrated that the PolyMet Mine Site had no significant impacts at its maximum modeled concentrations.

There are no additional facilities proposed for inclusion in the cumulative analysis to the south and southeast of the Mine Site, where impacts are the greatest at the limit of the 15 kilometer radius. There are also no large nearby emission sources to the south or southeast of the Mine Site. Based on these factors and the nature of the sources at the Mine Site, it is not necessary to extend the receptor grid beyond 15km. Expanding the receptor grid further could greatly increase model run times without providing additional useful information.

### $PM_{10}$ SIL Modeling Results

Figures 4 and 5 show the results of the $PM_{10}$ SIL modeling for the 24-hour and annual averaging periods respectively. As can be seen in the figures the $PM_{10}$ concentration drops below the SIL near the facility boundary for both averaging periods.

### Proposed Receptor Grid

The proposed Class II Cumulative NAAQS and Increment mine site receptor grid for the $PM_{2.5}$ and $PM_{10}$ modeling as discussed in Section F of the AQDMP-01 Form assumes a 100 meter space grid around the ambient air boundary with a 25 meter spaced area south of the unloading area where initial modeling showed maximum impacts. From the boundary out to 1km the receptors are spaced 100 meters, except in the area of maximum impacts, which was spaced at 50 meters. From 1 km out to 5 km the receptors were spaced every 500 meters. From 5km to the maximum extent of the grid, 15km, the receptors were spaced every kilometer. Source groups will be utilized in the modeling analysis to ignore impacts from a nearby facility on receptors located within their ambient air boundary. The extent of the receptor grid is basically the same as that used in the SIL analysis (15km) with the exception of extending the edge so it is a complete rectangle.

**Attachment J - NorthMet Nearby Source Emission Description**
March 14, 2012

This document briefly describes the emission data and model setup that will be used for sources adjacent to the NorthMet Project (Project) Mine Site and Plant Site locations.

The specific sources described in this write-up are the Mesabi Nugget and Cliffs Erie, LLC (Cliffs Erie) facilities near Hoyt Lakes, Minnesota and the Northshore Mining Peter Mitchell Mine near Babbitt, Minnesota. These facilities require a more detailed representation in the cumulative impacts modeling to be completed for the Project due to their close proximity to the Project site and inclusion in previous scoping discussions and impacts assessments for the Project.

**Mesabi Nugget:**

The Mesabi Nugget Project includes two phases referred to as Phase I or the Large Scale Demonstration Plant and Phase II or the Mesabi Mining project. Phase I has been fully permitted and has commenced operations. The environmental review and permitting process has begun for Phase II, but an air emission permit has not been issued to date.

The Mesabi Nugget Phase I Nugget Plant and Phase II Mining operations will both be modeled explicitly as nearby NAAQS and Increment sources for the Plant Site cumulative analysis. In May 2009, a Class II Air Dispersion Modeling Report was submitted for the Mesabi Nugget Phase II Environmental Impact Statement (EIS) containing the modeling analysis for the $PM_{10}$ and $PM_{2.5}$ NAAQS and the $PM_{10}$ Increment. MPCA and Barr modeling staff have verified that Barr possesses the modeling files most recently submitted by the project proposer. These modeling files will be used to model Mesabi Nugget Phase II in the Project modeling. MPCA has the modeling files and emission inventory for this project, so additional documentation will not be provided to support the Project modeling.

The Mesabi Phase I Nugget Plant was permitted in 2005 for the criteria pollutants $PM_{10}$, $SO_2$, $NO_X$, CO, and lead. In October 2009, a permit amendment was completed to update the $PM_{10}$ and $PM_{2.5}$ emissions to include additional concentrate delivery traffic on the main entrance paved road. The updated modeling was approved for the $PM_{10}$ and $PM_{2.5}$ NAAQS and $PM_{10}$ increment. PolyMet has requested the October 2009 $PM_{10}/PM_{2.5}$ modeling files from MPCA for explicitly modeling the Phase I Nugget plant with the Plant Site cumulative EIS analysis. The $SO_2$ and $NO_X$ emissions from the May 2005 permit will be used for the other criteria pollutant modeling for the Plant Site using the modeled stack parameters from the October 2009 modeling.

**Cliffs Erie:**
Cliffs Erie owns the former LTV Steel Mining Company (LTVSMC) taconite mine and processing plant near Hoyt Lakes, Minnesota. The site is now operating under mitigation, reclamation and closure conditions, which include minimal emission generating activities, in comparison to when it was operated as a taconite facility. Many of the emission units and associated land remaining from the LTVSMC operation have been purchased by PolyMet and are proposed to become part of the Project. A notable exception is the LTVSMC pellet plant which has been demolished.

Cliffs Erie has maintained the air emission permit for the site since they acquired it. The permit was reissued on December 14, 2011 as Air Emission Permit No. 13700009-006.

This facility will be included in the cumulative NAAQS evaluation for the Project. The facility was in operation at the baseline date, so it does not consume increment and will not be included in the increment assessment.

MPCA has provided a copy of the emission inventory submitted in support of the re-issuance application to PolyMet for use in cumulative impact modeling for the Project. In comments received on version 1 of the standalone write-up on nearby sources, MPCA identified sources to be removed from the inventory. The general procedure proposed for modeling this facility is to identify which sources in the current Cliffs Erie permit would have the potential to continue operations, under Cliffs Erie control, after the commencement of operations of the Project. The emissions that will remain under Cliffs Erie control are all fugitive in nature, and therefore are not assigned to specific stacks or vents. A volume source will be configured, centered around the Cliffs Erie Pellet Yard, and emissions from all activities identified as continuing to operate after Project operation commences will be assigned to this volume source. Table 1 below summarized the sources in the re-issued Cliffs Erie permit, their anticipated future status, and how they are proposed to be treated in the Project impact assessment.

**Table 1 - Proposed Modeling of Sources in Draft Cliffs Erie Permit**

| Source ID | Source Name | Future Status[1] | Proposed Treatment in Modeling |
|---|---|---|---|
| FS 009 | Pellets, Load | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 010 | Tailings, Load | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 011 | Tailings, Unload | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 014 | Waste Rock, Truck Load | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 015 | Waste Rock, Truck Unload | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 016 | Tailings, Road Dust | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 017 | Waste Rock, Road Dust | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 020 | Pellets, Storage Pile | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 021 | Tailings, Storage Pile | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 022 | Waste Rock, Storage Pile | May be operated by Cliffs Erie | Include in Cliffs Erie facility |

[1] Anticipated status of the source after commencement of Project operations.

| Source ID | Source Name | Future Status[1] | Proposed Treatment in Modeling |
|---|---|---|---|
| FS 032 | Tailings, Tailings Basin | Transferred to PolyMet | Tailings Basin Modeled with Project |
| EU 148 | Administrative Building Boiler 2 | Transferred to PolyMet | Modeled with Project |
| EU 149 | Administrative Building Boiler 3 | Transferred to PolyMet | Modeled with Project |

Further details on the sources and emissions are provided in an attached Excel spreadsheet titled "NorthMet Nearby Source Model Inputs ver 2".

This spreadsheet also includes the parameters for the volume source that will be used to represent the emission points at the Cliffs Erie facility in the Project modeling. It should be noted that the model configuration described here and represented in the spreadsheet will be used in initial modeling runs. If the preliminary results appear to show excessive impacts from the Cliffs Erie facility, a more refined modeling setup for the facility may be proposed in a subsequent submittal.

**Northshore Peter Mitchell Mine:**

The Northshore Mining Company Peter Mitchell Mine operates under Air Emission Permit No. 13700032-001. This facility will be included in the cumulative NAAQS evaluation for the Project. The facility was in operation at the baseline date, so it does not consume increment and will not be included in the increment assessment.

Emission rates were taken from this permit for the relevant emission sources. These sources are listed in the table below:

**Table 2 – Northshore Emission Sources to be Modeled**

| Source ID | Source Name | Source Type |
|---|---|---|
| EU 001 | Shop Boiler 1 | Point |
| EU 002 | Shop Boiler 2 | Point |
| EU 003 | Shop Boiler 3 | Point |
| EU 004 | Shop Boiler 4 | Point |
| EU 005 | Crusher 1, Primary and Secondary | Point |
| EU 009 | Portable Aggregate Crusher | Point |
| EU 010 | Ore Loadout at Crusher 1 | Volume |
| All FS | Fugitive Sources | Volume |

The emission rates for the relevant pollutants and the modeling parameters for each source are shown in the attached Excel spreadsheet titled "NorthMet Nearby Source Model Inputs ver 1". $PM_{2.5}$ emissions are not included in the Northshore mine permit. For initial modeling runs, $PM_{2.5}$ will be assumed equal to $PM_{10}$. Additional analysis may be performed if initial results do not show compliance with the NAAQS.

**Attachment K – Anticipated Outputs (OU Pathway)**

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| SIL | $NO_2$ | 1-hour | ALLAVE 1ST | 01H1HNO2SILOLM.PLT |
| | | Annual | ALLAVE | ANNNO2SIL06.PLT<br>ANNNO2SIL07.PLT<br>ANNNO2SIL08.PLT<br>ANNNO2SIL09.PLT<br>ANNNO2SIL10.PLT |
| SIL | $SO_2$ | 1-hour | ALLAVE 1ST | 01H1HSO2SIL06.PLT<br>01H1HSO2SIL07.PLT<br>01H1HSO2SIL08.PLT<br>01H1HSO2SIL09.PLT<br>01H1HSO2SIL010.PLT |
| | | 3-hour | ALLAVE 1ST | 03H1HSO2SIL06.PLT<br>03H1HSO2SIL07.PLT<br>03H1HSO2SIL08.PLT<br>03H1HSO2SIL09.PLT<br>03H1HSO2SIL10.PLT |
| | | 24-hour | ALLAVE 1ST | 24H1HSO2SIL06.PLT<br>24H1HSO2SIL07.PLT<br>24H1HSO2SIL08.PLT<br>24H1HSO2SIL09.PLT<br>24H1HSO2SIL10.PLT |
| | | Annual | ALLAVE | ANNNO2SIL06.PLT<br>ANNNO2SIL07.PLT<br>ANNNO2SIL08.PLT<br>ANNNO2SIL09.PLT<br>ANNNO2SIL10.PLT |
| SIL | $PM_{10}$ | 24-hour | ALLAVE 1ST | 24H1HPM10y8SIL06.plt<br>24H1HPM10y8SIL07.plt<br>24H1HPM10y8SIL08.plt<br>24H1HPM10y8SIL09.plt<br>24H1HPM10y8SIL10.plt<br>24H1HPM10y13SIL06.plt<br>24H1HPM10y13SIL07.plt<br>24H1HPM10y13SIL08.plt<br>24H1HPM10y13SIL09.plt<br>24H1HPM10y13SIL10.plt |
| | | Annual | ALLAVE | ANNPM10SILy806.plt<br>ANNPM10SILy807.plt<br>ANNPM10SILy808.plt<br>ANNPM10SILy809.plt<br>ANNPM10SILy810.plt<br>ANNPM10SILy1306.plt<br>ANNPM10SILy1307.plt<br>ANNPM10SILy1308.plt<br>ANNPM10SILy1309.plt<br>ANNPM10SILy1310.plt |

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| INCREMENT | $PM_{10}$ | 24-hour | ALLAVE 2ND | 24H2HPM10y8INC06.plt<br>24H2HPM10y8INC07.plt<br>24H2HPM10y8INC08.plt<br>24H2HPM10y8INC09.plt<br>24H2HPM10y8INC10.plt<br>24H2HPM10y13INC06.plt<br>24H2HPM10y13INC07.plt<br>24H2HPM10y13INC08.plt<br>24H2HPM10y13INC09.plt<br>24H2HPM10y13INC10.plt<br>24H2HPM10y8NoMNINC06.plt<br>24H2HPM10y8NoMNINC07.plt<br>24H2HPM10y8NoMNINC08.plt<br>24H2HPM10y8NoMNINC09.plt<br>24H2HPM10y8INoMNNC10.plt<br>24H2HPM10y13NoMNINC06.plt<br>24H2HPM10y13NoMNINC07.plt<br>24H2HPM10y13NoMNINC08.plt<br>24H2HPM10y13NoMNINC09.plt<br>24H2HPM10y13NoMNINC10.plt<br>24H2HPM10y8NoPMPINC06.plt<br>24H2HPM10y8NoPMPINC07.plt<br>24H2HPM10y8NoPMPINC08.plt<br>24H2HPM10y8NoPMPINC09.plt<br>24H2HPM10y8NoPMPINC10.plt<br>24H2HPM10y13NoPMPINC06.plt<br>24H2HPM10y13NoPMPINC07.plt<br>24H2HPM10y13NoPMPINC08.plt<br>24H2HPM10y13NoPMPINC09.plt<br>24H2HPM10y13NoPMPINC10.plt |
| | | Annual | ALLAVE | ANNPM10INCy806.plt<br>ANNPM10INCy807.plt<br>ANNPM10INCy808.plt<br>ANNPM10INCy809.plt<br>ANNPM10INCy810.plt<br>ANNPM10INCy1306.plt<br>ANNPM10INCy1307.plt<br>ANNPM10INCy1308.plt<br>ANNPM10INCy1309.plt<br>ANNPM10INCy1310.plt<br>ANNPM10INCNoMNy806.plt<br>ANNPM10INCNoMNy807.plt<br>ANNPM10INCNoMNy808.plt<br>ANNPM10INCNoMNy809.plt<br>ANNPM10INCNoMNy810.plt<br>ANNPM10INCNoMNy1306.plt<br>ANNPM10INCNoMNy1307.plt<br>ANNPM10INCNoMNy1308.plt |

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| | | | | ANNPM10INCNoMNy1309.plt<br>ANNPM10INCNoMNy1310.plt<br>ANNPM10INCNoPMPy806.plt<br>ANNPM10INCNoPMPy807.plt<br>ANNPM10INCNoPMPy808.plt<br>ANNPM10INCNoPMPy809.plt<br>ANNPM10INCNoPMPy810.plt<br>ANNPM10INCNoPMPy1306.plt<br>ANNPM10INCNoPMPy1307.plt<br>ANNPM10INCNoPMPy1308.plt<br>ANNPM10INCNoPMPy1309.plt<br>ANNPM10INCNoPMPy1310.plt |
| NAAQS | $PM_{10}$ | 24-hour | ALLAVE 1ST–6TH | 24H1HPM10y8NQS06.plt [1]<br>24H1HPM10y8NQS07.plt [1]<br>24H1HPM10y8NQS08.plt [1]<br>24H1HPM10y8NQS09.plt [1]<br>24H1HPM10y8NQS10.plt [1]<br>24H1HPM10y13NQS06.plt [1]<br>24H1HPM10y13NQS07.plt [1]<br>24H1HPM10y13NQS08.plt [1]<br>24H1HPM10y13NQS09.plt [1]<br>24H1HPM10y13NQS10.plt [1]<br>24H2HPM10y8NQS06.plt [1]<br>24H2HPM10y8NQS07.plt [1]<br>24H2HPM10y8NQS08.plt [1]<br>24H2HPM10y8NQS09.plt [1]<br>24H2HPM10y8NQS10.plt [1]<br>24H2HPM10y13NQS06.plt [1]<br>24H2HPM10y13NQS07.plt [1]<br>24H2HPM10y13NQS08.plt [1]<br>24H2HPM10y13NQS09.plt [1]<br>24H2HPM10y13NQS10.plt [1]<br>24H3HPM10y8NQS06.plt [1]<br>24H3HPM10y8NQS07.plt [1]<br>24H3HPM10y8NQS08.plt [1]<br>24H3HPM10y8NQS09.plt [1]<br>24H3HPM10y8NQS10.plt [1]<br>24H3HPM10y13NQS06.plt [1]<br>24H3HPM10y13NQS07.plt [1]<br>24H3HPM10y13NQS08.plt [1]<br>24H3HPM10y13NQS09.plt [1]<br>24H3HPM10y13NQS10.plt [1]<br>24H4HPM10y8NQS06.plt [1]<br>24H4HPM10y8NQS07.plt [1]<br>24H4HPM10y8NQS08.plt [1]<br>24H4HPM10y8NQS09.plt [1]<br>24H4HPM10y8NQS10.plt [1]<br>24H4HPM10y13NQS06.plt [1] |

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| | | | | 24H4HPM10y13NQS07.plt [1]<br>24H4HPM10y13NQS08.plt [1]<br>24H4HPM10y13NQS09.plt [1]<br>24H4HPM10y13NQS10.plt [1]<br>24H5HPM10y8NQS06.plt [1]<br>24H5HPM10y8NQS07.plt [1]<br>24H5HPM10y8NQS08.plt [1]<br>24H5HPM10y8NQS09.plt [1]<br>24H5HPM10y8NQS10.plt [1]<br>24H5HPM10y13NQS06.plt [1]<br>24H5HPM10y13NQS07.plt [1]<br>24H5HPM10y13NQS08.plt [1]<br>24H5HPM10y13NQS09.plt [1]<br>24H5HPM10y13NQS10.plt [1]<br>24H6HPM10y8NQS06.plt [1]<br>24H6HPM10y8NQS07.plt [1]<br>24H6HPM10y8NQS08.plt [1]<br>24H6HPM10y8NQS09.plt [1]<br>24H6HPM10y8NQS10.plt [1]<br>24H6HPM10y13NQS06.plt [1]<br>24H6HPM10y13NQS07.plt [1]<br>24H6HPM10y13NQS08.plt [1]<br>24H6HPM10y13NQS09.plt [1]<br>24H6HPM10y13NQS10.plt [1] |
| | | Annual | ALLAVE | ANNPM10NQSy806.plt [1]<br>ANNPM10NQSy807.plt [1]<br>ANNPM10NQSy808.plt [1]<br>ANNPM10NQSy809.plt [1]<br>ANNPM10NQSy810.plt [1]<br>ANNPM10NQSy1306.plt [1]<br>ANNPM10NQSy1307.plt [1]<br>ANNPM10NQSy1308.plt [1]<br>ANNPM10NQSy1309.plt [1]<br>ANNPM10NQSy1310.plt [1] |
| SIL | $PM_{2.5}$ | 24-hour | ALLAVE 1ST | 24H1HPM25SILy806.PLT<br>24H1HPM25SILy807.PLT<br>24H1HPM25SILy808.PLT<br>24H1HPM25SILy809.PLT<br>24H1HPM25SILy810.PLT<br>24H1HPM25SILy1306.PLT<br>24H1HPM25SILy1307.PLT<br>24H1HPM25SILy1308.PLT<br>24H1HPM25SILy1309.PLT<br>24H1HPM25SILy1310.PLT |
| | | Annual | ALLAVE | ANNPM25SILy806.PLT<br>ANNPM25SILy807.PLT<br>ANNPM25SILy808.PLT<br>ANNPM25SILy809.PLT |

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| | | | | ANNPM25SILy810.PLT<br>ANNPM25SILy1306.PLT<br>ANNPM25SILy1307.PLT<br>ANNPM25SILy1308.PLT<br>ANNPM25SILy1309.PLT<br>ANNPM25SILy1310.PLT |
| NAAQS | $PM_{2.5}$ | 24-hour | ALLAVE 8TH | 24H8HPM25y8NQS06.plt [1]<br>24H8HPM25y8NQS07.plt [1]<br>24H8HPM25y8NQS08.plt [1]<br>24H8HPM25y8NQS09.plt [1]<br>24H8HPM25y8NQS10.plt [1]<br>24H8HPM25y13NQS06.plt [1]<br>24H8HPM25y13NQS07.plt [1]<br>24H8HPM25y13NQS08.plt [1]<br>24H8HPM25y13NQS09.plt [1]<br>24H8HPM25y13NQS10.plt [1] |
| | | Annual | ALLAVE | ANNPM25NQSy806.plt [1]<br>ANNPM25NQSy807.plt [1]<br>ANNPM25NQSy808.plt [1]<br>ANNPM25NQSy809.plt [1]<br>ANNPM25NQSy810.plt [1]<br>ANNPM25NQSy1306.plt [1]<br>ANNPM25NQSy1307.plt [1]<br>ANNPM25NQSy1308.plt [1]<br>ANNPM25NQSy1309.plt [1]<br>ANNPM25NQSy1310.plt [1] |

[1] Each of these plot files will be created for the source groups modeled. They are (ALL, NoPMP, NoMN, NoNSM).

Barr Footer: ArcGIS 10.0, 2012-01-17 11:16 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_1_PolyMet_MineSite_SIL_Receptors.mxd User: jjm




Figure 1

SIGNIFICANT IMPACT ANALYSIS
RECEPTOR GRID
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-17 11:20 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_2_PolyMet_MineSite_24hourPM25SIL_Results.mxd User: jjm

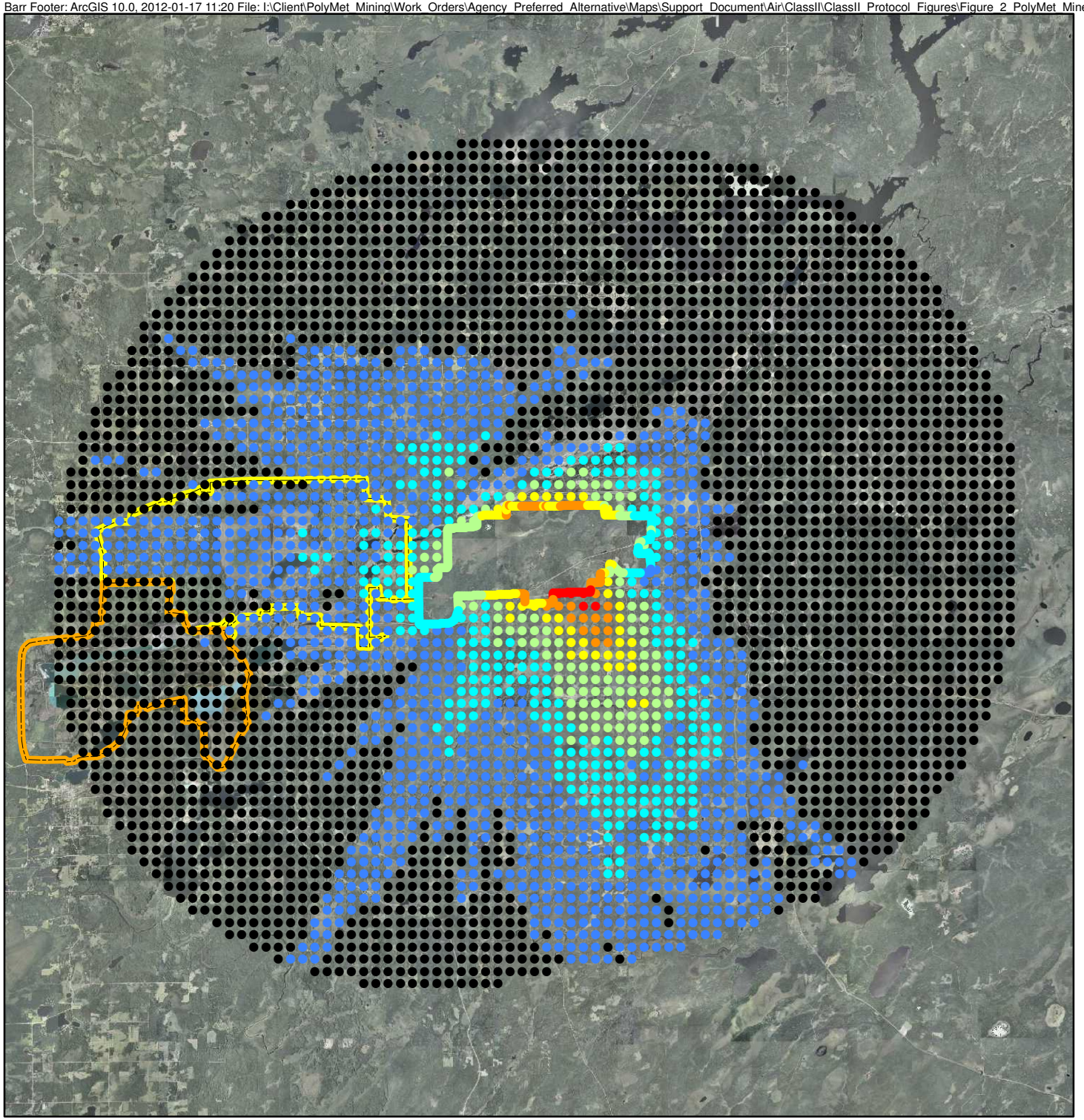
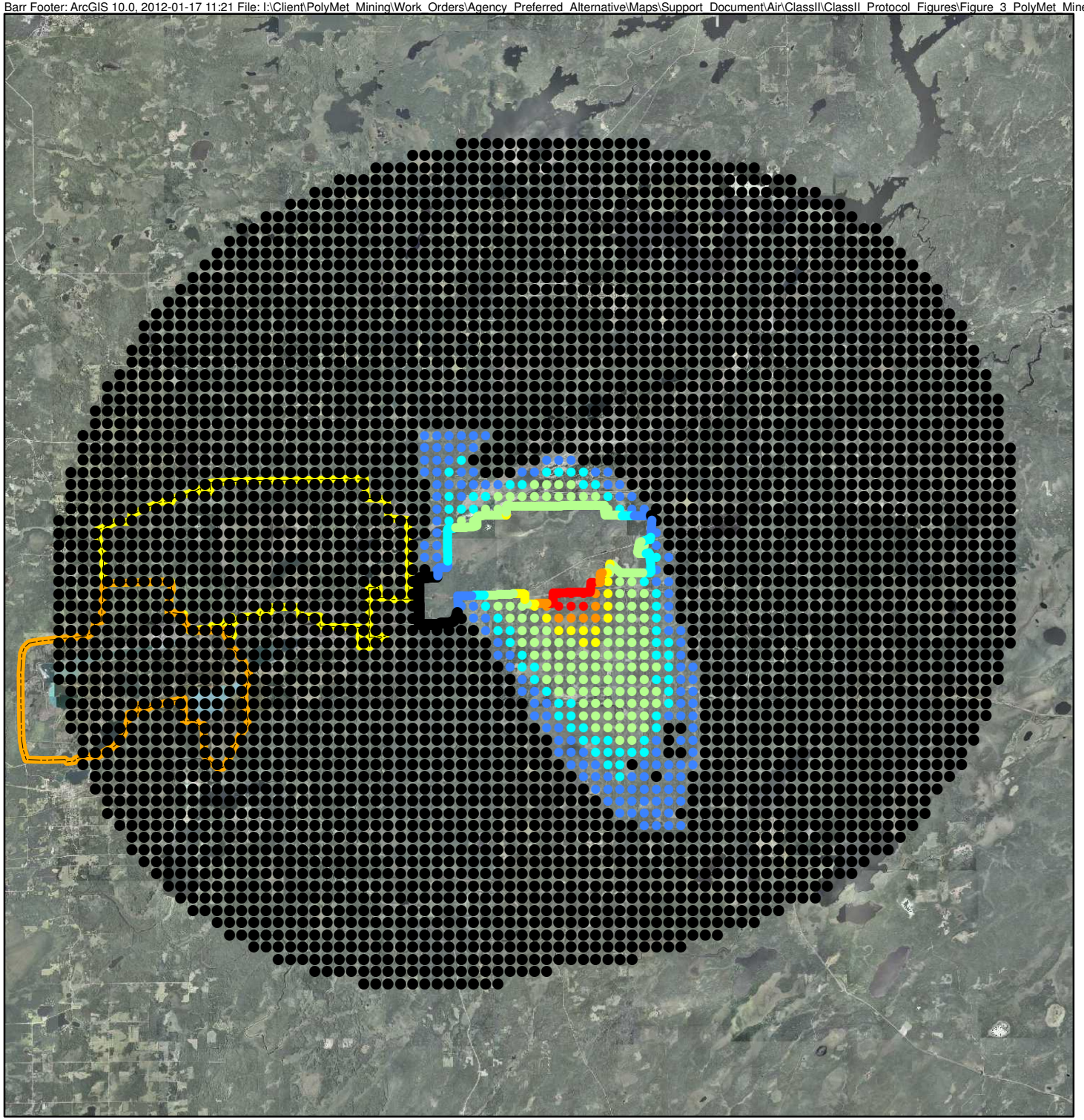



Figure 2

24 HOUR PM2.5 SIL RESULTS
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-17 11:21 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_3_PolyMet_MineSite_AnnualPM25SIL_Results.mxd User: jjm



## Max Concentration (ug/m3)

- 0.020 - 0.300
- 0.301 - 0.400
- 0.401 - 0.500
- 0.501 - 1.000
- 1.001 - 1.200
- 1.201 - 1.426
- 1.427 - 2.200
- Mesabi Nugget AAB
- NorthMet Plant Site AAB

N

Kilometers

5 0 5

Figure 3

Annual PM2.5 SIL RESULTS
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-17 11:23 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_4_PolyMet_MineSite_24hourPM10SIL_Results.mxd User: jjm

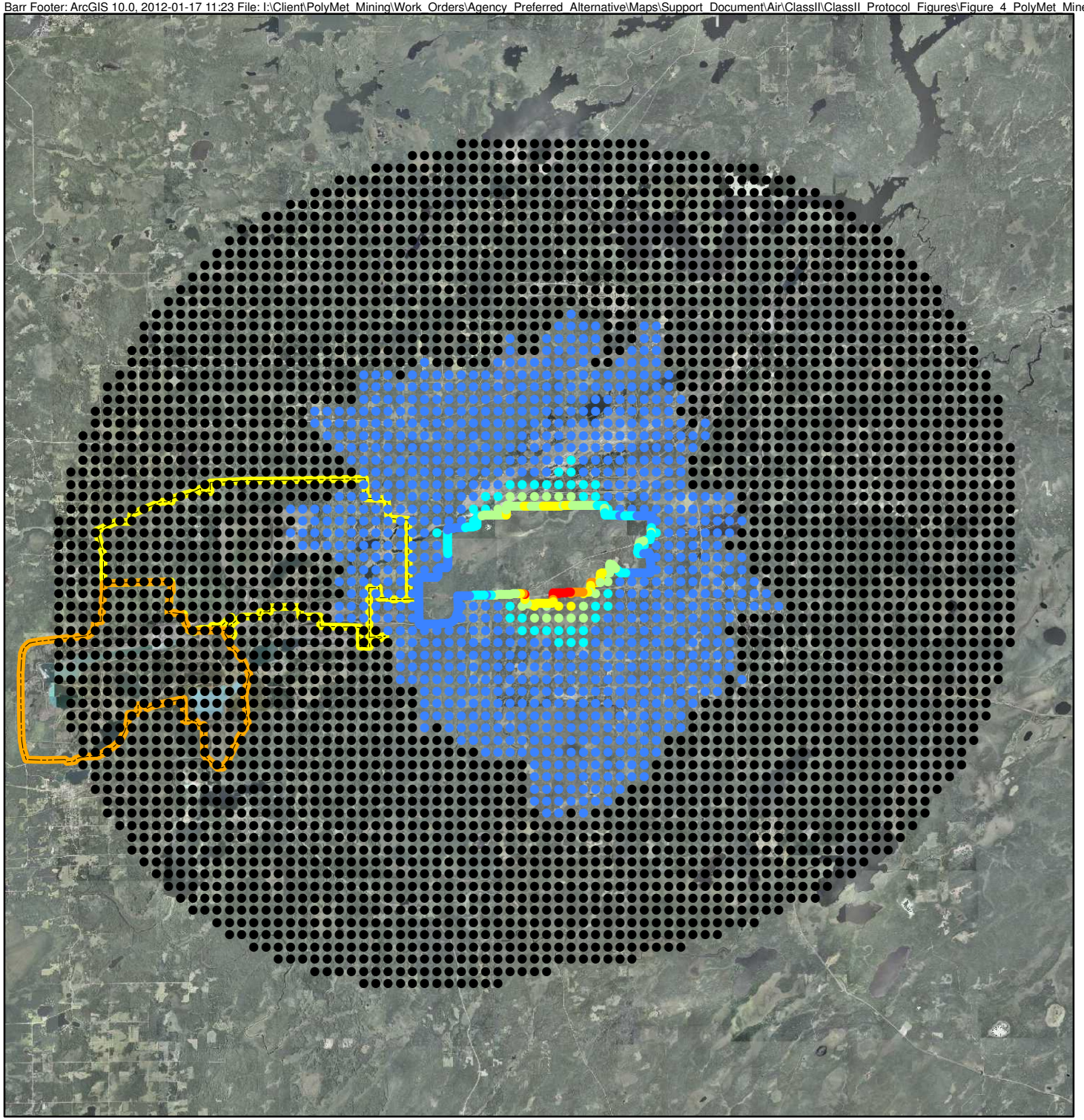



Figure 4

24 HOUR PM10 SIL RESULTS
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-17 11:24 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_5_PolyMet_MineSite_AnnualhourPM10SIL_Results.mxd User: jjm

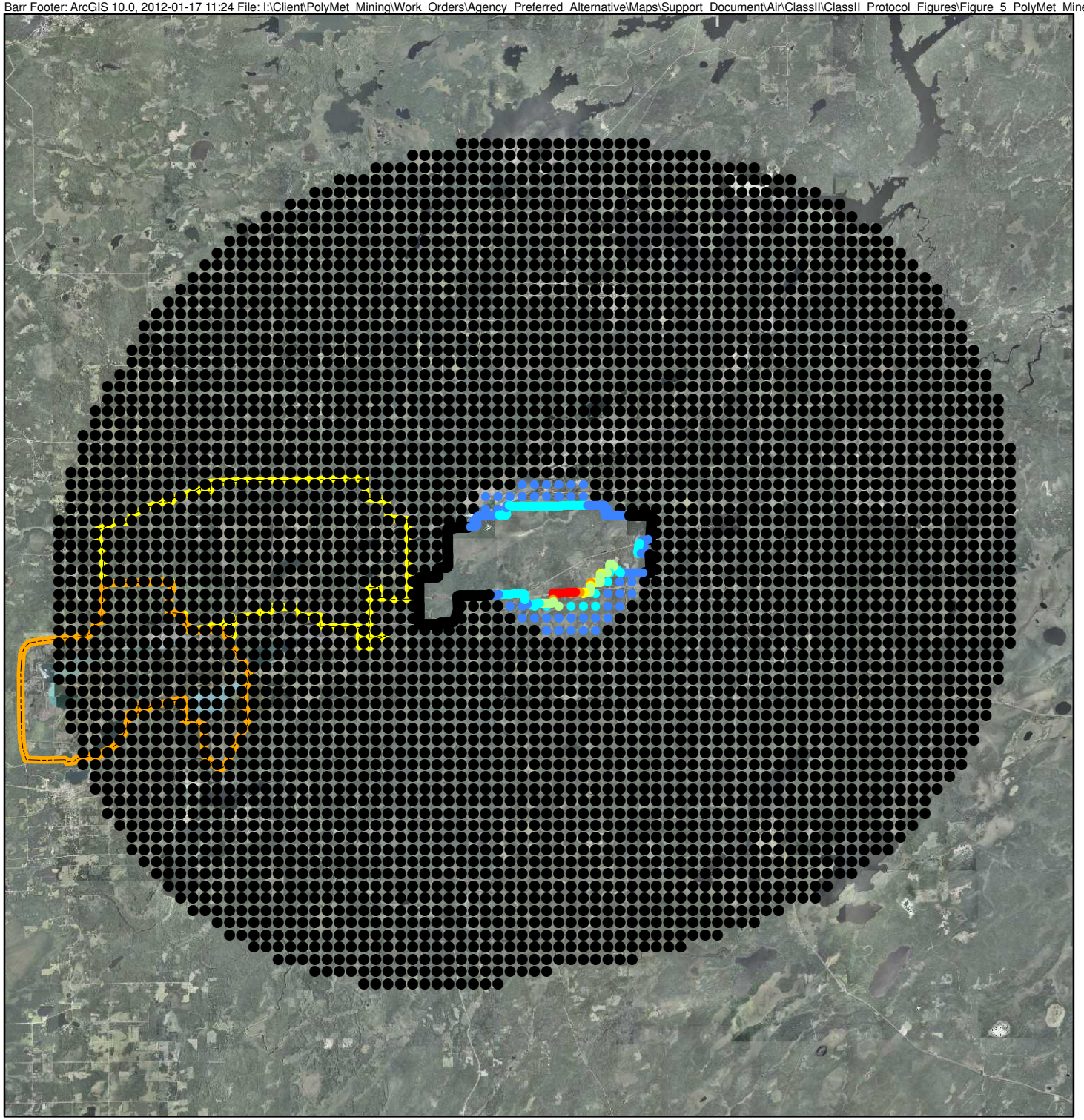
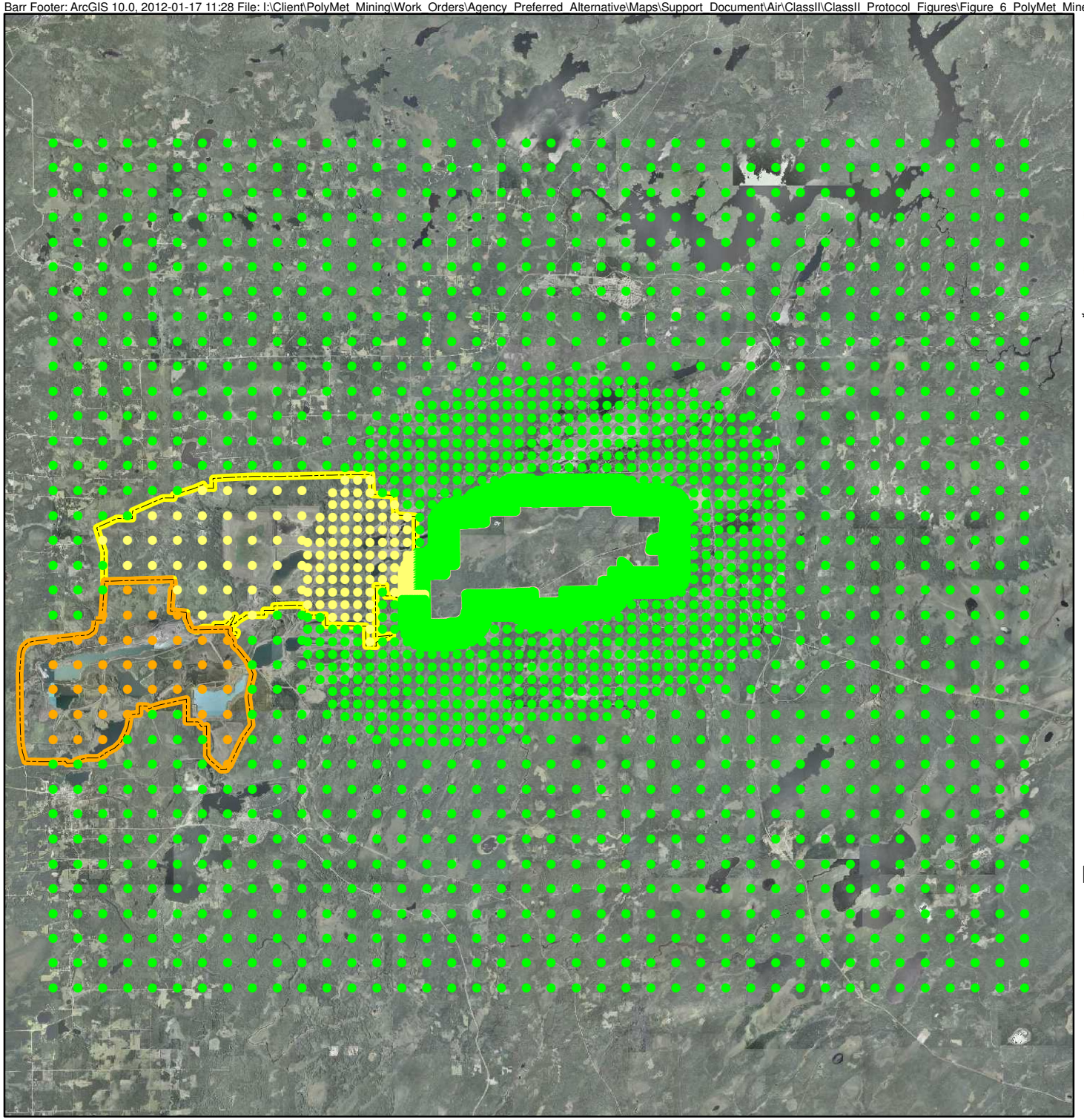



Figure 5

ANNUAL PM10 SIL RESULTS
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-17 11:28 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_6_PolyMet_MineSite_EISCumulative_NAAQS_INCREMENT_Receptors.mxd User: jjm



- Cumulative Receptors
- Mesabi Nugget
- NorthMet Plant Site
- Mesabi Nugget AAB
- NorthMet Plant Site AAB

**Northshore Peter Mitchell Mine on-site receptors to be determined.

N

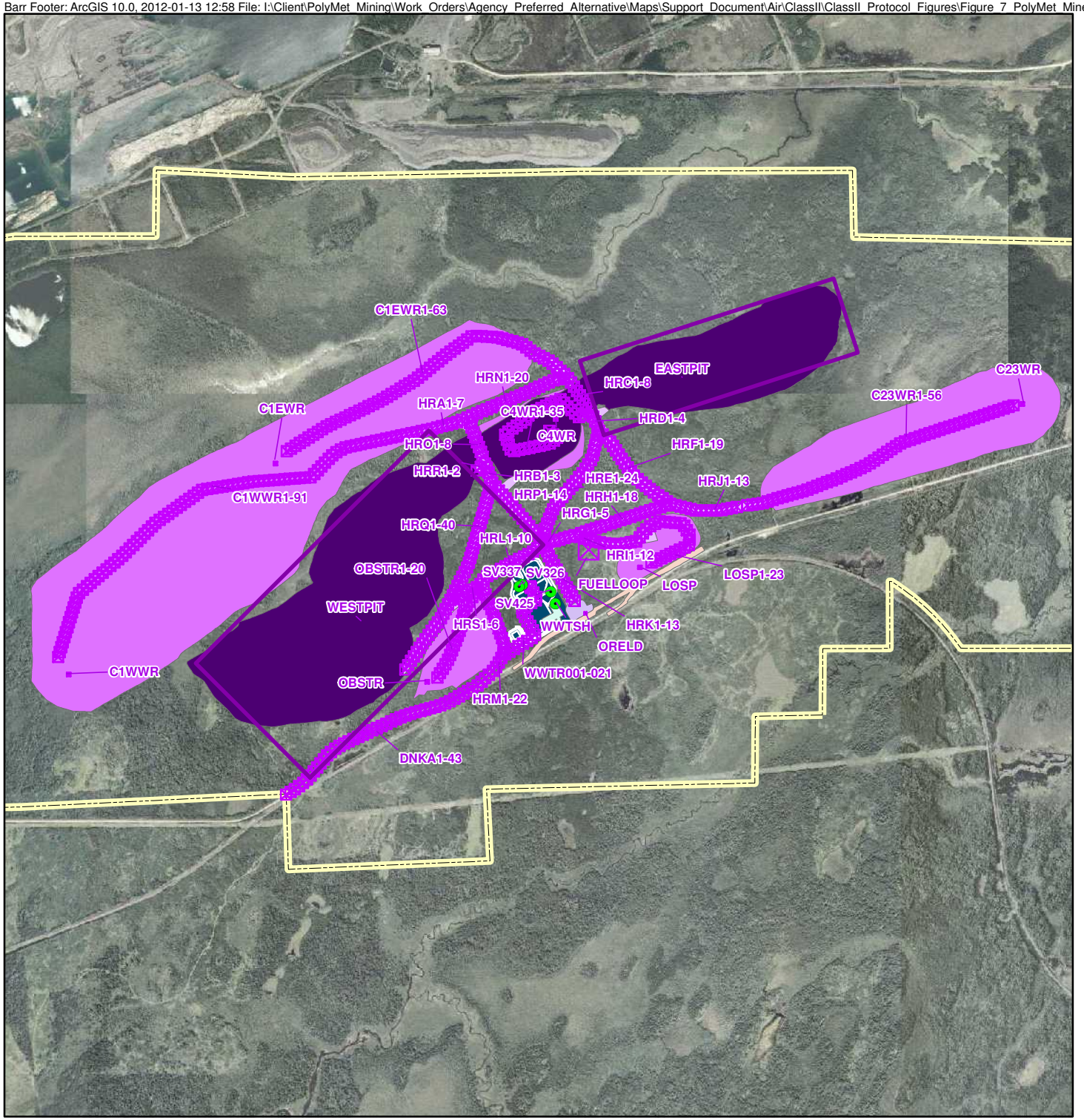
Kilometers

5 0 5

Figure 6

EIS CUMULATIVE NAAQS/INCREMENT
RECEPTOR GRID
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-13 12:58 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_7_PolyMet_MineSite_Year11_SourceLayout.mxd User: jjm




- Point Sources
- Open Pit Sources
- Volume Sources
- Ambient Air Boundary

N

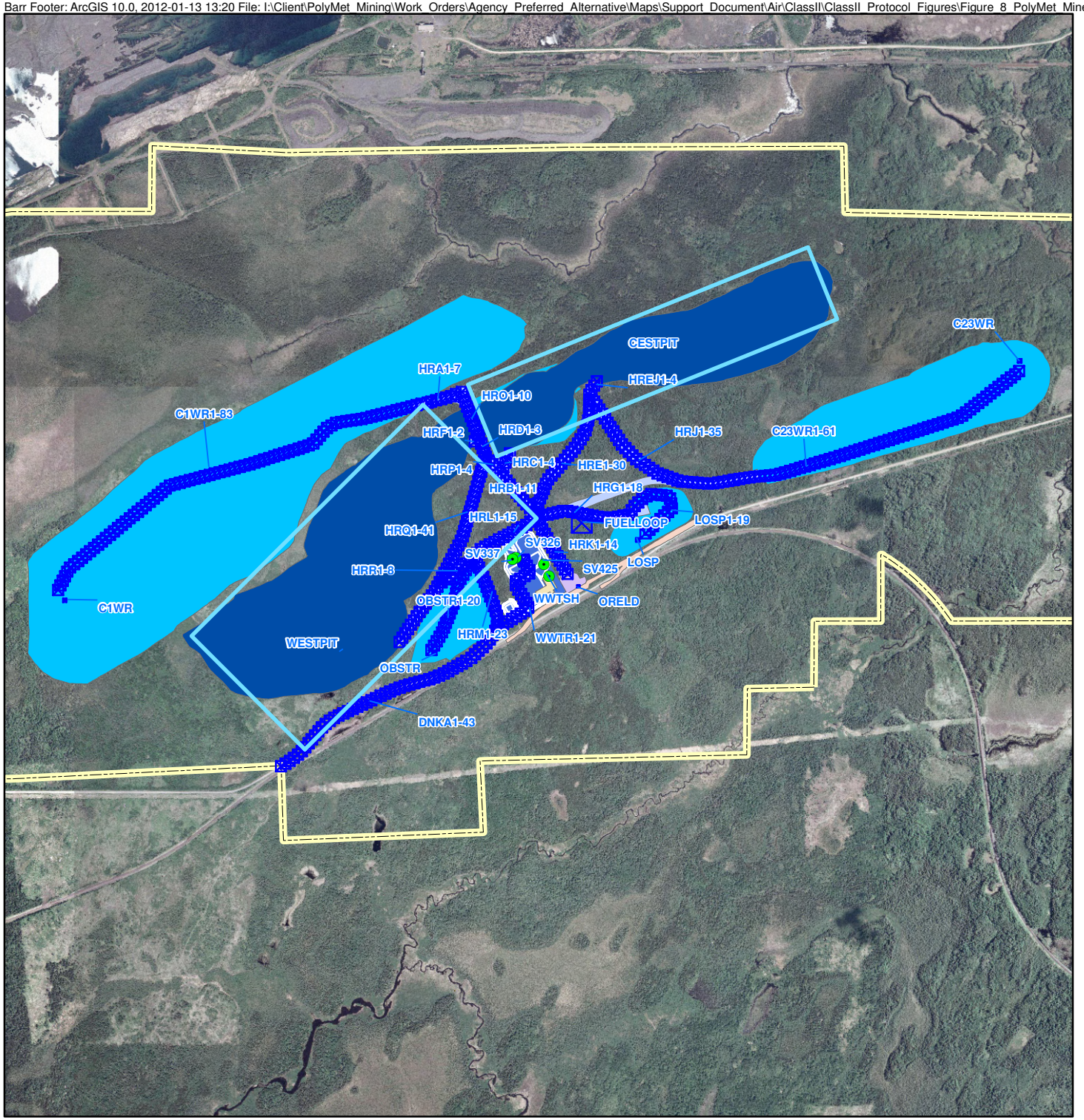
Meters

500 0 500

Figure 7

YEAR 11 SOURCE LAYOUT
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

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- Point Sources
- Open Pit Sources
- Volume Sources
- Ambient Air Boundary

N

Meters

500 0 500

Figure 8

YEAR 20 SOURCE LAYOUT
PolyMet Mine Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

**Attachment E**

**Plant Site Class II Air Quality Dispersion Modeling Protocol**

# Plant Site Class II Air Quality Dispersion Modeling Protocol

**NorthMet Project**

**PolyMet Mining Incorporated**

**Hoyt Lakes, MN**

This document provides the Class II dispersion modeling protocol for the Plant Site in the format requested by the Minnesota Pollution Control Agency (MPCA). This includes MPCA form AQDMP-01, five attachments and eight figures. The attachments and figures are listed below.

## Attachments (name references corresponding section of the AQDMP-01 form):

Attachment B - Class II Modeling Surface Meteorology – Minimum Wind Speed for Modeling
Attachment C – Non-Default Modeling Options
Attachment J – Nearby Sources
Attachment K – Anticipated Outputs (OU Pathway)

## Figures:

Figure 1 – SIL Receptor Grid with Exceedances
Figure 2 – EIS Plant Only Receptor Grid
Figure 3 – EIS Cumulative Analysis Receptor Grid
Figure 4 – Plant Modeled Source Layout
Figure 5 – Tailings Basin Modeled Source Layout

In addition to this document, requested electronic files will be provided via the Project Air FTP Site.

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

# AQDMP-01

Air Quality Dispersion Modeling Protocol (AQDMP)
Protocol Form for Criteria Pollutant Modeling

*Doc Type: Air Dispersion Modeling*

**Guidance Information on Page 13**

**Instructions:** Permit applicants required to conduct air dispersion modeling should submit two paper copies of the completed Air Quality Dispersion Modeling Protocol form (AQDMP-01), the Air Quality Dispersion Modeling Protocol Spreadsheet (AQDMPS-01), and all accompanying files to:

Air Quality Permit Document Coordinator
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Applicants may also submit an electronic version in addition to the two paper copies.

Electronic copies of the forms and accompanying files should be sent to: AirModeling.PCA@state.mn.us.

## Facility Information

AQ file no.: _____ AQ facility/permit ID no.: _____ Today's date (mm/dd/yyyy): 5/17/2012

Three-letter modeling facility ID (ex., XEK = Xcel Energy Allen S. King, MEC = Mankato Energy Center, etc.): PMP

Facility name: NorthMet Plant Site

Facility street address: 6500 County Road 666

City: Hoyt Lakes County: St. Louis

State: MN Zip code: 55750 Elevation at facility: 493 m

Facility contact: Kevin Pylka Protocol prepared by: Jennifer Koenen, Barr Engineering Co

Facility contact phone: (218) 471 - 2162 Preparer phone: (952) 832 - 2682

Facility contact e-mail address: kpylka@polymetmining.com Preparer e-mail address: jkoenen@barr.com

Latitude, Longitude of facility (Decimal degrees to **four** decimal places): 47.5981 N, 92.1391 W

UTM coordinates of facility (NAD83, zone 15 extended **ONLY**): x = 564,719.00 m East, y = 5,271,989.00 m North

### Files to accompany protocol

*Use the checkboxes to indicate that the following **required** files are included with the completed protocol form.*
*Please **do not use** spaces or special characters in the file names and pathways.*

☒ 1. Sample AERMOD input files for **each** modeled criteria pollutant (*.inp, *.adi, *.ami)
***Note:** Input file should include receptor grid and building downwash (if applicable)

☒ 2. BPIPPRM input file (*.bpi)

☒ 3. Elevation files for input into AERMAP (*.tif (NED files), *.dem(s))

☒ 4. Background data files with concentrations for each applicable pollutant (annual, seasonal, monthly, daily, etc.)

☐ 5. AQDMPS-01 spreadsheet

☒ 6. **Optional**, but recommended, files and supporting documents – Please list below:

***Examples include***: sample AERMOD output files (with "CO RUNORNOT NOT"), SMS Spreadsheet, images and figures, SIL analysis and/or paved roads fugitive dust modeling output files, etc.

Figure 1 SIL Receptor Grid with Exceedences; Figure 2 EIS Plant Only Receptor Grid; Figure 3 EIS Cumulative Analysis Receptor Grid; Figure 4 Plant Modeled Source Layout; Figure 5 Tailings Basin Modeled Source Layout; PolyMet_Plantsite_EI.xls (alternative to AQDMPS-01.xls); Wind Erosion_06-10_alternative_PolyMet_bulk_tailings.xls; Wind Erosion_06-10_alternative_LTV_coarse_tailings.xls; HOURLY_PM10EMISS_RATES_FOR_SFCMET06-10_HIBBING.xlsx; HOURLY_PM25EMISS_RATES_FOR_SFCMET06-10_HIBBING.xlsx

## Section A. Purpose for Air Dispersion Modeling and Related Information

1. What is the purpose for conducting the ambient air dispersion modeling? (check all that apply)
   ☐ Permit requirement ☐ EAW ☒ EIS ☐ SIP ☐ PSD
   ☐ Other – please explain: _____

   a. If EAW and/or EIS are selected, please specify the regulatory trigger for modeling (ex., air emissions increase of 250 TPY, 25 MW operating capacity or design, petition, voluntary, etc. – see Minn. R. ch. 4410 for more information) and the name of MPCA EAW staff consulted with (N/A if not applicable or if no EAW staff were consulted):

      Mandatory EIS per MN Rules 4410.4400 Subpart 8b construction of a new facility for mining metallic minerals. Modeling scope agreed upon through process established by state and federal co-lead agencies.

      MPCA EAW staff name(s): Suzanne Baumann Date of consultation (mm/dd/yyyy): Ongoing

      ***Note**: If EAW and/or EIS are to be performed and air modeling will be conducted, cumulative effects will need to be addressed, as per the CARD decision. Please then select "NAAQS/MAAQS" in question 8 (A.8). Contact the Environmental Review Unit Supervisor (currently Craig Affeldt) for any questions regarding applicability and requirements.

2. Were MPCA air dispersion modeling staff consulted while completing this form? ☒ Yes ☐ No

   a. If yes, please provide the following consultation information:

      MPCA modeling staff name(s): Ruth Robersion Date of consultation (mm/dd/yyyy): Ongoing

      Topic of consultation:

      Discussion of version 1 of protocol submitted in April of 2011 and periodic discussion as part of air workgroup established for the project.

3. What type of air emission permit does this facility currently hold?
   ☒ No current permit ☐ Federal (Title V/Part 70) ☐ State ☐ State Registration ☐ Capped ☐ General
   ☐ Other: _____

4. Will you be applying for a permit or a permit amendment for the project? ☒ Yes ☐ No

5. Please provide a project title and a description of the proposed project:

   a. Project title (10 words or less): NorthMet Project - PolyMet Plant

   b. Project description (50 words or less):

      PolyMet plans to construct and operate a mine, to reactivate portions of the LTVSMC facility and to build a hydrometallurgical concentrate processing facility at the former LTVSMC site (Plant Site is subject of this protocol). More detail is available in the NorthMet Project Description Version 3 Submitted September 13, 2011

6. Is the proposed project subject to PSD? ☐ Yes ☒ No

   a. If yes, list pollutants: _____

   b. Is this facility considered a major source for PSD: ☐ Yes ☒ No

7. Has the PSD minor source baseline been set for: St. Louis County? ☒ Yes ☐ No

   a. If yes, for which pollutant(s) and the year(s) it was set (check all that apply)?

      ☒ $NO_2$ 1991 ☒ $PM_{10}$ 1979 ☐ *$PM_{2.5}$* _____ ☒ $SO_2$ 1986

      PSD major source baseline *($PM_{2.5}$ trigger date will be on Oct. 20, 2011, 1 year after F.R. publication date.)*

      ☒ $NO_2$ 1988 ☒ $PM_{10}$ 1975 ☒ *$PM_{2.5}$* 2010 ☒ $SO_2$ 1975

8. What type of analysis will be conducted? (check all that apply)
   ☒ NAAQS/MAAQS ☒ PSD Class II Increments ☒ PSD Class I Increments ☒ SIL Analysis ☐ Screening
   ☒ Other: AERA

9. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section B. EPA Pre-Processors and EPA Post-Processors

1. Will AERMAP be used? ☒ Yes ☐ No
   If no, please explain: _____

   a. What version of AERMAP is proposed to be used: AERMAP version 11103
      If other, please explain: _____

   b. What type of elevation data will be used:

☒ NED 1/3 arc second ☐ NED 1 arc second ☐ DEM 7.5 min ☐ DEM 1.0 degree

☐ Other - Please describe: _____

*All UTM coordinates must be in NAD83, Zone 15 Extended (**not** NAD27).*

2. Will BPIP-PRIME version 04274 be used? ☒ Yes ☐ No

   If no, please explain: _____

   *Tiering of buildings must follow MPCA's modeling guidance from section 6 of the Oct. 2004 "MPCA Air Dispersion Modeling Guidance For Minnesota Title V Modeling Requirements And Federal Prevention of Significant Deterioration (PSD) Requirements (Version 2.2)."*

3. Will MPCA pre-processed AERMET data be used? ☒ Yes ☐ No If yes, proceed to question 4.

   **Note –** MPCA's pre-processed meteorological data with AERMET incorporates the following details:

   - *AERSURFACE version 08009 is used to determine surface characteristics using 1992 LULC data.*
   - *Yearly-averaged moisture conditions (wet, dry, or average) based on historical ranks are accounted for in AERSURFACE to aid in the determination of Bowen ratio values.*
   - *Default 1.0 km radius for surface roughness and 10 km by 10 km domain for albedo and Bowen ratio used in AERSURFACE*

   a. If **no**, will on-site meteorological data be processed and used? ☐ Yes ☐ No

      **If no, skip to question 4 and provide additional information in question 5.*

   b. If **yes** to question a, please answer the following questions.

      i. Will AERSURFACE be used to determine surface characteristics around the meteorological tower? *(Default is "Yes")* ☐ Yes ☐ No

      ii. What version of AERSURFACE is proposed to be used: [Select from list] _____

      iii. What LULC data will be used? [Select from list] _____

      If other, please explain: _____

      iv. Will yearly-averaged moisture conditions (wet, dry, or average) based on historical ranks be accounted for in AERSURFACE (for the Bowen Ratio)? *(Default is "Yes")* ☐ Yes ☐ No

      v. Will the default 1.0 km radius for surface roughness, and 10 km by 10 km domain for albedo and Bowen ratio be used? *(Default is "Yes")* ☐ Yes ☐ No

      If no, please explain: _____

4. Are any **EPA** post-processors (such as LEADPOST) proposed to be used in the analysis? ☐ Yes ☒ No

   a. If yes, what post-processor(s) and version(s):

5. Are any user-developed pre-processors or post-processors proposed to be used in the analysis? ☒ Yes ☐ No

   a. If yes, what pre-processors or post-processors, and describe their functions:

      A post-processor may be developed to set the surface wind speeds less than 0.5 m/s to calms in the MPCA processsed surface file (.sfc).

6. Additional information for this section that was not included above (if not applicable, place N/A in field):

   Attachment B included with this protocol describes the method used for post-processing the MPCA processed surface meteorology to assign wind speeds less than 0.5 m/s as calm.

## Section C. Model Selection and Options (Key CO Pathway Inputs)

1. Identify the air dispersion model and version proposed to be used in the analysis: Other

   a. If other, please list: version 12060

2. What criteria pollutants are required and will be modeled (check all that apply)?

   ☒ CO ☒ $NO_2$ ☒ $PM_{2.5}$ ☒ $PM_{10}$ ☒ $SO_2$ ☐ Pb ☐ $H_2S$ ☐ Other: _____

   *Please refer to **Tables App.1 and App.2 in the Appendix** for averaging times and form of standard for each criteria pollutant(s). Refer to the most recent version of the EPA's AERMOD User's Guide for correct pollutant IDs to use. Use EPA's most recent modeling guidance' methods for $PM_{2.5}$.*

3. What model options (CO pathway keywords) are proposed to be used in the analysis for the source under review (check all that apply)? (See Tables B-1 and B-2 of the "*AERMOD User's Guide, Addendum for Version 11103*")

☒ Regulatory Default - list pollutants: SO2, CO ☒ Non-Default - List pollutants: NO2, PM10, PM2.5

☒ Concentration ☒ Rural ☐ Urban ☒ ELEV ☐ FLAT

☐ Other(s) not listed: _____

a. If Urban, please specify population area, population, and surface roughness radius:
Population area: _____ Population: _____ Surface roughness height: 1.0 km

b. If Non-Regulatory Default, please specify non-default options: OLM (1 hour NO2), Half-Life (PM10), and Secondary Formation of Combustion Sources (PM2.5) (see Attachment C)

4. Will alternative air dispersion models and/or methods, as specified by Appendix W, be applied (e.g., parallel version(s) of model, PVMRM, OLM, secondary formation, etc.)? ☒ Yes ☐ No

If yes, please explain: _____

a. If yes, will approval be required by MPCA and/or EPA Region V air modeling staff? ☐ Yes ☐ No
If yes, please select: ☒ MPCA (State-only action) ☒ EPA Region V (PSD/SIP action)
If no, please explain: _____

5. If $NO_2$ is required to be analyzed for the one-hour and annual NAAQS, what tier methodology(s) is proposed?

☐ N/A, $NO_2$ not required (skip to question 6)

☐ Tier 1 (100% $NO_x$ to $NO_2$ conversion, most conservative)

☐ Tier 2 (Default ambient ratio of 0.80, or an appropriate ratio value)

☒ Tier 3 (OLM, requires justification and approval by MPCA and/or EPA Region 5)

☐ Tier 3 (PVMRM, requires justification and approval by MPCA and/or EPA Region 5)

a. If Tier 2, please provide the ambient ratio proposed (**default** = 0.80): 0.80

b. If Tier 3 is anticipated to demonstrate compliance in the modeling analysis (OLM or PVMRM), please provide the following details now to expedite MPCA's review:
i. In-stack ratio of $NO_2/NO_x$ (NO2STACK) (**default=0.50**): 0.50
ii. Equilibrium ratio (NO2EQUIL) (**default=0.90**): 0.90

c. If Tier 3 is anticipated, please provide details below regarding **MPCA-generated** ozone values (in **µg/m$^3$**)
*(Please check all option(s) proposed to be used):*
☒ MPCA-generated $O_3$ values will be used
☐ MPCA-generated values will NOT be used (proceed to question d)
i. ☐ CO OZONEFIL (hourly):
*1.* O3FileName: _____
*2.* File creation date: _____
*3.* FORTRAN subroutine: _____
ii. ☐ CO O3VALUES O3flag: SEASON OZONUNIT: ☐ PPB ☐ PPM ☒ UG/M3
**Note**: MPCA O3flag uses SEASON as a default, as well as OZONUNIT set to UG/M3.
*1.* Please input the O3values (i=1,n) for the O3flag specified above (C.5.c.ii):
***Example***: For "CO O3VALUES SEASON", n=4 values (winter #, spring #, summer #, fall #)
_____
iii. ☐ CO OZONEVAL (monitored value): 75 O3Units: ☐ UG/M3 ☒ PPB ☐ PPM
**Note**: MPCA OZONEVAL uses 75 PPB as a default.

d. If Tier 3 is anticipated, please provide details below regarding **user-generated** ozone values
*(Please check all option(s) proposed to be used):*
☐ User-generated $O_3$ values will be used
☐ User-generated values will NOT be used (proceed to question e)
i. ☐ CO OZONEFIL (hourly):
1. O3FileName: _____
2. O3Units: ☐ UG/M3 ☐ PPM ☐ PPB
3. O3Format: _____
ii. ☐ CO O3VALUES O3flag: _____ OZONUNIT: ☐ PPB ☐ PPM ☐ UG/M3
**Note**: O3flag can be defined as ANNUAL, SEASON, MONTH, etc. PPB is the AERMOD default for OZONUNIT. See Table B-2, Appendix B, of the "AERMOD User's Guide, Addendum for Version 11103".
*1.* Please input the O3values (i=1,n) for the O3flag specified above (C.5.d.ii):

***Example***: For "CO O3VALUES SEASON", n=4 values (winter #, spring #, summer #, fall #)

iii. ☐ CO OZONEVAL (monitored value): _____ O3Units: ☐ UG/M3 ☐ PPB ☐ PPM

**Note**: UG/M3 is the AERMOD default for OZONEVAL O3units.

e. Is EPA approval needed for the modeling protocol (e.g., Tier 3 $NO_2$)? *Tier 3 $NO_2$ methodologies that require approval by Region 5 modeling staff need to have said approval before submission of this form and attach approval.*

☒ Yes – PSD/SIP permit action ☐ No – State-only action

6. Are the following criteria from Appendix W, section 3.2.2, paragraph (e), met in this protocol? ☒ Yes ☐ No

If no, please explain: _____

*e. "Finally, for condition (3) in paragraph (b) of this subsection…an alternative refined model may be used provided that:*

i. *The model has received a scientific peer review;*

ii. *The model can be demonstrated to be applicable to the problem on a theoretical basis;*

iii. *The data bases which are necessary to perform the analysis are available and adequate;*

iv. *Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and*

v. *A protocol on methods and procedures to be followed has been established."*

7. Additional information for this section that was not included above (including justification for non-default options, additional CO pathway keywords not mentioned above, or additional values listed in 5a or 5b):

Attachment C included with this protocol describes the Half-Life method used for the PM10 modeling and the off-set emission rate method used to account for secondary formation of PM2.5 from combustion sources.

## Section D. Emission Source Characterizations and Parameters (Key SO Pathway Inputs)

Include and list the facility's modeling parameters for all source types in the *MPCA's Modeling Parameters Spreadsheet* (Form AQDMPS-01). For background sources listed within SO Pathway, please see Section I.

1. Please indicate which of the following source characterizations are present at your facility and will be included for modeling analysis (check all that apply ):

*"Yes" = Source-type present and will model; "N/A" = Source-type not present; "No" = Source-type present but will not model.*

a. **Point sources**:

☒ Yes ☐ N/A ☐ No-please explain: _____

i. Are any of the point sources capped and/or horizontal stacks (see guidance in section 6.1, AERMOD Implementation Guide (03/19/2009)) and, if yes, accounted for in the following?

☒ No ☐ Yes – exit velocity(s) = 0.001 m/s ☐ Yes – Non-Default POINTCAP and /or POINTHOR*

**Please provide justification for use of non-default option in question b, below.*

ii. Additional information for this subsection (if not applicable, place N/A in field):

Details on the point sources modeled are included in the Emission Inventory spreadsheet in the tab labeled "Stack Model Inputs". Figure 4 shows the point source locations.

b. **Volume sources**:

☒ Yes ☐ N/A ☐ No-please explain: _____

**Tip**: Please refer to Figure App.1 in the appendix on calculating the lateral and vertical dimensions.

i. Will there be any volume source(s) overlapping or within 1.0 meters of any receptors?

☒ No ☐ Yes*

**Volume source should then be converted to an area source of commensurate size (per section 6.2 of EPA's AERMOD Implementation Guide (03/19/2009)) or be further refined.*

ii. Additional information for this subsection (if not applicable, place N/A in field):

The plant site volume sources represent the fugitive dust from the vehicles traveling around the tailings basin and along the unpaved Dunka Road, tailings material handling, and building vents. The space heaters are vented out of the roof of numerous plant site buildings that are primarily represented as volume sources. The details are included in the Emission Inventory spreadsheet in the tab labeled "Fugitive Model Inputs".

c. **Area sources** (includes AREACIRC and AREAPOLY):

☒ Yes ☐ N/A ☐ No-please explain: _____

i. Additional information for this subsection (if not applicable, place N/A in field):

The tailings basin erodible beach areas are represented by multiple area sources. The details are included in the Emission Inventory spreadsheet in the tab labeled "Fugitive Model Inputs". All beach areas are shown in Figure 5; a subset of these would be erodible at a given point in time. The worst case erodible beach area location will be confirmed through modeling.

d. **Open pit sources**:

☐ Yes ☒ N/A ☐ No-please explain: _____

i. Additional information for this subsection (if not applicable, place N/A in field):

2. Are fugitive emissions emitted from the source, and if yes, will they be accounted for in the modeling analysis? (Examples of fugitive emissions include but are not limited to: traffic on paved and/or unpaved roads, stockpiles of various materials, wind erosion, loadout, unloading, etc.)

(Yes = fugitive emissions are emitted AND will be included in modeling analysis; N/A = no fugitive emissions are emitted; No = fugitive emissions are emitted and will NOT be included in modeling analysis)

☒ Yes ☐ N/A ☐ No-please explain*: _____

** Please provide justification for excluding any fugitive emission sources within the modeling.*

a. If yes, please list the facilities' fugitive sources: material handling, unpaved road traffic, conveying, wind erosion

***Note**: If modeling for paved road fugitive dust, please read and complete Section E.*

b. Will the Standardized Mobile Source (SMS) Spreadsheet be used to determine emissions due to paved and/or unpaved roads (unpaved spreadsheets under development)? ☐ Yes ☒ No

3. Will all insignificant activities emitted from the source for $PM_{10}$ (with emissions over 0.1 lb/hr), $PM_{2.5}$ (with emissions over 0.02 lb/hr), or other pollutants be accounted for in the modeling?

☒ Yes ☐ N/A ☐ No-please explain*: _____

** Please provide justification for excluding any insignificant activities within the modeling.*

*Scale for other pollutants. For example, (0.1 lb/hr) / (150 µg/m$^3$) = (X lb/hr) / (35 µg/m$^3$), where X = 0.02 lb/hr.*

*Refer to guidance in section 10 of the Oct. 2004 "MPCA Air Dispersion Modeling Guidance For Minnesota Title V Modeling Requirements And Federal Prevention of Significant Deterioration (PSD) Requirements (Version 2.2)"*

4. Are intermittent emissions sources present at the facility? ☒ Yes ☐ No – Skip to question 5.

a. If yes, please provide detail on the types and operations of the intermittent emission source(s) (include the source IDs, any regular uses, testing frequencies, emergency uses, peaking vs. non-peaking units, days and hours of operation or testing, etc.):

SV108/109/426 are backup generator stacks and will be modeled for PM10 and PM2.5, assuming 8,760 hours of operation. SV304/305 are fire pump stacks and will be modeled for PM10 and PM2.5 assuming 8,760 hours of operation. If these very conservative assumptions produce unacceptable results, the maximum operating hours per day will be used in the modeling or worst case short term emissions for the entire Plant Site will be determined.

b. If yes to question 4, will intermittent emission sources be included in the modeling analysis?

☒ Yes – please list the source ID(s): SV108, SV109, SV304, SV305, SV426

☐ No – please list the source ID(s): _____

i. If no, please provide explanation for not including in the modeling analysis: _____

5. Does your facility have alternative operating scenarios? ☐ Yes ☒ No

a. If yes, will multiple operating scenarios be modeled?

☐ Yes - # of scenarios to be modeled: _____ ☐ No – most conservative scenario will be modeled

b. If yes to 5a above, please describe the operating scenarios and the differences between them:

**Note**: If multiple scenarios will be modeled, please list the scenarios in the AQDMPS-01 spreadsheet.

6. Will emission factors/scalars (SO EMISFACT) be used to demonstrate compliance in the air dispersion modeling analysis? ☒ Yes ☐ No

a. If yes, describe for which sources and the types of emission factors/scalars that will be applied:

By Wind Speed: LCRSTA-K, PBLKTA-I ; By Month/Hour/Day: JTB001-194, ITB001-133, NTB001-149, WTB001-098, CTB001-054, WWT001-032

7. Will hourly emission file(s) be used for this analysis (HOUREMIS)? ☒ Yes* ☐ No

**If yes, please provide the hourly emission file(s) with the submittal of this form and list file in question 6 under the "Files To Accompany Protocol" section.*

8. Please list the anticipated source groups (SRCGROUP) that will be used in the modeling analysis:

   ***Tip**: For NAAQS modeling, please include for source groups:

   "SO SRCGROUP ALL BACKGROUND", "SO SRCGROUP BKG BACKGROUND", "SO SRCGROUP FAR 1-99999999".

   NAAQS1, NAAQS2, INCRM, PMP, Nearby, NAAQSnoNSM, NAAQSnoPMM, INCnoPMM, ALL, STAX, VENTS, (possibly more depending on the extent of cumulative receptor grid and the nearby sources that need to be included in the NO2 and SO2 modeling analysis)

9. Will $NO_2/NO_x$ ratios be used for OLM or PVMRM options? ☐ N/A ☒ Yes ☐ No
10. Will "OLMGROUP ALL" be used for the OLM option? ☐ N/A ☒ Yes ☐ No
11. Will all applicable PSD increment consuming and/or expanding sources be modeled for your source?

    ☒ Yes ☐ No-please explain (SIL-only, NAAQS-only, etc.): _____

12. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section E. Paved Roads Fugitive Dust

Current MPCA policy regarding modeling of paved road fugitive dust emissions, in support of air quality permitting or environmental review, recommends that:

> New facilities or facilities undergoing physical expansions will not be required to model paved road fugitive dust emissions if a facilities' predicted ambient impacts for $PM_{10}$ and $PM_{2.5}$ are less than a specified percent of the NAAQS and/or PSD Class II Increment. Physical expansions do not include increases in emission limits.

This policy does not apply to modeling that supports permitting in maintenance areas or the development of State Implementation Plans. Exceptions to the policy can and will occur. Please see the MPCA air modeling webpage for policy.

If paved road fugitive dust emissions are proposed to be included in your modeling analysis and you did **not** answer "Neither" to question 1b, MPCA guidance recommends that the source in question first model its' facility (**without** including paved road fugitive dust emissions) plus nearby sources plus background (i.e., FAC w/o paved roads + nearby source impacts + background impacts). Results then can be recorded using Table E-01 below for $PM_{10}$ and $PM_{2.5}$. If your facility has multiple paved roads operating scenarios, results recorded in Table E-01 must reflect the most conservative scenario.

1. Does your facility have paved road fugitive dust emissions for **$PM_{10}$** and **$PM_{2.5}$**?

   ☒ Yes ☐ No – Please continue to the next section (F)

   a. Will your facility include paved road fugitive dust emissions in the modeling analysis? ☐ Yes ☒ No

   b. Is your facility either a new facility or an existing facility undergoing a physical expansion?

      ☒ New facility ☐ Existing w/ phys. expan. ☐ Neither*

      ** If neither, policy does not apply. Please answer questions 2 – 5, and proceed to the next section (F) **without** filling in Table E-01.*

   c. If yes to question 1 and no to question 1a, please provide justification for not including paved road fugitives:

      Preliminary results less than 95% of the standard. Final results will be used to determine need for inclusion in submitted modeling (and associated emission inventory).

2. How many vehicles per day drive on and off your facility's property? (Provide the maximum number from all scenarios.)

   Employee traffic and parking: _____ Third-party truck traffic: _____

3. Does your facility have multiple operating scenarios for traffic on your property (i.e., seasonal traffic changes)?

   ☐ Yes ☐ No

   a. If yes, please provide additional details for the operating scenarios, such as changes in traffic counts, types of vehicles, silt loadings, cleaning frequencies, etc.

      _____

4. Will you be using the most recent version of the MPCA's Standardized Mobile Source (SMS) spreadsheet to determine paved road fugitive dust emissions and source parameters?

   ☐ Yes* ☐ No **If yes, please submit SMS with this modeling protocol form and indicate on the cover page of this form.*

5. Additional information for this section that was not included above or below (if not applicable, place N/A in field):
   Paved roads were used at the PM10 baseline date, so any emissions generated do not consume increment.

***Note:*** *Modeling output files must be submitted, if completing Table E-01.*

**Table E-01** (Use max modeled concentrations from all operating scenarios)

| | Averaging Period | NAAQS (µg/m$^3$) | Modeled NAAQS Impact Concentrations w/ Background and Nearby Sources(µg/m$^3$) | % of NAAQS/MAAQS | PSD Class II Increments (µg/m$^3$) | Modeled Class II Increment Impact Concentrations (µg/m$^3$) | % of Class II Increments |
|---|---|---|---|---|---|---|---|
| $PM_{10}$ | 24-hour | 150 | | 0.00% | 30 | | 0.00% |
| | Annual | 50 | | 0.00% | 17 | | 0.00% |
| $PM_{2.5}$ | 24-hour | 35 | | 0.00% | 9 | | 0.00% |
| | Annual | 15 | | 0.00% | 4 | | 0.00% |

Table E-02 indicates the resultant category(s) for your facility, based on the % of the standard(s) for $PM_{10}$ and $PM_{2.5}$ (see results in columns "% of NAAQS" and "% of Class II Increments" in Table E-01 above). This uses the highest % from all averaging periods for each pollutant and standard. The category descriptions are provided in Table E-03. Answers to question 2 above will help determine permit conditions if modeled concentrations result in a category 2 designation.

**Table E-02**

| | NAAQS | | | | PSD Class II Increments | | | |
|---|---|---|---|---|---|---|---|---|
| | ***NAAQS/MAAQS Result(s) w/ Background and Nearby Sources (%)*** | **Cat. 1** | **Cat. 2** | **Cat. 3** | ***PSD Class II Result(s) (%)*** | **Cat. 1** | **Cat. 2** | **Cat. 3** |
| $PM_{10}$ | 0.00% | *# < 60%* | *60% < # < 95%* | *95% < #* | 0.00% | *# < 35%* | *35% < # < 75%* | *75% < #* |
| $PM_{2.5}$ | 0.00% | *# < 80%* | *80% < # < 95%* | *95% < #* | 0.00% | *# < 40%* | *40% < # < 80%* | *80% < #* |

**Table E-03**

| | |
|---|---|
| Cat 1: | Paved road fugitive emissions not required to be modeled, and no paved road fugitive dust permit conditions. Requirements in Minn. Rule 7011.150 apply. |
| Cat 2: | Paved road fugitive emissions not required to be modeled, with paved road fugitive dust permit conditions determined by levels of traffic at the facility. |
| Cat 3: | Paved road fugitive emissions **are** required to be modeled, with site-specific paved road fugitive dust permit conditions. Re-modeling and/or addition of paved road fugitive emissions source group required. |

## Section F. Receptors (RE Pathway)

Please refer to guidance from Table 4 and 5 of the October 2004 "*MPCA Air Dispersion Modeling Guidance For Minnesota Title V Modeling Requirements And Federal Prevention of Significant Deterioration (PSD) Requirements (Version 2.2)"*, as well as federal guidance.

1. What type of receptor grid will be used? Discrete Cartesian
   a. If other, or a combination, please describe:
   b. Will grid be converted to discrete Cartesian? ☐ Yes ☐ No ☒ N/A – already discrete Cartesian
2. How many receptors in total will be included in the receptor grid? 7,028 receptors
3. What will be the grid dimensions? (Ex., radius of 10 km, 5 km by 5 km, etc.) 66 km X 60 km
4. What is the proposed spacing of receptors for…?
   a. Inside the property boundary(s): see 6 meters

b. On the fenceline(s): see 6 meters

c. On the property line(s): see 6 meters

d. Beyond the property line(s): see 6 meters

5. Will FLAGPOLE receptors be included in the receptor grid?

(N/A = No high-rise structures w/ ambient air within 3 miles of source; No = High-rise structures w/ ambient air exist within 3 miles of source, but will not include in receptor grid.)

☐ Yes ☐ N/A ☒ No – Please continue to the next question (6)

6. Additional information for this section that was not included above (if not applicable, place N/A in field):

The EIS Class II NAAQS and Increment plant only receptor grid assumes a 100 meter space grid around the ambient air boundary with a 25 meter spaced area south of the main plant and tailings basin where initial modeling showed maximum impacts. From the boundary out 1km the receptors are spaced 250 meters, except in the area of maximum impacts, which was spaced at 50 meters. From 1 km out to 5 km the receptors were spaced every 500 meters. From 5km to the maximum extent of the grid, 25km, the receptors were spaced every kilometer. Source groups will be utilized in the modeling analysis to ignore impacts from a nearby facility on receptors located within their ambient air boundary. Figure 2 shows the proposed EIS Class II plant only receptor grid. The EIS Class II Cumulative NAAQS/Increment receptor grid is 4,439 receptors and shown in Figure 3. The ambient air boundary has receptor spacing every 50 meters with 1 km spaced receptors extending 25 km from the ambient air boundary. This ambient air boundary was chosen and accepted to reflect the combined impacts of the PolyMet plant site with the nearby projects that share a boundary with it. The plant only receptor grid demonstrates that the project itself will not contribute to any Increment or NAAQS violations on the nearby facilities properties, which wouldn't have their impacts included at receptors within their own ambient air boundaries.

## Section G. Meteorological Data (ME Pathway)

**Note:** If modeling with more than one meteorological data set (i.e., portable facility), please list in question 8 the information requested in questions 1-4 for the additional data sets.

1. What meteorological surface station is proposed for use? Please indicate the station name, the state the surface station is located in, and the three letter call sign\identifier. (Ex.: Minneapolis/St. Paul Int'l Arpt; MN; MSP) Or check the box to indicate that on-site surface meteorological data will be used instead of NWS surface meteorological data.

Surface station name: Hibbing Airport State: MN Three-letter call sign/identifier: HIB

☐ Onsite surface data

2. What meteorological upper air station is proposed for use? Please indicate the station name, the state the surface station is located in, and the three letter call sign\identifier. (Ex.: Chanhassen; MN; MPX)

Upper air station name: International Falls State: MN Three-letter call sign/identifier: INL

3. What consecutive 5- year period will be used? 2006 to 2010

4. Were the proposed AERMET files pre-processed by MPCA staff?

☒ Yes ☐ No

a. If yes, please provide the name of the met data zip file that was received or obtained from the MPCA and the date it was obtained:

Name: HIBINL5Y_20062010 .zip Date (mm/dd/yyyy): 05/05/2011

b. Please indicate what version of AERMET will be used: AERMET version 11059

If other, please explain:

5. Will on-site meteorological data be used, instead of NWS meteorological data processed by MPCA staff?

☐ Yes ☒ No

**Note:** If site-specific meteorological data will be collected and used, please follow the federal guidance (EPA's), as specified in section 8.3 and section 8.3.3.2 (QA/QC) of 40 CFR Part 51 dated 11/09/2005 (Appendix W).

a. If site-specific surface meteorological data will be collected and used, where will the **location** of the meteorological tower be set (city and state, coordinates, etc.)?

N/A

b. If site-specific meteorological data will be collected and used, what **year** of data is proposed to be used?

N/A

6. What justification(s) applies for the proposed surface and upper air stations identified above? (Check all that apply)

☐ Similar surface characteristics as meteorological tower ☐ Similar land use characteristics

☐ Similar wind patterns/characteristics ☐ Proximity to surface and/or upper air station(s)

☒ Other – Please describe: Nearest Surface Station with available minute data.

a. Please provide additional detail for your justifications:

7. Will wind speed categories be used?

   ☒ Yes ☐ No – Skip to question 8.

   a. If yes, please list the user-specified wind speed categories for the ME WINDCATS pathway:

   | | | | | |
   |---|---|---|---|---|
   | 4.70 | 7.80 | 11.60 | 13.40 | 16.0 |

   b. If yes, please list the user-specified wind speed emission factors for the SO EMISFACT WSPEED pathway:

   | | | | | |
   |---|---|---|---|---|
   | PM10: LCRST/PBLKT = 0/1.21E-05<br>PM2.5: LCRST/PBLKT = 0/1.81E-06 | PM10: LCRST/PBLKT = 1.18E-05/4.60E-05<br>PM2.5: LCRST/PBLKT= 1.76E-06/6.90E-06 | PM10: LCRST/PBLKT = 3.85E-05/8.33E-05<br>PM2.5: LCRST/PBLKT= 5.78E-06/1.25E-05 | PM10: LCRST/PBLKT = 6.71E-05/1.19E-04<br>PM2.5: LCRST/PBLKT= 1.01E-05/1.79E-05 | PM10: LCRST/PBLKT = 8.71E-05 /1.43E-04<br>PM2.5: LCRST/PBLKT = 1.31E-05 /2.15E-05 |

8. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section H. SIL Analysis and Results

1. Will a SIL analysis be conducted in conjunction with this project, in order to determine if a cumulative analysis is required?

   ☐ N/A – Proceed to the next section (I)

   ☐ No – Will not model against SILs and instead proceed directly to conducting a cumulative analysis

   ☒ Yes – List for which pollutants: SO2, NO2, CO, PM10, PM2.5

2. Extent of SIL receptor grid: 50 km

3. If a preliminary SIL analysis has been conducted for this project, it is optional but highly recommended that results be provided (in the Table H-01 below), as well as including corresponding model output files.

**Table H-01, Class II Significant Impact Levels Modeling Results for:**

| Pollutant | Averaging Time | Modeled Impacts (H1H) (µg/m$^3$) | SILs (µg/m$^3$) **As of 10/26/2010* | % of SIL | Exceed SIL? | Radius of Impact (If exceeds SIL) |
|---|---|---|---|---|---|---|
| **$SO_2$** | *1-hr* | 581.00 | 7.83 | 7420.18% | Yes - Refined Modeling | 25 km |
| | *3-hr* | 292.00 | 25 | 1168.00% | | |
| | *24-hr* | 92.00 | 5 | 1840.00% | | |
| | *Annual* | 11.00 | 1 | 1100.00% | | |
| **$PM_{10}$** | *24-hr* | | 5 | 0.00% | Yes - Refined Modeling | km |
| | *Annual* | | 1 | 0.00% | | |
| **$PM_{2.5}$** | *24-hr* | 21.00 | 1.2 | 1750.00% | Yes - Refined Modeling | 25 km |
| | *Annual* | 4.00 | 0.3 | 1333.30% | | |
| **$NO_x$** | *1-hr* | 65.00 | 7.52 | 864.36% | Yes - Refined Modeling | 25 km |
| | *Annual* | 3.00 | 1 | 300.00% | | |
| **CO** | *1-hr* | 204.00 | 2000 | 10.00% | No - Complete | km |
| | *8-hr* | 105 | 500 | 21.00% | | |

4. Additional information for this section that was not included above (if not applicable, place N/A in field):

   Class II SIL modeling files are included with this protocol on the supplemental files CD. Based on previous modeling it is anticipated that the 1 hour SO2/NO2 and 24 hour PM2.5 SILs are the limiting standards when setting the radius of impact for a Class II analysis. A PM10 SIL was not performed since a full NAAQS/Increment analysis is already required as part of the EIS and the maximum impacts from initial modeling are much closer to the source than 25 km.

## Section I. Background Values

Please refer to pages 35-39 (Section 2.4) and Table B-4 of the "*AERMOD User's Guide, Addendum for Version 11103*" for guidance as well as the latest version of the MPCA's Air Dispersion Modeling Guidance for Title V and PSD.
***Contact MPCA air dispersion modeling staff for MPCA-generated products.**

1. Are background concentrations required for your analysis?

   ***Tip**: If "NAAQS/MAAQS" was selected in question A.8, the answer is "Yes".

   ☒ Yes – List pollutants required for: SO2, PM10, PM2.5, NOX

   ☐ No – Please explain and proceed to question 4 (e.g., SIL analysis-only, etc.):

   **Note**: All MPCA and user-generated background concentrations, including uniform and temporally varying concentrations, will need to be specified in the input file(s).

2. **Will MPCA-generated background concentrations (in µg/m$^3$) be used?**

   ☐ No ☒ Yes – List pollutants to be used for: SO2, NOX

   If yes, check MPCA-generated background concentrations option(s) to be used (check all that apply):

   a. ☒ SO BACKGRND BGflag *Default for BGflag (question I.2.a.iii) for MPCA-generated is "SEASON"*

      i. File name(s): PMP$47.5981N_92.1391W_20062010_HOURLY_SO2__ALLSITESviaALLMAX.bkg - Annual via 1 Hour (38 ug/m3)
      PMP$47.5981N_92.1391W_20062010_HOURLY_NO2__ALLSITESviaALLMAX.bkg - Annual via 1 Hour (69 ug/m3)

      ii. File creation date(s): 12-1-2011

      iii. BGflag(s) – List all that apply: Annual

   b. ☐ SO BACKGRND HOURLY

      i. File name(s):

      ii. File creation date(s):

      iii. FORTRAN subroutine:

   **Tip**: Please include MPCA-generated background concentrations as an external file in the modeling input file. Ex., "SO INCLUDED BGflag filename" or "SO BACKGRND HOURLY hourlyfilename"

3. **Will user-generated background concentrations be used?**

   ☐ No ☒ Yes – List pollutants to be used for: PM10 and PM2.5

   a. If yes, please provide a description below of the user-generated background concentration(s) and any considerations given to the methodology:

      The Virginia, MN monitor is a site representative of the Iron Range and has been used as a background site for recent PSD permits at Northern Minnesota Taconite mining facilities. The 3 year average of the high 2nd second high 24 hour PM10 and PM2.5 values for 2008-2010 will be added directly to the modeled 24 hour concentrations (PM10 = 36; PM2.5 = 16.5). The maximum annual average monitored PM10 and PM2.5 concentrations from 2008-2010 will be added directly to the modeled annual concentrations (PM10 = 14; PM2.5 = 5.8).

   b. Background data sources (check all that apply): ☒ MPCA website ☒ EPA website

      ☐ Other – explain:

   c. Examined monitors out to a distance of: km

   d. Monitors excluded and reasons why:

   e. Facility characteristics:

      i. Facility land use (industrial, residential, agricultural, cropland, mixed, etc.): industrial with mixed forests

      ii. Facility setting: ☐ Urban ☐ Suburban ☒ Rural

   f. Ambient air monitor(s) characteristics:

      i. Monitor land use (industrial, residential, agricultural, cropland, mixed, etc.): industrial with mixed forest

      ii. Monitor setting: ☐ Urban ☐ Suburban ☒ Rural

   g. Form of background value(s) (maximum, 98$^{th}$ percentile, etc.): 24 hour - 3 year average High 2nd High (2008-2010)
      Annual - Maximum annual average for 2008-2010

   h. Please check user-generated background concentrations option(s) to be used (check all that apply):

      ☐ SO BACKGRND BGflag *(BGflag can be defined as ANNUAL, SEASON, MONTH, etc. See Table B-4, Appendix B, of the AERMOD User's Guide Addendum)*

      i. File name(s): See number 4.

      ii. File creation date(s):

iii. BGflag(s) – List all that apply: _____

☐ SO BACKGRND HOURLY

i. File name(s): _____

4. Additional information for this section that was not included above (if not applicable, place N/A in field):

The annual background concentration will be applied to the modeled concentration outside of the AERMOD run, so no background data file was created.

## Section J. Nearby Sources

***Contact MPCA air dispersion modeling staff for MPCA-generated products.**

1. Will any nearby sources be modeled explicitly for the analysis?

☐ N/A ☐ No ☒ Yes – List pollutants required for: PM10, PM2.5, SO2, NOX

2. **Will MPCA-generated nearby sources be used for any of the criteria pollutants?**

☐ N/A ☒ No ☐ Yes – List pollutants to be used for: _____

*If yes, check MPCA-generated nearby sources option(s) to be used (check all that apply):*

a. ☐ First-approximation representative (FAR) data

i. File name(s): _____

ii. Creation date(s): _____

iii. Distance(s) (DMAX) (km): CO: 50 $NO_2$: 50 $PM_{10}$: 50 $PM_{2.5}$: 50 $SO_2$: 50

iv. Scalar(s) (SMAX): CO: $NO_2$: $PM_{10}$: $PM_{2.5}$: $SO_2$:

iv. Coefficients for Coef. * D test(s): CO: $NO_2$: $PM_{10}$: $PM_{2.5}$: $SO_2$:

**Tip:** Please include MPCA-generated nearby sources as an external file in the modeling input file. Ex., "SO INCLUDED filename". Do not change the MPCA-generated source ID's (SrcID) of the nearby sources, or alter the files in any way without MPCA approval (ex., replacing FAR data with refined data).

b. ☐ Refined nearby source modeling

i. ☐ FAR sources replaced with refined modeling data (if checked, please list FAR ID's & FAC ID's)

ii. ☐ Other refined nearby sources (if checked, please list FAC ID's)

3. **Will user-generated nearby sources be used for any of the criteria pollutants?**

☐ N/A ☐ No ☒ Yes – List pollutants to be used for: PM10, PM2.5, SO2, NOX

*If yes, please explain:*

Attachment J describes in more detail the nearby sources to be included in the cumulative NAAQS analysis. As requested by MPCA, a First Approximation Run (FAR) analysis was completed for regional NOX and SO2 sources to determine additional nearby sources to explicitly model. The modeling files are included in the supplemental material.

4. Additional information for this section that was not included above (if not applicable, place N/A in field):

## Section K. Anticipated Outputs (OU Pathway)

*Please refer to Tables B-11 and B-12 of the "*AERMOD User's Guide, Addendum for Version 11103*".

1. Please list the plot file(s) (*.plt) that will be generated for each pollutant and averaging time combination (OU PLOTFILE) (Required for all modeled criteria pollutants):

See #9.

**Note**: Plot files with combined averaging times for the same pollutant, and extensions such as ***.grf**, should be separated into individual *.plt files. For example, $PM_{10}$ should have at least two individual plot files: one for the 24-hour averaging period for source group ALL and a second for the annual averaging period for source group ALL. Group ALL should include BACKGRND if conducting NAAQS modeling (e.g., "SO SRCGROUP ALL BACKGRND").

2. Please list the keyword and parameters that will be used in the modeling output files for the keyword RECTABLE (Required)

(Ex., “NO2 = OU RECTABLE ALLAVE 1-8”, “SO2 = OU RECTABLE ALLAVE 1-4”):

See #9.

3. Please list the keyword and parameters that will be used in the modeling output files for the keyword MAXTABLE (OU MAXTABLE Aveper Maxnum) (Maxnum=80) (Required):

   Not being used at this time.

4. Will source contribution (OU EVENTOUT SOCONT) or hourly contribution (OU EVENTOUT DETAIL) files be generated for event output files? (Required for $PM_{10}$ and CO):

   ☐ SOCONT ☐ DETAIL ☐ N/A (not modeling for $PM_{10}$ and/or CO)

5. Please specify the parameters for use with OU MAXDCONT (for use with 1-hour $NO_2$, 1-hour $SO_2$, and 24-hour $PM_{2.5}$ only): (Required)

   ☒ 1-hour $NO_2$ – GrpID: NAAQS Upper Rank: 1 LowerRank or ThreshValue: 8 FileName: TBD

   ☒ 1-hour $SO_2$ – GrpID: NAAQS Upper Rank: 1 LowerRank or ThreshValue: 4 FileName: TBD

   ☒ 24-hour $PM_{2.5}$ – GrpID: NAAQS1/NAAQS2 Upper Rank: 1 LowerRank or ThreshValue: 8 FileName: TBD

6. Will output files of daily maximum 1-hour values for each processed day (OU MAXDAILY) be generated for this analysis (for 1-hour $NO_2$ and 1-hour $SO_2$ only)? (Optional)

   ☒ No ☐ Yes – for: ☐ 1-hour $NO_2$ and/or ☐ 1-hour $SO_2$

7. Will output files of daily maximum 1-hour values by year, for each processed year (OU MXDYBYYR) be generated for this analysis (for 1-hour $NO_2$ and 1-hour $SO_2$ only)? (Optional)

   ☒ No ☐ Yes – for: ☐ 1-hour $NO_2$ and/or ☐ 1-hour $SO_2$

8. Other outputs to be generated (please specify the keyword and the parameter options):

9. Additional information for this section that was not included above (if not applicable, place N/A in field):

   See Attachment K.

## Appendix

**Figure App.1**

TABLE 3-1.

SUMMARY OF SUGGESTED PROCEDURES FOR ESTIMATING INITIAL LATERAL DIMENSIONS $\sigma_{yo}$ AND INITIAL VERTICAL DIMENSIONS $\sigma_{zo}$ FOR VOLUME AND LINE SOURCES

| Type of Source | | Procedure for Obtaining Initial Dimension |
|---|---|---|
| (a) Initial Lateral Dimensions ($\sigma_{yo}$) | | |
| Single Volume Source | $\sigma_{yo}$ = | length of side divided by 4.3 |
| Line Source Represented by Adjacent Volume Sources (see Figure 1-8(a) in EPA, 1995) | $\sigma_{yo}$ = | length of side divided by 2.15 |
| Line Source Represented by Separated Volume Sources (see Figure 1-8(b) in EPA, 1995) | $\sigma_{yo}$ = | center to center distance divided by 2.15 |
| (b) Initial Vertical Dimensions ($\sigma_{zo}$) | | |
| Surface-Based Source ($h_e$ = 0) | $\sigma_{zo}$ = | vertical dimension of source divided by 2.15 |
| Elevated Source ($h_e$ > 0) on or Adjacent to a Building | $\sigma_{zo}$ = | building height divided by 2.15 |
| Elevated Source ($h_e$ > 0) not on or Adjacent to a Building | $\sigma_{zo}$ = | vertical dimension of source divided by 4.3 |

**Table App.1 – Modeled Form of the NAAQS/MAAQS by Averaging Periods**

| Pollutant | 1-hour | 3-hour | 8-hour | 24-hour | Monthly | Annual |
|---|---|---|---|---|---|---|
| ***CO*** | H2H | - | H2H | - | - | - |
| ***$NO_2$*** | 98$^{th}$ percentile of the daily max. 1-hour values | - | - | - | - | H1H |
| ***Pb*** | - | - | - | - | H1H | - |
| ***$PM_{10}$*** | - | - | - | H6H of the multiyear values | - | H1H |
| ***$PM_{2.5}$*** | - | - | - | 98$^{th}$ percentile of daily max. 24-hour values | - | H1H |
| ***$SO_2$*** | 99$^{th}$ percentile of the daily max. 1-hour values | H2H | - | H2H | - | H1H |

**Table App.2 – Modeled Form of PSD Increment by Averaging Periods**

| Pollutant | 1-hour | 3-hour | 24-hour | Annual |
|---|---|---|---|---|
| ***$NO_2$*** | - | - | - | H1H |
| ***$PM_{10}$*** | - | - | H2H | H1H |
| ***$PM_{2.5}$*** | - | - | H2H* | H1H |
| ***$SO_2$*** | - | H2H | H2H | H1H |

***Criteria pollutants modeled for SIL analyses should be modeled as H1H's.***

## Helpful Webpages, Documents/Guidance, and Modeling Tips

Please consult the following webpages and documents for the most current modeling guidance and recommendations when filling out this form:

- U.S. EPA's Support Center for Regulatory Atmospheric Modeling: http://www.epa.gov/scram001/
  **Please check the SCRAM webpage regularly for the most recent updates to guidance, models, and standards; especially, for modeling guidance related to: 24-hour $PM_{2.5}$, 1-hour $NO_2$, and 1-hour $SO_2$ NAAQS.**
- U.S. EPA's 40 CFR Part 51 Appendix W: http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf
- U.S. EPA's AERMOD Implementation Guide: http://www.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf
- U.S. EPA's AirData: http://www.epa.gov/air/data/index.html
- MPCA's Air Dispersion Modeling: http://www.pca.state.mn.us/nwqh421
- MPCA's Ambient Air Monitoring Network Plan: http://www.pca.state.mn.us/mvri439
- MPCA's Environmental Review: http://www.pca.state.mn.us/xggx692
- USGS' National Map Seamless Viewer (NED data): http://seamless.usgs.gov/website/seamless/viewer.htm

For questions on this form, or data requests from MPCA air dispersion modeling staff, please send an e-mail to: AirModeling.PCA@state.mn.us. Please be sure to include with your questions or requests: the form ID (ADQMP-01), facility name and permit #, and contact information.

Questions can also be asked by calling one of the MPCA's air dispersion modeler's (phone numbers are listed on the MPCA's Air Dispersion Modeling webpage, link above).

***Tip*:** Please be sure to use UTM Coordinates, NAD83, Zone 15 Extended for all locational data. Zone 14 will not be acceptable. This is to keep consistency between coordinates of all Minnesota sources.

***Tip*:** For NAAQS modeling, please include the following source groups:

- SO SRCGROUP ALL BACKGROUND
- SO SRCGROUP BKG BACKGROUND
- SO SRCGROUP FAR 1-99999999
- SO SRCGROUP FAC [FAC sources)

**Under-Development by MPCA Staff**:

Procedures and data involving the following subject areas are under-development and therefore, MPCA air dispersion modeling staff should be contacted (via the email address above) to discuss data files, methods, and/or procedures for:

- Standardized Mobile Source (SMS) Spreadsheet
- Background concentration data
- Nearby sources
- Pre-processed AERMET meteorological data files
- Ozone data generated for Tier 3 NO2 modeling

**Acronyms**

| | |
|---|---|
| $\mu g/m^3$ | Micrograms per cubic meter |
| AERMAP | AERMOD Terrain Preprocessor |
| AERMET | AERMOD Meteorological Preprocessor |
| AERMINUTE | AERMOD 1-Minute ASOS Wind Data Processor |
| AERMOD | AMS/EPA Regulatory Model |
| AERSURFACE | AERMOD Surface Characteristic Tool |
| AQ | Air Quality |
| AQDMP-01 | Air Quality Dispersion Modeling Protocol form |
| AQDMPS-01 | Air Quality Dispersion Modeling Protocol Spreadsheet |
| BPIP-PRIME | Building Profile Input Program for PRIME |
| CO | Carbon Monoxide |
| DEM | Digital Elevation Model |
| EAW | Environmental Assessment Worksheet |
| EIS | Environmental Impact Statement |
| EPA | U.S. Environmental Protection Agency |
| FAC | 3-letter facility ID |
| FAR | First-Approximation Representative |
| H1H | High-first-high value |
| H2H | High-second-high value |
| H6H | High-sixth-high value |
| $H_2S$ | Hydrogen Sulfide |
| km | Kilometer |
| LULC | Land Use Land Cover |
| MAAQS | Minnesota State Ambient Air Quality Standard |
| MPCA | Minnesota Pollution Control Agency |
| NAAQS | National Ambient Air Quality Standard |
| NAD | North American Datum of 1983 |
| NED | National Elevation Dataset |
| $NO_2$ | Nitrogen Dioxide |
| NWS | National Weather Service |
| OLM | Ozone Limiting Method |
| Pb | Lead |
| $PM_{10}$ | Particulate Matter less than 10 um in size |
| $PM_{2.5}$ | Particulate Matter less than 2.5 um in size |
| POINTCAP | Capped-release point source (AERMOD beta, non-default) |
| POINTHOR | Horizontal-release point source (AERMOD beta, non-default) |
| PPB | Parts Per Billion |
| PPM | Parts Per Million |
| PRIME | Plume Rise Model Enhancements |
| PSD | Prevention of Significant Deterioration Program |
| PVMRM | Plume Volume Molar Ratio Method |
| SCRAM | Support Center for Regulatory Atmospheric Modeling |
| SIL | Significant Impact Level |
| $SO_2$ | Sulfur Dioxide |
| SIP | State Implementation Plan |
| SMS | Standardized Mobile Source |
| UG/M3 | Micrograms per cubic meter ($\mu g/m^3$) |
| UTM | Universal Transverse Mercator |

## Attachment B - CLASS II MODELING SURFACE METEOROLOGY – Minimum Wind Speed for Modeling

This document contains a proposal to modify the current meteorological data set used in the Class II modeling to change wind speeds below 0.5 m/s to 0 m/s (calm). A proposal to use an alternate meteorological data set was submitted on August 5, 2011. This proposal was rejected by EPA as described in a document distributed via e-mail on November 28, 2011. During discussion of this proposal, EPA indicated that an alternative proposal for treating calm winds would likely be acceptable. This document describes such a proposal submitted on October 28, 2011. EPA has not completed the formal approval process to date, but it is anticipated based on discussion during weekly NorthMet air group meetings that EPA intends to approve this proposal.

**Issue:** The current meteorological data set being used for the Northmet Project Class II Air Dispersion Modeling Analysis is the 2006 – 2010 Hibbing, Minnesota airport surface data set processed using AERMINUTE for the AERMOD dispersion model. AERMINUTE processes an airport's ASOS (Automated Surface Observing System) data (which are two-minute averages stored at one minute intervals) to calculate hourly average meteorological data fields required for AERMOD. The minimum wind speed calculated by AERMINUTE for the Hibbing data set is 0.28 m/s. Our proposal is to revise the data set so the minimum wind speed is 0.5 m/s. This revision will make the AERMINUTE data set consistent with the minimum wind speed required for an on-site meteorological data set (Table 5-2 in Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005).

**Discussion:** The MPCA processed and provided the Hibbing, MN 2006 – 2010 AERMINUTE meteorological data set. We are proposing to substitute all wind speeds in this data set which are less than 0.5 m/s with 0 m/s. AERMOD interprets wind speeds of 0 m/s as calm. AERMOD does not calculate pollutant dispersion for calm hours. This substitution will change 997 hours (2.3% of total) in the data set. There are 43,800 hours in the data set.

The minimum recorded wind speed for an ASOS station is 2 knots (1.02 m/s) . The AERMINUTE program substitutes one-half the reporting limit (1 knot = 0.51 m/s) in its calculation of hourly averages (see excerpt below). The proposed change to the minimum wind speed in the meteorological data set is therefore both consistent with AERMINUTE data usage and the requirements of an on-site meteorological data set.

From Section 3.3 of AERMINUTE User's Instructions

If the record's date is inside the processing date range, the 2-minute average wind speed and direction are processed as:

- If the wind speed is less than 2 knots:
  - If the station is not part of the IFW group, or the station is part of the IFW group and the date and time of the record is before the station's IFW commission date, the 2-minute wind is considered to be "calm" and the wind speed is set to half the instrument threshold, i.e., 0.51 m/s (1 knot), consistent with guidance for processing site-specific wind data. The wind speed will be used in calculating the hourly average wind speed but the direction is considered to be invalid and will not be used in calculating the hourly wind direction.
  - If the station is part of the IFW group and the record's date is on or after the station's IFW commission date, the minute is flagged as non-calm and the speeds are converted from knots to m/s, since the threshold for sonic anemometers is effectively zero. The wind speed and wind direction are used in hourly averages.
- If the wind speed is 2 knots or greater, regardless of IFW group status and date, the 2-minute wind speed is converted from knots to m/s. The wind speed and wind direction are used in hourly averages.

## Attachment C – Non-Default Modeling Options

### I. $PM_{10}$ Particulate Deposition

$PM_{10}$ modeling conducted to date has used the OPENPIT option for the mining pit areas. The OPENPIT option requires particle size data (particle size category, mass fraction, density) as model inputs. The particle size data required by the OPENPIT option are also necessary model inputs for modeling sources including deposition. However, it was noted in preliminary modeling for the NorthMet Draft Environmental Impact Statement (DEIS) that in using the OPENPIT option along with particulate deposition for the remaining sources, the AERMOD model produced results that were not consistent with expected concentration patterns and were therefore unrealistic. Specifically, the model showed maximum concentrations from the pit at far receptors in a bull's eye pattern. Both the OPENPIT algorithm and the particulate deposition algorithm in the model are complex. While the internal calculations of the model are not readily apparent, the inconsistency of the results indicated that the model was not producing reliable results for particulate deposition and OPENPIT sources.

To address this issue, an alternative approach to accounting for particulate deposition was proposed and approved for the DEIS modeling. The same approach will be used for the modeling for the Supplemental Draft Environmental Impact Statement (SDEIS). In this alternative approach, particulate deposition is represented by the Decay Term (D). As stated in the model user's guide: "The Decay Term in Equation (1-1) is a simple method of accounting for pollutant removal by physical or chemical processes."

The decay term is calculated as a half-life as follows:

$D = \exp [ - \psi \ x / u_s ]$

Where: $\psi$ = decay coefficient ($s^{-1}$)
x = downwind distance (m)
$u_s$ = wind speed (corrected for release height)

and $\psi = 0.693 / T_{1/2}$

$T_{1/2}$ = pollutant half life (s)

Example :
$T_{1/2}$ = 900 s
x = 1000 m
$u_s$ = 4 m/s

$$D = \exp [ - (0.693/900) 1000 / 4 ]$$
$$= 0.825$$

In this case, 17.5% of the plume would be removed for a receptor at 1 km distance from the source. The model applies the Decay Term after conducting the other dispersion calculations.

The pollutant half life ($T_{1/2}$) is used to represent the various physical mechanisms which remove particulate mass from the plume. Deposition occurs from gravitational settling, removal by vegetation, particle agglomeration, and other mechanisms. The pollutant half life was estimated using the gravitational settling velocity (Stoke's Law) term as described in the model user's guide, as follows.

$$v_g = (\rho - \rho_{air}) g d_p^2 c_2 / [ 18 \mu ] * S_{CF} \qquad \text{(Equation 1-84)}$$

Where:
- $v_g$ = gravitational settling velocity (cm/s)
- $\rho$ = particle density (g/cm$^3$) = 2.7 for haul roads (crushed ore)
- $\rho_{air}$ = air density (= 1.2 x $10^{-3}$ g/cm$^3$)
- $d_p$ = particle diameter (µm) = 7.4 for mass-mean particle size
- $c_2$ = units conversion constant (1 x $10^{-8}$ cm$^2$/µm$^2$)
- $\mu$ = viscosity of air (1.81 x $10^{-4}$ g/cm/s)
- $S_{CF}$ = slip correction factor (see Equation 1-85; for a 7.4 µm particle $S_{CF}$ = 1.02)
- $g$ = acceleration due to gravity (981 cm/s$^2$

For the particle characteristics given above (7.4 µm diameter, 2.7 g/cm3 density), the gravitational settling term $v_g$ = 0.455 cm/s.

To calculate the pollutant half life, it was assumed that the time required for a 7.4 µm particle to settle from an average release height of 5 m would approximate the time-dependent component of deposition. For a 5 m release height, the settling time is T = 5 m x 100 cm/m / 0.455 cm/s = 1,100 s.

The calculation of pollutant half life and use of the decay coefficient to represent deposition was used in Midwest Research Institute's report prepared for the MPCA entitled: Iron Range Air Quality Analysis (June 1979). The MRI report also provided detailed emission inventories and modeling analysis (including model calibration) which were required for EPA approval of Minnesota's State Implementation Plan (SIP). During the late 1970s, the Iron Range was in nonattainment for TSP, and the 1979 modeling analysis was part of determining the actual attainment status and identifying mitigation measures and future attainment status. An important component of the modeling analysis was to adequately address particulate deposition so that the model results could be directly compared

to monitoring data. To account for particle deposition, the 1979 modeling assumed a particle density of 3 g/cm$^3$, a particle diameter of 12.25 µm, and a release height of 5 m, for a half life of 370 s.

The proposed pollutant half life of 1,100 s is 3 times greater than was assumed in the MRI study, with the greatest difference in the half life resulting from the smaller particle diameter used in this analysis. The 1979 analysis also assumed that particles less than 5 µm did not settle out. For this analysis, we propose to model particles less than 2.5 µm as though they do not deposit. For the mining fugitive dust sources, $PM_{2.5}$ accounts for 10% of the total $PM_{10}$. Therefore, the modeled emission rate will be scaled by a factor of 1.1 to account for the $PM_{2.5}$ portion of the $PM_{10}$ that would not be predicted to settle out.

**Reference:**

Midwest Research Institute, 1979. *Iron Range Air Quality Analysis*. Draft Final Report. MRI Project No. 4532-L(2). June 5, 1979. Prepared for Minnesota Pollution Control Agency.

USEPA, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models. Volume II – Description of Model Algorithms. USEPA – OAQPS. RTP, NC. September 1995.

USEPA, 2004. AERMOD Deposition Algorithms – Science Document (Revised Draft). March 19, 2004. http://www.epa.gov/scram001/dispersion_prefrec.htm#aermod.

**Determination of the mass mean particle diameter of 7.4 µm**

A size distribution curve representative of mechanically generated particulates is shown in Figure 2 on the Particle Size Categories page appended at the end of this discussion or can be accessed at the following website. http://www.epa.gov/air/oaqps/eog/bces/module3/category/category.htm (http://www.epa.gov/eogapti1/module3/category/category.htm).

This Figure 2 shows the frequency % particle by mass for three types of atmospheric particulates (ultrafine, fine, and coarse - supercoarse). The Particle Formation page http://www.epa.gov/air/oaqps/eog/bces/module3/formation/formate.htm (http://www.epa.gov/eogapti1/module3/formation/formate.htm) goes into some detail over the mechanisms associated with formation of the three classes of atmospheric particulates shown in Figure 2. As described on the Particle Formation page, physical attrition (mechanically generated) particles are shown to be primarily greater than $PM_{10}$ and correspond to the coarse - supercoarse curve on Figure 2.

The mass mean particle diameter used in the proposed decay coefficient reflects mechanically generated particulate. EPA's size spectrum shown in Figure 2 was used to apportion the particulate matter between 3 and 10 microns and develop the mass mean particle diameter. Figure 2 is generic in that it is representative of atmospheric particulates and is not specific to any industry or source type. Using Figure 2 for this calculation was recommended by MPCA on a previous project. Interpolation of the coarse - supercoarse curve for the coarse particle size range (between 2.5 and 10 microns which is representative of the fugitive $PM_{10}$ modeling) of Figure 2 leads to a mass mean diameter of 7.4 microns as shown below in Table 1 and Figures 3 and 4:

**Table 1 – $PM_{10}$ Mass Percent from EPA Figure 2**

| Particle Size | Frequency % Particles by Mass [1] | Normalized Mass % | Cumulative Normalized Mass % |
|---|---|---|---|
| 3 | 0.6 | 2.7% | 2.7% |
| 4 | 1.2 | 5.3% | 8.0% |
| 5 | 1.8 | 8.0% | 16.0% |
| 6 | 2.7 | 12.0% | 28.0% |
| 7 | 3.4 | 15.1% | 43.1% |
| 8 | 3.8 | 16.9% | 60.0% |
| 9 | 4 | 17.8% | 77.8% |
| 10 | 5 | 22.2% | 100.0% |

Figure 3 shows the cumulative mass % (normalized to 100%) derived from EPA's Figure 2. Note that Figure 3 did not use a mathematical representation of EPA's Figure 2 as one was not provided in EPA's references. Instead, Figure 3 was obtained by selecting the particle size and reading the mass % off of the Y-axis in Figure 2. The total mass % was normalized to 100% as shown in Table 1 above. Figure 4 shows the linear interpolation for the cumulative mass percent between the 7 and 8 µm particle sizes in Figure 3. As shown in Figure 4, the 50% cumulative mass percent intersects the 7.4 µm particle size.

[1] Interpolated from Figure 2 for the midpoint of the category (e.g., 10 micron frequency % is midpoint between 9 and 10 microns).

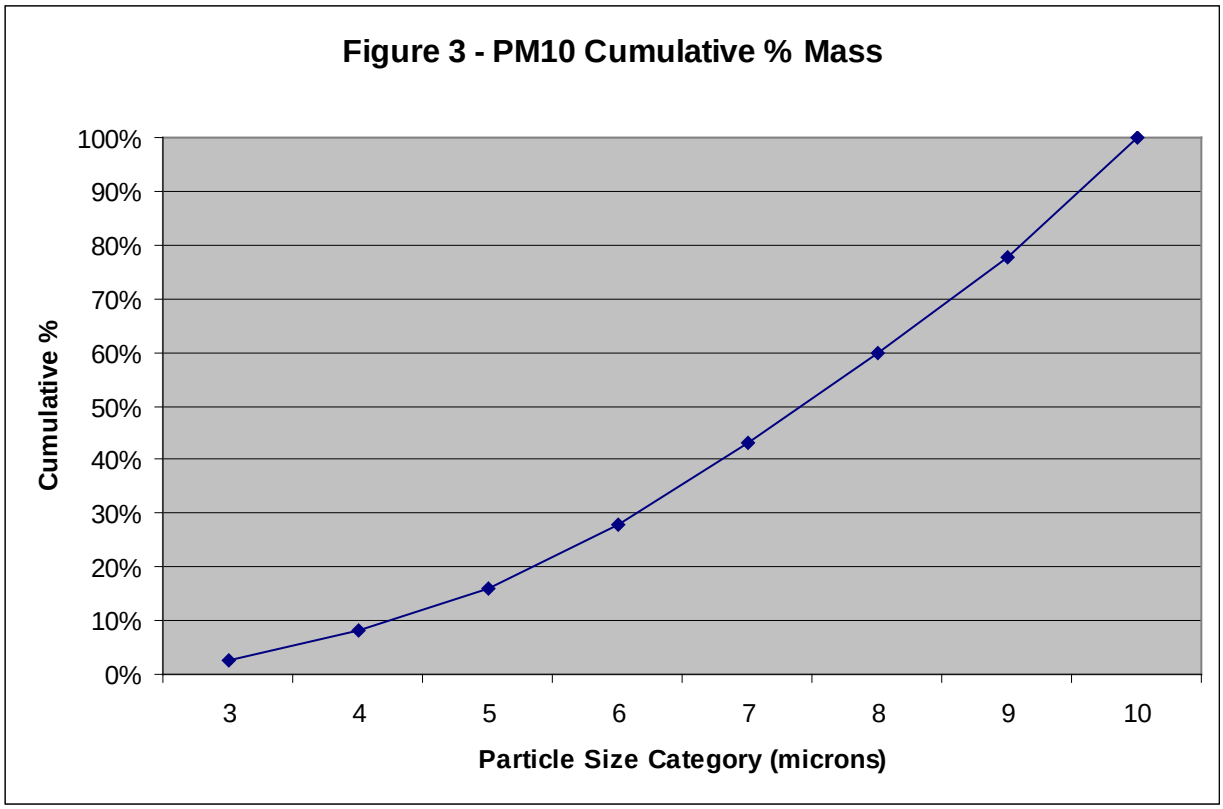



Figure 3 is derived from EPA's Figure 2 for the coarse particle size distribution curve.

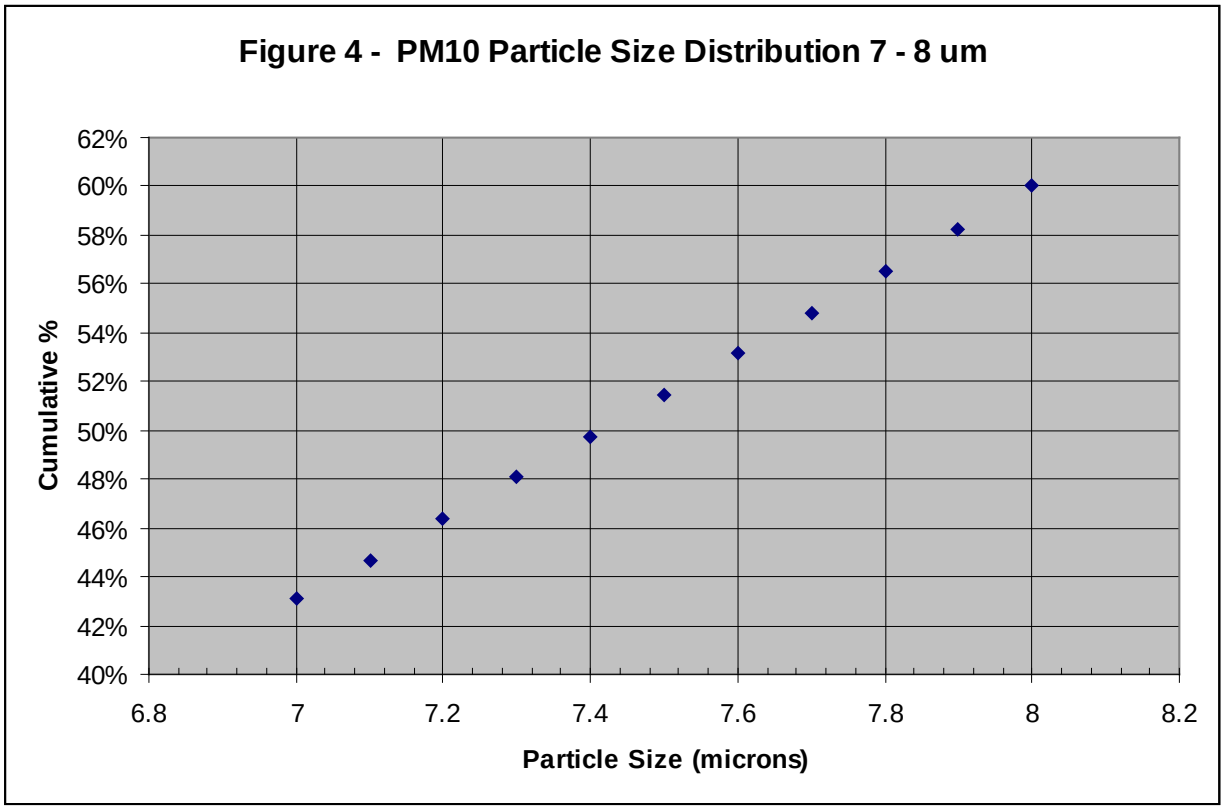



Figure 4 shows the linear interpolation between the 7 and 8 µm particle size categories from Figure 3 to determine the 7.4 µm mass mean particle size.

# Basic Concepts in Environmental Sciences

# Module 3: Characteristics of Particles - Particle Size Categories

**EPA Particle Size Terminology**

Since the range of particle sizes of concern for air emission evaluation is quite broad it is beneficial to divide this range into smaller categories. Defining different size categories is useful since particles of different sizes behave differently in the atmosphere and the respiratory system.

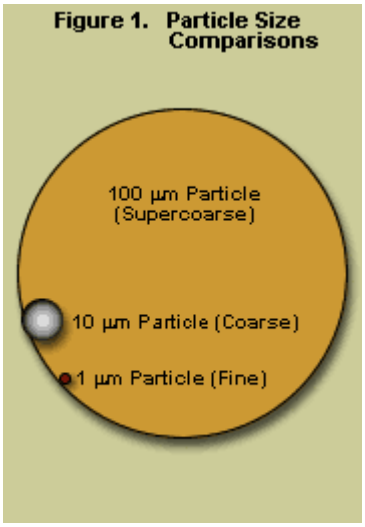
The EPA has defined four terms for categorizing particles of different sizes. Table 1 displays the EPA terminology along with the corresponding particle sizes.

**Table 1. EPA Terminology for Particle Sizes**

| EPA Description | Particle Size |
|---|---|
| Supercoarse | $d_{pa} > 10\ \mu m$ |
| Coarse | $2.5\ \mu m < d_{pa} \leq 10\ \mu m$ |
| Fine | $0.1\ \mu m < d_{pa} \leq 2.5\ \mu m$ |
| Ultrafine | $d_{pa} \leq 0.1\ \mu m$ |

Figure 1 provides a visual comparison of the size of a fine particle (1.0 $\mu m$), coarse particle (10 $\mu m$), and a supercoarse particle (100 $\mu m$). There is a substantial difference in size between these particles, all of which are considered moderate-to-large in air pollution control.

**Figure 1. Particle Size Comparisons**



**Regulated Particulate Matter Categories**

In addition to the terminology provided in Table 1 the EPA also categorizes particles as follows:

Total Suspended Particulate Matter (TSP)

$PM_{10}$

$PM_{2.5}$

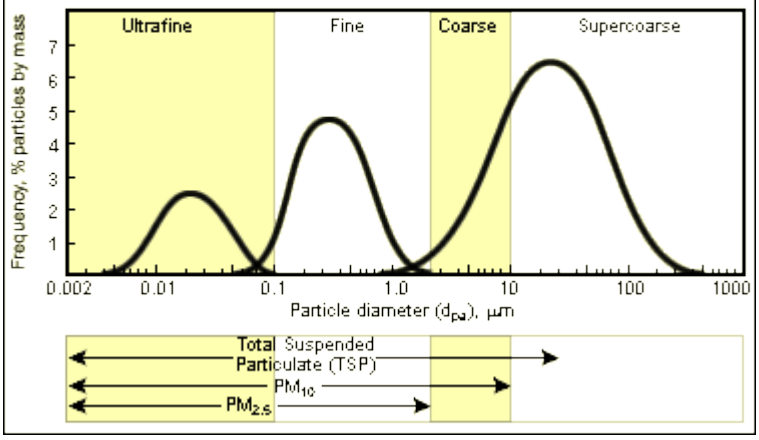
Particles less than 0.1 μm

Condensable Particulate Matter

These particle categories are important because particulate matter is regulated and tested for under these categories. The National Ambient Air Quality Standard for $PM_{2.5}$ was remanded by a District of Columbia court in May of 1999 and is under litigation as of the writing of these modules (December 1999). Air quality standards are presented in these modules as they were promulgated by the EPA, with no presumptions made regarding the outcome of the pending litigation.

Figure 2 displays a typical size distribution of atmospheric particulate matter that combines the two classification schemes discussed above.

**Figure 2. Ambient Particulate Matter Size Distributions**



## Total Suspended Particulate Matter

Particles ranging in size from 0.1 micrometer to about 30 micrometer in diameter are referred to as **total suspended particulate matter (TSP)**. TSP includes a broad range of particle sizes including fine, coarse, and supercoarse particles.

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## $PM_{10}$

The U.S. EPA defines $PM_{10}$ as particulate matter with a diameter of 10 micrometers collected with 50% efficiency by a $PM_{10}$ sampling collection device. However, for convenience in these modules, the term $PM_{10}$ will be used to include all particles having an aerodynamic diameter of less than or equal to 10 micrometers.

$PM_{10}$ is regulated as a specific type of "pollutant" because this size range is considered respirable. In other words, particles less than approximately 10 micrometers can penetrate into the lower respiratory tract. The particle size range between 0.1 and 10 micrometers is especially important in air pollution studies. A major fraction of the particulate matter generated in some industrial sources is in this size range. $PM_{10}$ is discussed in more detail in Module 6.

## Attachment C – Non-Default Modeling Options

### II. $PM_{10}$ Half-Life Modeling Analysis

The AERMOD model is setup that when the half-life option is selected it is applied to every source in the input file and does not allow the user to specify which sources it can be applied to (similar to the urban source option). The purpose of modeling $PM_{10}$ with half-life is to account for the deposition of particulate matter from mechanically generated fugitive dust sources. There are numerous sources included in the Plant Site modeling analysis that are not considered mechanically generated. In order to model all of the $PM_{10}$ Plant Site sources together, the LAKES AERMOD-View Multi-Chem utility will be used to combine the post-files of the mechanically generated half-life sources and the non-half-life sources together by each hour and receptor to determined the combined 24 hour and annual $PM_{10}$ NAAQS and Increment concentration results.

The LAKES Multi-Chem utility allows the user to model multiple emission rates for the same input file by splitting out a single AERMOD input file into individual source, unitized model runs. Each source is modeled individually at 1 g/s with an output plot file and post file for the maximum 1hour concentration. Multi-Chem then post-processes the individual source files, combining them together by hour and receptor and multiplying each source's individual concentration results by an emission rate specified in a text file input to the software. Using this utility creates a significant amount of data files due to a post file created for every individual source. Since the format of the post-files is the same whether for a single source or a combination of sources, PolyMet is proposing to use the Multi-Chem post-processing capabilities, but not for individual source, unitized post file runs.

The $PM_{10}$ modeling for the Plant Site will be divided into two separate modeling files. The first file will model the non-half life sources listed in the paragraph above in regulatory default mode using the hourly $PM_{10}$ emission rates calculated in the emission inventory. The input file will be setup to model the 1 hour concentration and output the maximum 1 hour high $1^{st}$ high concentration plot file and post file. The second file will model the mechanically generated fugitive dust sources using the half-life option using the hourly $PM_{10}$ emission rates calculated in the emission inventory multiplied by 1.1 to account for the 10% of the $PM_{10}$ that is made up of $PM_{2.5}$ and is not subject to deposition. The output will be the maximum 1 hour high $1^{st}$ high concentration plot file and post file similar to the first input file. Using the Multi-Chem post-processing utility, these post files will be combined on an hour by hour basis for each receptor. Since the actual modeled hourly $PM_{10}$ emission rates will be accounted for in the post files, the emission rate text file that is required for the Multi-Chem

utility will list the emission rates for the two post-files as 1 g/s. In this way, the half-life and non-half-life sources will be combined in time and space and the 24 hour $PM_{10}$ high 2nd high plot file can be produced for determining the Increment results and the high 1st high through high 6th high plot files can be produced for determining the NAAQS results. Using this method provides the option of modeling half-life for specific sources without the necessity of creating individual input files and an overwhelming number of post files.

## Attachment C – Non-Default Modeling Options

### III. $PM_{2.5}$ Secondary Formation

This section describes the proposed 24-hour $PM_{2.5}$ NAAQS modeling methodology to account for secondary formation of $PM_{2.5}$ due to the plant site combustion sources. The modeling analysis will use the off-set ratio method described in the National Association of Clean Air Agencies (NACAA) Report[2] published January 7, 2011. The method multiplies the direct $PM_{2.5}$ emissions of combustion sources with an offset ratio to reflect the $PM_{2.5}$ created from secondary formation. The offset ratio represents the amount of $NO_X$ or $SO_2$ that contributes to $PM_{2.5}$ concentrations through secondary formation. This value is called the total equivalent primary $PM_{2.5}$ emission rate. The equation (Primary $PM_{2.5}$ [TPY] + [$SO_2$ TPY]/15 + [$NO_X$ TPY]/77) was used to calculate the total equivalent $PM_{2.5}$ emission rates for each of the combustion sources.

The combustion sources used the hourly $SO_2$ and $NO_X$ emission rates converted to TPY to calculate the total equivalent $PM_{2.5}$ emissions. The offset ratios for $NO_X$ and $SO_2$ used in this equation are from the NAACA document and were developed in that report for a source located in Northern Minnesota.

There will be nine combustion sources at the Plant Site (five considered intermittent sources) which make up only 3.4% of the total direct $PM_{2.5}$ emissions. Therefore, secondary particulate formation is not expected to contribute significantly to the maximum modeled $PM_{2.5}$ concentration.

[2] "$PM_{2.5}$ Modeling Implementation for Projects Subject to National Ambient Air Quality Demonstration Requirements Pursuant to New Source Review", NACAA $PM_{2.5}$ Modeling Implementation Workgroup

**Attachment J - NorthMet Nearby Source Emission Description**
March, 2, 2012

This document briefly describes the emission data and model setup that will be used for sources adjacent to the NorthMet Project (Project) Plant Site location. Additional sources will be included in the sulfur dioxide and nitrogen dioxide modeling for compliance with the 1-hour National Ambient Air Quality Standards (NAAQS) per guidance and procedures developed by the Minnesota Pollution Control Agency (MPCA).

The specific sources described in this write-up are the Mesabi Nugget and Cliffs Erie, LLC (Cliffs Erie) facilities near Hoyt Lakes, Minnesota and the Northshore Mining Peter Mitchell Mine near Babbitt, Minnesota. These facilities require a more detailed representation in the cumulative impacts modeling to be completed for the Project due to their close proximity to the Project site and inclusion in previous scoping discussions and impacts assessments for the Project. Additional sources requiring explicit modeling based on the First Approximation Run (FAR) modeling analysis are listed below and their modeling files will be requested/supplied by the MPCA.

One increment expanding source will also be included the Plant Site modeling: the LTV Steel Mining Company (LTVSMC) taconite plant that operated near Hoyt Lakes, Minnesota. Most of the LTVSMC emission sources were located within the Plant Site boundary. Only these sources will be modeled for increment expansion. The modeling inputs, which were previously approved for the NorthMet Draft Environmental Impact Statement (DEIS), are included with the supplemental files for this protocol.

**1 Hour $SO_2$/$NO_2$ FAR Analysis:**

Following MPCA's request a 1 hour $NO_2$ and $SO_2$ FAR modeling analysis was conducted to determine any additional nearby sources to be included in the $SO_2$ and $NO_2$ cumulative NAAQS modeling for the Plant Site. The FAR modeling analysis used the 1 hour $NO_2$ and $SO_2$ modeling files "PMP$47.5981N_92.1391W_2005NEIandFAR2G_NO2_.far" and "PMP$47.5981N_92.1391W_2005NEIandFAR2G_SO2_.far" supplied by Dennis Becker of the MPCA in December 2011 as inputs. These files contain location specific AERMOD input parameters for nearby $NO_2$ and $SO_2$ emitters in a conservative format assuming total facility emissions from a single volume source.

These inputs are modeled for a receptor centered on the Plant Site and compared to the 1 hour SIL. If the nearby source exceeds the SIL, then it will be included in the Cumulative Analysis, but with refined input data supplied by the MPCA. The modeling files are included in the supplemental files attached with this protocol and the additional nearby sources to include for the $SO_2$ and $NO_2$ NAAQS modeling are summarized below.

$SO_2$: Northshore Peter Mitchell Mine (described below); Ispat Inland Steel; U.S. Steel – Minntac; Virginia Public Utilities; and Minnesota Power

$NO_2$: Ispat Inland Steel; U.S. Steel – Minntac; Virginia Public Utilities; and Minnesota Power

**Mesabi Nugget:**
The Mesabi Nugget Project includes two phases referred to as Phase I or the Large Scale Demonstration Plant and Phase II or the Mesabi Mining project. Phase I has been fully permitted and has commenced operations. The environmental review and permitting process has begun for Phase II, but an air emission permit has not been issued to date.

The Mesabi Nugget Phase I Nugget Plant and Phase II Mining operations will both be modeled explicitly as nearby NAAQS and Increment sources for the Plant Site cumulative analysis. In May 2009, a Class II Air Dispersion Modeling Report was submitted for the Mesabi Nugget Phase II Environmental Impact Statement (EIS) containing the modeling analysis for the $PM_{10}$ and $PM_{2.5}$ NAAQS and the $PM_{10}$ Increment. MPCA and Barr modeling staff have verified that Barr possesses the modeling files most recently submitted by the project proposer. These modeling files will be used to model Mesabi Nugget Phase II in the Project modeling. MPCA has the modeling files and emission inventory for this project, so additional documentation will not be provided to support the Project modeling.

The Mesabi Phase I Nugget Plant was permitted in 2005 for the criteria pollutants $PM_{10}$, $SO_2$, $NO_X$, CO, and lead. In October 2009, a permit amendment was completed to update the $PM_{10}$ and $PM_{2.5}$ emissions to include additional concentrate delivery traffic on the main entrance paved road. The updated modeling was approved for the $PM_{10}$ and $PM_{2.5}$ NAAQS and $PM_{10}$ increment. PolyMet has requested the October 2009 $PM_{10}/PM_{2.5}$ modeling files from MPCA for explicitly modeling the Phase I Nugget plant with the Plant Site cumulative EIS analysis. The $SO_2$ and $NO_X$ emissions from the May 2005 permit will be used for the other criteria pollutant modeling for the Plant Site using the modeled stack parameters from the October 2009 modeling.

**Cliffs Erie:**
Cliffs Erie owns the former LTV Steel Mining Company (LTVSMC) taconite mine and processing plant near Hoyt Lakes, Minnesota. The site is now operating under mitigation, reclamation and closure conditions, which include minimal emission generating activities, in comparison to when it was operated as a taconite facility. Many of the emission units and associated land remaining from the LTVSMC operation have been purchased by PolyMet and are proposed to become part of the Project. A notable exception is the LTVSMC pellet plant which has been demolished.

Cliffs Erie has maintained the air emission permit for the site since they acquired it. The permit was reissued on December 14, 2011 as Air Emission Permit No. 13700009-006.

This facility will be included in the cumulative NAAQS evaluation for the Project. The facility was in operation at the baseline date, so it does not consume increment and will not be included in the increment assessment.

MPCA has provided a copy of the emission inventory submitted in support of the re-issuance application to PolyMet for use in cumulative impact modeling for the Project. In comments received on version 1 of the standalone write-up on nearby sources, MPCA identified sources to be removed from the inventory. The general procedure proposed for modeling this facility is to identify which sources in the current Cliffs Erie permit would have the potential to continue

operations, under Cliffs Erie control, after the commencement of operations of the Project. The emission units that will remain under Cliffs Erie control are all fugitive in nature, and therefore are not assigned to specific stacks or vents. A volume source will be configured, centered around the Cliffs Erie Pellet Yard, and emissions from all activities identified as continuing to operate after Project operation commences will be assigned to this volume source. Table 1 below summarized the sources in the re-issued Cliffs Erie permit, their anticipated future status, and how they are proposed to be treated in the Project impact assessment.

**Table 1 - Proposed Modeling of Sources in Draft Cliffs Erie Permit**

| Source ID | Source Name | Future Status[1] | Proposed Treatment in Modeling |
|---|---|---|---|
| FS 009 | Pellets, Load | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 010 | Tailings, Load | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 011 | Tailings, Unload | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 014 | Waste Rock, Truck Load | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 015 | Waste Rock, Truck Unload | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 016 | Tailings, Road Dust | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 017 | Waste Rock, Road Dust | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 020 | Pellets, Storage Pile | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 021 | Tailings, Storage Pile | Transferred to PolyMet | Tailings Basin Modeled with Project |
| FS 022 | Waste Rock, Storage Pile | May be operated by Cliffs Erie | Include in Cliffs Erie facility |
| FS 032 | Tailings, Tailings Basin | Transferred to PolyMet | Tailings Basin Modeled with Project |
| EU 148 | Administrative Building Boiler 2 | Transferred to PolyMet | Modeled with Project |
| EU 149 | Administrative Building Boiler 3 | Transferred to PolyMet | Modeled with Project |

Further details on the sources and emissions are provided in an attached Excel spreadsheet titled "NorthMet Nearby Source Model Inputs ver 2".

[1] Anticipated status of the source after commencement of Project operations.

This spreadsheet also includes the parameters for the volume source that will be used to represent the emission points at the Cliffs Erie facility in the Project modeling. It should be noted that the model configuration described here and represented in the spreadsheet will be used in initial modeling runs. If the preliminary results appear to show excessive impacts from the Cliffs Erie facility, a more refined modeling setup for the facility may be proposed in a subsequent submittal.

**Northshore Peter Mitchell Mine:**

The Northshore Mining Company Peter Mitchell Mine operates under Air Emission Permit No. 13700032-001. This facility will be included in the cumulative NAAQS evaluation for the Project. The facility was in operation at the baseline date, so it does not consume increment and will not be included in the increment assessment.

Emission rates were taken from this permit for the relevant emission sources. These sources are listed in the table below:

**Table 2 – Northshore Emission Sources to be Modeled**

| Source ID | Source Name | Source Type |
|---|---|---|
| EU 001 | Shop Boiler 1 | Point |
| EU 002 | Shop Boiler 2 | Point |
| EU 003 | Shop Boiler 3 | Point |
| EU 004 | Shop Boiler 4 | Point |
| EU 005 | Crusher 1, Primary and Secondary | Point |
| EU 009 | Portable Aggregate Crusher | Point |
| EU 010 | Ore Loadout at Crusher 1 | Volume |
| All FS | Fugitive Sources | Volume |

The emission rates for the relevant pollutants and the modeling parameters for each source are shown in the attached Excel spreadsheet titled “NorthMet Nearby Source Model Inputs ver 1”. $PM_{2.5}$ emissions are not included in the Northshore mine permit. For initial modeling runs, $PM_{2.5}$ will be assumed equal to $PM_{10}$. Additional analysis may be performed if initial results do not show compliance with the NAAQS.

**Attachment K – Anticipated Outputs (OU Pathway)**
**V# means "version number" since the number of iterations is unknown. # will be replaced by a numerical value**

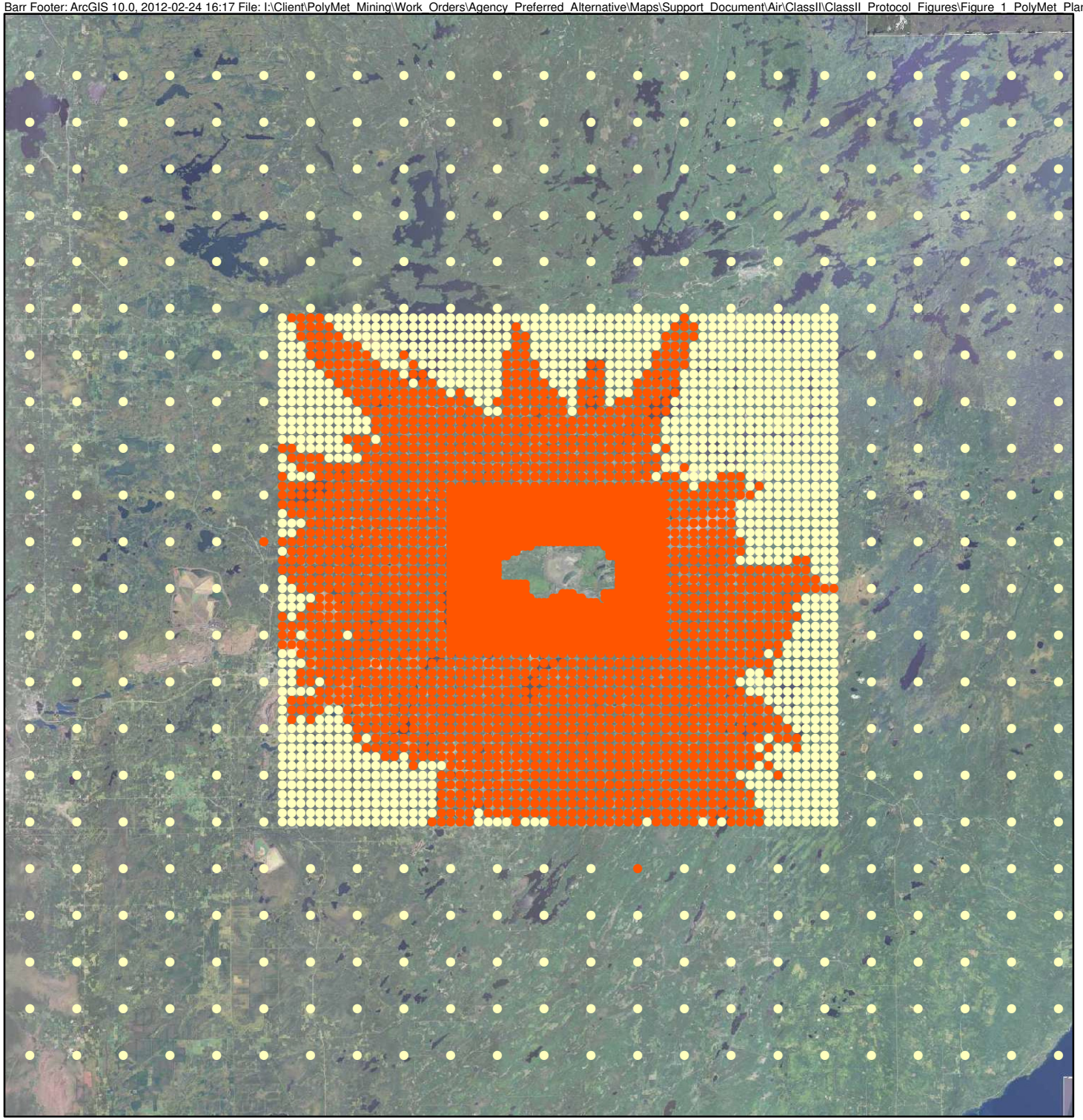
| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| SIL | $NO_2$ | 1-hour | ALLAVE 1ST | 01H1HGALLv2.PLT |
| | | Annual | ALLAVE | ANNSILGALLv106.PLT<br>ANNSILGALLv107.PLT<br>ANNSILGALLv108.PLT<br>ANNSILGALLv109.PLT<br>ANNSILGALLv110.PLT |
| NAAQS | $NO_2$ | 1-hour | ALLAVE 8TH | 01H8HGALLv#.PLT |
| | | Annual | ALLAVE | ANNNQSGALLv#06.PLT<br>ANNNQSGALLv#07.PLT<br>ANNNQSGALLv#08.PLT<br>ANNNQSGALLv#09.PLT<br>ANNNQSGALLv#10.PLT |
| INCREMENT | $NO_2$ | Annual | ALLAVE | ANNINCGALLv#06.PLT<br>ANNINCGALLv#07.PLT<br>ANNINCGALLv#08.PLT<br>ANNINCGALLv#09.PLT<br>ANNINCGALLv#10.PLT |
| SIL | $SO_2$ | 1-hour | ALLAVE 1ST | 01H1HGALLv206.PLT<br>01H1HGALLv207.PLT<br>01H1HGALLv208.PLT<br>01H1HGALLv209.PLT<br>01H1HGALLv210.PLT |
| | | 3-hour | ALLAVE 1ST | 03H1HGALLv206.PLT<br>03H1HGALLv207.PLT<br>03H1HGALLv208.PLT<br>03H1HGALLv209.PLT<br>03H1HGALLv210.PLT |
| | | 24-hour | ALLAVE 1ST | 24H1HGALLv206.PLT<br>24H1HGALLv207.PLT<br>24H1HGALLv208.PLT<br>24H1HGALLv209.PLT<br>24H1HGALLv210.PLT |
| | | Annual | ALLAVE | ANNALLv206.PLT<br>ANNALLv207.PLT<br>ANNALLv208.PLT<br>ANNALLv209.PLT<br>ANNALLv210.PLT |

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| NAAQS | $SO_2$ | 1-hour | ALLAVE 4TH | 01H4HGALLv#.PLT |
| | | 3-hour | ALLAVE 2ND | 03H2HGALLnv#06.PLT<br>03H2HGALLnv#07.PLT<br>03H2HGALLnv#08.PLT<br>03H2HGALLnv#09.PLT<br>03H2HGALLnv#10.PLT |
| | | 24-hour | ALLAVE 2ND | 24H2HGALLnv#06.PLT<br>24H2HGALLnv#07.PLT<br>24H2HGALLnv#08.PLT<br>24H2HGALLnv#09.PLT<br>24H2HGALLnv#10.PLT |
| | | Annual | ALLAVE | ANNALLnv#06.PLT<br>ANNALLnv#07.PLT<br>ANNALLnv#08.PLT<br>ANNALLnv#09.PLT<br>ANNALLnv#10.PLT |
| INCREMENT | $SO_2$ | 3-hour | ALLAVE 2ND | 03H2HGALLiv#06.PLT<br>03H2HGALLiv#07.PLT<br>03H2HGALLiv#08.PLT<br>03H2HGALLiv#09.PLT<br>03H2HGALLiv#10.PLT |
| | | 24-hour | ALLAVE 2ND | 24H2HGALLiv#06.PLT<br>24H2HGALLiv#07.PLT<br>24H2HGALLiv#08.PLT<br>24H2HGALLiv#09.PLT<br>24H2HGALLiv#10.PLT |
| | | Annual | ALLAVE | ANNALLiv#06.PLT<br>ANNALLiv#07.PLT<br>ANNALLiv#08.PLT<br>ANNALLiv#09.PLT<br>ANNALLiv#10.PLT |
| SIL | $PM_{2.5}$ | 24-hour | ALLAVE 1ST | 24H1Hpm25GALL06.plt<br>24H1Hpm25GALL07.plt<br>24H1Hpm25GALL08.plt<br>24H1Hpm25GALL09.plt<br>24H1Hpm25GALL10.plt |
| | | Annual | ALLAVE | ANNpm25GALL06.plt<br>ANNpm25GALL07.plt<br>ANNpm25GALL08.plt<br>ANNpm25GALL09.plt<br>ANNpm25GALL10.plt |

| Standard | Pollutant | Averaging Period | Output Table | Result Plot Files |
|---|---|---|---|---|
| NAAQS | $PM_{2.5}$ | 24-hour | ALLAVE 8TH | 24H8v#GALL06.plt<br>24H8v#GALL07.plt<br>24H8v#GALL08.plt<br>24H8v#GALL09.plt<br>24H8v#GALL10.plt |
| | | Annual | ALLAVE | AN00v#GALL06.plt<br>AN00v#GALL07.plt<br>AN00v#GALL08.plt<br>AN00v#GALL09.plt<br>AN00v#GALL10.plt |
| INCREMENT | $PM_{10}$ | 24-hour | ALLAVE 2ND | PMTEN_24_h2_INCv#06.plt<br>PMTEN_24_h2_INCv#07.plt<br>PMTEN_24_h2_INCv#08.plt<br>PMTEN_24_h2_INCv#09.plt<br>PMTEN_24_h2_INCv#10.plt |
| | | Annual | ALLAVE | PMTEN_annual_INCv#06.plt<br>PMTEN_annual_INCv#07.plt<br>PMTEN_annual_INCv#08.plt<br>PMTEN_annual_INCv#09.plt<br>PMTEN_annual_INCv#10.plt |
| NAAQS | $PM_{10}$ | 24-hour | ALLAVE 1ST–6TH | PMTEN_24_h1_NAAQSv#.plt[1]<br>PMTEN_24_h2_NAAQSv#.plt[1]<br>PMTEN_24_h3_NAAQSv#.plt[1]<br>PMTEN_24_h4_NAAQSv#.plt[1]<br>PMTEN_24_h5_NAAQSv#.plt[1]<br>PMTEN_24_h6_NAAQSv#.plt[1] |
| | | Annual | ALLAVE | PMTEN_annual_NAAQSv#06.plt<br>PMTEN_annual_NAAQSv#07.plt<br>PMTEN_annual_NAAQSv#08.plt<br>PMTEN_annual_NAAQSv#09.plt<br>PMTEN_annual_NAAQSv#10.plt |

[1]These plot files will be repeated for years 2006-2010

Barr Footer: ArcGIS 10.0, 2012-02-24 16:17 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_1_PolyMet_PlantSite_SIL_Receptor_Grid_with_Exceedences.mxd User: jjm



PASS

EXCEEDENCE

N

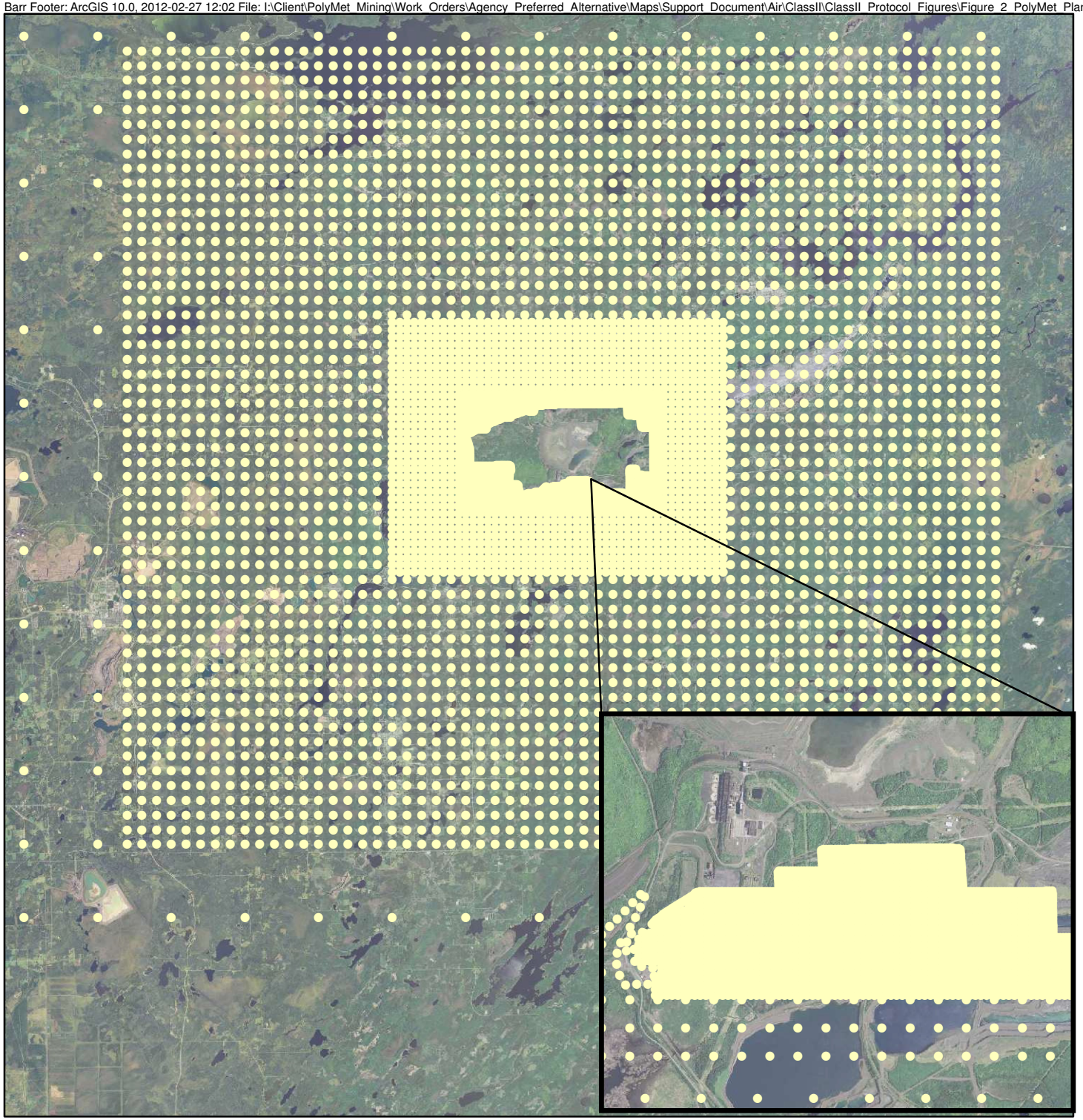
Kilometers

10 0 10

Figure 1

SIL Receptor Grid with Exceedences
PolyMet Plant Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

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EIS Plant Only Receptors

Kilometers

5 0 5

Figure 2

EIS Plant Only Receptor Grid
PolyMet Plant Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-02-27 13:40 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_3_PolyMet_PlantSite_CumulativeEIS_Receptor_Grid_with_Exceedences.mxd User: jjm



Cumulative EIS Receptors

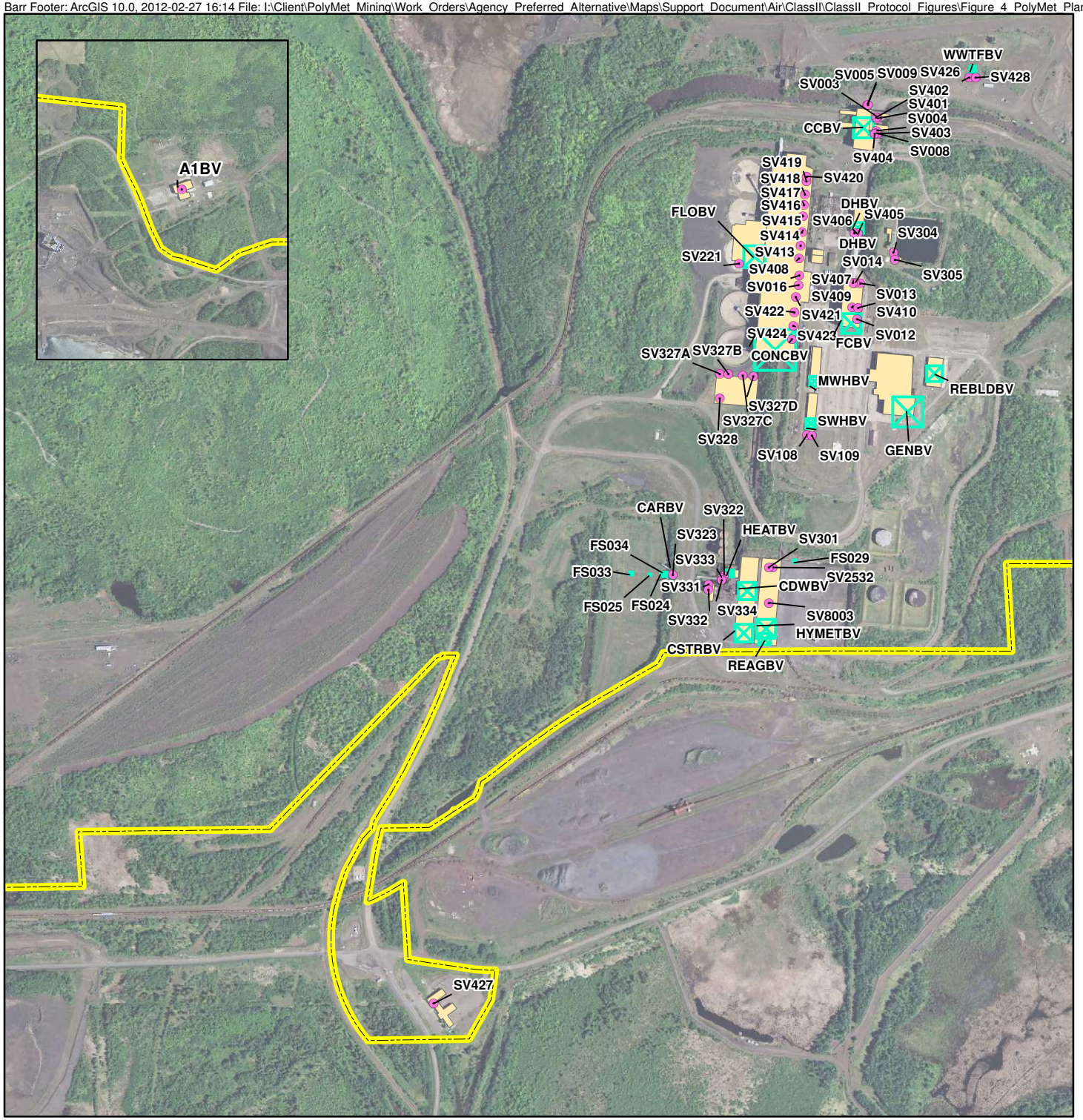
N

Kilometers

5 0 5

Figure 3

EIS Cumulative Analysis Receptor Grid
PolyMet Plant Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN




Point Sources

Volume Sources

BPIP Structures

Ambient Air Boundary

N

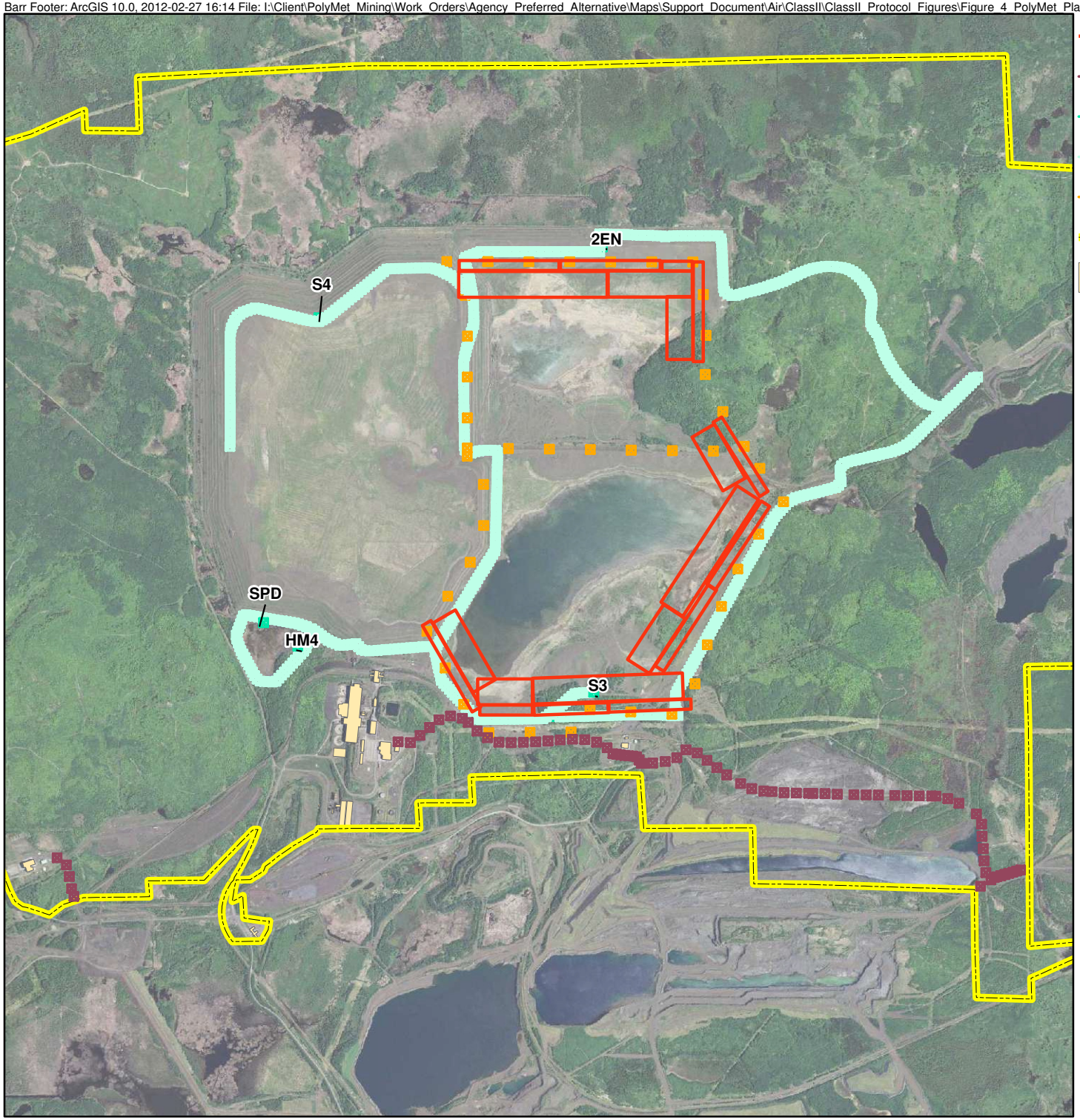
Meters

100 0 100

Figure 4

Plant Modeled Source Layout
PolyMet Plant Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-02-27 16:14 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Protocol_Figures\Figure_4_PolyMet_PlantSite_Modeled_Source_Layout.mxd User: jjm




Tailings Basin Erodible Beach Area
Dunka Road Traffic
Tailings Construction Handling
Tailings Construction Roads
Tailings Maintenance Traffic
Ambient Air Boundary
BPIP Structures

N

Meters
500 0 500

Figure 5

Tailings Basin Modeled Source Layout
PolyMet Plant Site EIS
Class II Modeling Protocol
NorthMet Project
Hoyt Lakes, MN

**Attachment F**

**Mine Site Class II Air Quality Dispersion Modeling Report**

# Mine Site Class II Air Quality Dispersion Modeling Report

**Version 2**

**August 2012**

**NorthMet Project**

**PolyMet Mining Incorporated**

**Hoyt Lakes, MN**

This document provides the Class II dispersion modeling report for the Mine Site in the format requested by the Minnesota Pollution Control Agency (MPCA). This includes MPCA form AQDMR-01 and seven figures. The figures are listed below.

## Figures:

Figure 1 EIS Cumulative NAAQS-Increment Receptor Grid
Figure 2 24 Hour PM10 Increment Year 8 Results
Figure 3 24 Hour PM10 Increment Year 13 Results
Figure 4 24 Hour PM10 NAAQS Year 8 Results
Figure 5 24 Hour PM10 NAAQS Year 13 Results
Figure 6 24 Hour PM25 NAAQS Year 8 Results
Figure 7 24 Hour PM25 NAAQS Year 13 Results

In addition to this document, requested electronic files will be provided via the Project Air FTP Site. The electronic files will include updated emission calculation spreadsheets for the Mine Site and the nearby sources.

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

# AQDMR-01

## Air Quality Dispersion Modeling Report(AQDMR)

Protocol Form for Criteria Pollutant Modeling

*Doc Type: Air Dispersion Modeling*

**Acronym Information on Page 6**

**Instructions:** Permit applicants required to conduct air dispersion modeling should submit two paper copies of the completed Air Quality Dispersion Modeling Report form (AQDMR-01) and all accompanying files to:

Air Quality Permit Document Coordinator
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Applicants may also submit an electronic version in addition to the two paper copies.

Electronic copies of the forms and accompanying files should be sent to: AirModeling.PCA@state.mn.us.

## Facility Information

AQ tracking number: _____

AQ file no.: _____ AQ facility/permit ID no.: _____ Today's date (mm/dd/yyyy): 8/27/2012

Three-letter modeling facility ID (ex., XEK = Xcel Energy Allen S. King, MEC = Mankato Energy Center, etc.): PMM

Facility name: PolyMet Mining Inc.

Facility street address: 6500 County Road 666

City: Hoyt Lakes County: St. Louis

State: MN Zip code: 55750 Elevation at facility: 493 m

Facility contact: Kevin Pylka Protocol prepared by: Jennifer Koenen, Barr Engineering Co.

Facility contact phone: (218) 471 - 2162 Preparer phone: (952) 832 - 2682

Facility contact e-mail address: kpylka@polymetmining.com Preparer e-mail address: jkoenen@barr.com

Latitude, Longitude of facility (Decimal degrees to **four** decimal places): 47.6141 N, 91.9690 W

UTM coordinates of facility (NAD83, zone 15 extended **only**): x = 577,480.00 m East, y = 5,273,931.00 m North

**This report is associated with:**

- ☐ Permit application
- ☐ Permit requirement
- ☒ Other: EIS

## Project Description (50 words or less)

PolyMet plans to construct and operate a mine (subject of this protocol), to reactivate portions of the LTV Steel Mining Company facility and to build a hydrometallurgical concentrate processing facility at the former LTVSMC site. More detail is available in the NorthMet Project Description Version 3 Submitted September 13, 2011.

## Files to Accompany Modeling Report

Include the following files with the completed modeling report form. Use checkbox to indicate that all applicable files are included.

1. ☒ AERMOD input files (*.inp, *.adi, *.ami)
   ☒ AERMOD output files (*.out, *.ado, *.amo)
   ☒ AERMOD plot files (*.plt)
   ☒ AERMOD post files (*.pst) – If applicable
   ☒ AERMOD event files (*.evi, *.evo) – If applicable

☒ AERMOD miscellaneous/other files (MAXDCONT, ?, ?, etc.) – If applicable

2. AERMET files: ☒ *.sfc ☒*.pfl
3. BPIP-PRIME files: ☒ Input (*.bpi) ☒ Output (*.bpo, *.sum)
4. AERMAP files: ☒ Terrain (*.dem(s), *.tif (NED files)), ☐ Input (*.ami), ☒ Output (*.rou, *.sou, etc.)
5. Background data files: ☒ Background concentrations for applicable pollutants (seasonal, monthly, daily, hourly, etc.)
6. Modeling Results: ☒ Figures (*.jpeg, *.pdf), ☐ GIS Maps (*.shp)
7. AQDMPS-01 spreadsheet*: ☐
8. Other files and supporting documents (SMSv*.xls, Far sources, readme, etc.):

   The final PolyMet Mine Site emission inventory will be included with this report in lieu of the AQDMPS-01 spreadsheet as stated in the approved modeling protocol.

* *Provide the final spreadsheet (i.e. AQDMPS-01) and indicate/highlight changes.*

## Section 1. Modeling Protocol

1. The Air Dispersion Modeling presented in this report is based on a Protocol that has been:

   ☒ Approved ☐ Conditionally approved ☒ *MPCA approval date (mm/dd/yyyy): Ruth Roberson Review: 3/19/2012; Sarah Seelen Review: 3/26/2012; Approval Email Sent: 3/27/2012

   **This is the date given on AQDM PAN-01 form*

2. Does this Modeling submittal **completely** follow the Approved Protocol? ☐ Yes ☒ No

   If yes, proceed to Section 3.

   If no, proceed to Section 2.

## Section 2. Changes to Modeling Protocol

**Table 1: Protocol Changes** (Please indicate which sections in Approved Protocol contain changes.)

**Modeling protocol by sections**

| Section and section name | Change/No change |
|---|---|
| Files to accompany protocol | No Change |
| Section A<br>*Purpose for Air Dispersion Modeling and Related Information* | No Change |
| Section B<br>*EPA Pre-Processors and EPA Post-Processors* | No Change |
| Section C<br>*Model Selection and Options (Key CO Pathway Inputs)* | Change |
| Section D<br>*Emission Source Characterizations and Parameters (Key SO Pathway Inputs)* | Change |
| Section E<br>*Paved Roads Fugitive Dust (as per MPCA April 25, 2011 Policy)* | No Change |
| Section F<br>*Receptors (RE Pathway)* | Change |
| Section G<br>*Meteorological Data (ME Pathway)* | No Change |
| Section H<br>*SIL Analysis and Results* | No Change |
| Section I<br>*Background Values* | No Change |
| Section J<br>*Nearby Sources* | Change |
| Section K | Change |

| | |
|---|---|
| *Anticipated Outputs (OU Pathway)* | |

## Section 2.1: Detailed Changes to Modeling Protocol

Please provide specific information corresponding to those sections in Table 1 where changes are indicated.

### Section A. Purpose for air dispersion modeling and related information

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section B. EPA pre-processors and EPA post-processors

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section C. Model selection and options (Key CO pathway inputs)

MPCA approved change: ☒ Yes ☐ No Date (mm/dd/yyyy): 8/21/12

Describe changes and/or indicate section item number(s):

1. AERMOD version 12060 will be used. MPCA report review form for version 1 of this report indicated that this change was acceptable.

### Section D. Emission source characterizations and parameters (Key SO pathway inputs)

MPCA approved change: ☐ Yes ☒ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

1b. Category 1 year 20 stockpile haul road revised, so haul length changed and number and location of volume sources making up the haul road was updated. This change was included in the emission inventory submitted with version 1 of this report. MPCA did not comment on these changes.

8. The source groups for the PM2.5 NAAQS modeling were also slightly changed and renamed. The source groups included are: ALL, NOPMP, NOMN, NONSM, PMM, and NSM.

### Section E. Paved roads fugitive dust

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section F. Receptors (RE pathway)

MPCA approved change: ☐ Yes ☒ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

6. The receptor grid did not change from the protocol, however, the property ownership and tax records were evaluated to determine an appropriate ambient air boundary for Northshore Peter Mitchell Mine, so its impacts would not be evaluated on its own property. Figure 1 with this report is a revised protocol Figure 6 with the Peter Mitchell Mine property receptors highlighted.

### Section G. Meteorological data (ME pathway)

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section H. SIL analysis and results

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section I. Background values

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section J. Nearby sources

MPCA approved change: ☒ Yes ☐ No Date (mm/dd/yyyy): 8/7/2012

Describe changes and/or indicate section item number(s):

Revised emission rates for the Northshore Mining Company Peter Mitchell Mine have been agreed upon with MPCA. Revised calculations are included with the neaby source spreadsheet provided electronically.

### Section K. Anticipated outputs (OU pathway)

MPCA approved change: ☐ Yes ☒ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

1. The plot file names listed in the Section K Attachment of the protocol have been updated with the final report. The DVD containing the modeling files for the PolyMet Mine Site contains a readme.txt file outlining the nomenclature of the AERMOD input, output, and plot files.

## Section 3. Paved Roads Fugitive Dust (Optional)

Facilities that have indicated in AQDMP-01 form the exclusion of paved roads in the air dispersion modeling should provide the results of that modeling in Table 1. (See the AQDMP-01 form for details.)

**Table 1: Paved Road Dust modeling results**

| | Averaging Period | NAAQS ($\mu g/m^3$) | Total Modeled NAAQS Concentration (includes Background and Nearby Sources) ($ug/m^3$) | % of NAAQS | PSD Class II Increments ($\mu g/m^3$) | Modeled Class II Increment Impact Concentrations ($\mu g/m^3$) | % of Class II Increments |
|---|---|---|---|---|---|---|---|
| $PM_{10}$ | 24-hour | 150 | | 0.00% | 30 | | 0.00% |
| | Annual | 50 | | 0.00% | 17 | | 0.00% |
| $PM_{2.5}$ | 24-hour | 35 | | 0.00% | 9 | | 0.00% |
| | Annual | 15 | | 0.00% | 4 | | 0.00% |

## Section 4. Modeling Results

**Table 2: Pollutants and averaging periods** (Indicate with an "X" all pollutant and averaging period(s) modeled.)

| Pollutant | Averaging Period | Standard | | Increment |
|---|---|---|---|---|
| | | NAAQS | MAAQS | |
| CO | 1-hr | | | |
| | 8-hr | | | |

| | | | | |
|---|---|---|---|---|
| **Lead** | Rolling 3 mo. Avg | | | |
| | Quarterly Avg | | | |
| **$NO_2$** | 1-hr | | | |
| | Annual | | | |
| **$SO_2$** | 1-hr | | | |
| | 3-hr | | | |
| | 24-hr | | | |
| | Annual | | | |
| **$PM_{10}$** | 24-hr | X | X | X |
| | Annual | X | X | X |
| **$PM_{2.5}$** | 24-hr | X | X | |
| | Annual | X | X | |

**Table 3: NAAQS/MAAQS modeling results** (Enter modeling results along with the percent of standard.)

| Pollutant | Averaging period | NAAQS standard ($ug/m^3$) | MAAQS standard ($ug/m^3$) | Total modeled concentration (includes background and nearby sources) ($ug/m^3$) | Percent of standard (%) | |
|---|---|---|---|---|---|---|
| | | | | | NAAQS | MAAQS |
| **CO** | 1-hr | 40,000 | 35,000 | | | |
| | 8-hr | 10,000 | 10,000 | | | |
| **Lead** | Rolling 3 mo. Avg | 0.15 | *** | | | |
| | Quarterly Avg | 1.5 | 1.5 | | | |
| **$NO_2$** | 1-hr | 188 | *** | | | |
| | Annual | 100 | 100 | | | |
| **$SO_2$** | 1-hr | 196 | 1300 | | | |
| | 3-hr | *** | 1300/*915 | | | |
| | 24-hr | 365 | 365 | | | |
| | Annual | 80 | 60 | | | |
| **$PM_{10}$** | 24-hr | 150 | 150 | 88.4 | 59% | 59% |
| | Annual | *** | 50 | 28.5 | 57% | 57% |
| **$PM_{2.5}$** | 24-hr | 35 | 65 | 32.5 | 93% | 50% |
| | Annual | 15 | 15 | 10.4 | 69% | 69% |

**SO2 3-hr for Northern Minnesota is 915 ug/m3.*

**Table 4: Increment modeling results** (Provide the increment modeling results along with the percent of standard.)

| Pollutant | Averaging Period | Class II Increment ($ug/m^3$) | Total Modeled Concentration (includes other increment sources) ($ug/m^3$) | Percent of Standard (%) |
|---|---|---|---|---|
| **$NO_2$** | 1-hr | *** | | |
| | Annual | 25 | | |
| **$SO_2$** | 1-hr | *** | | |
| | 3-hr | 512 | | |
| | 24-hr | 91 | | |
| | Annual | 20 | | |
| **$PM_{10}$** | 24-hr | 30 | 26.9 | 90% |
| | Annual | 17 | 5.5 | 32% |
| **$PM_{2.5}$** | 24-hr | 9 | | |
| | Annual | 4 | | |

## Section 5. Discussion

Enter any discussion comments:

## Section 6. Modeling Results Figures/Maps

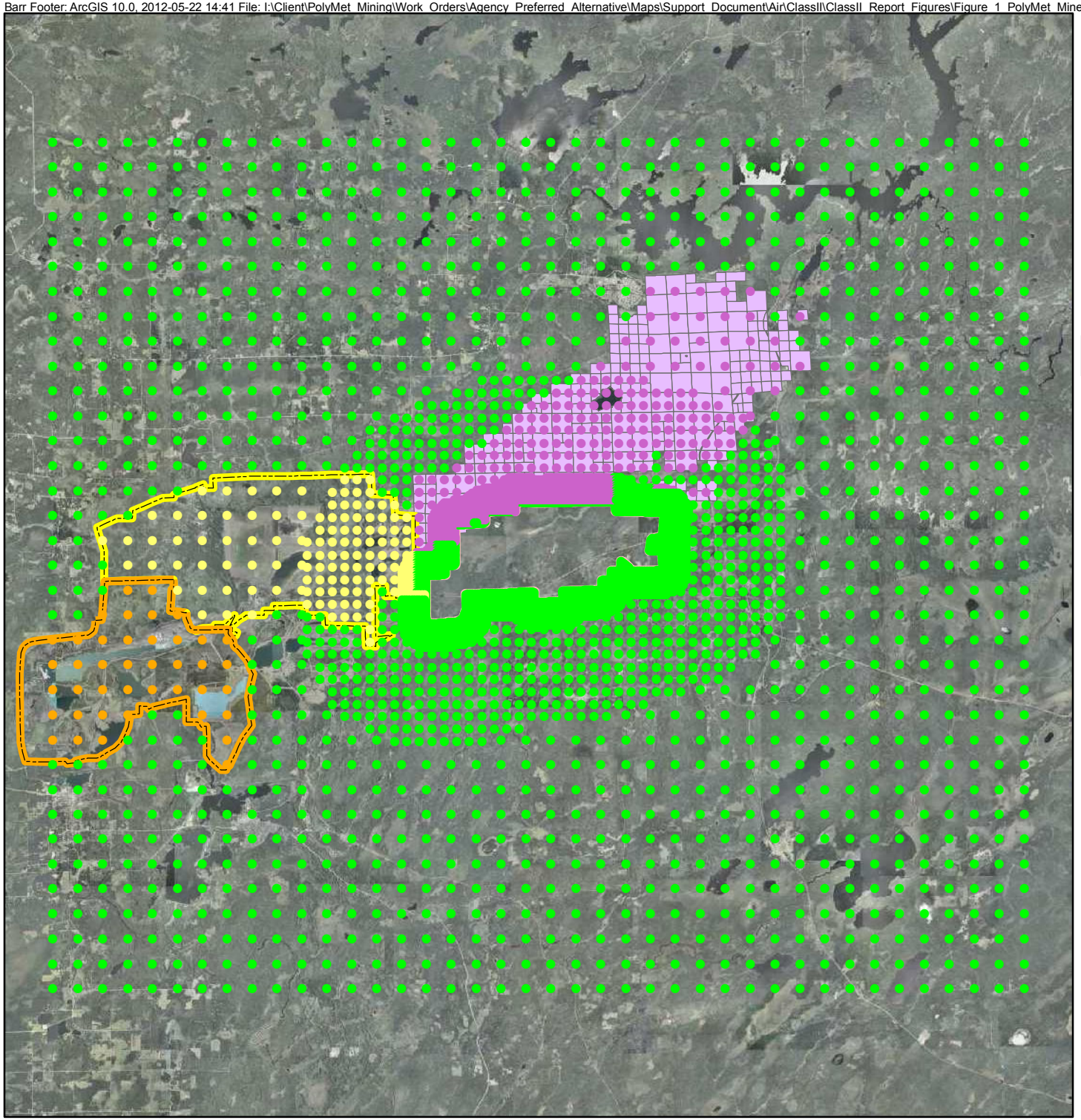
Insert a figure or map showing the facility emission sources, receptors, and the location of the modeled maximum concentration(s) for each applicable pollutant, corresponding averaging periods, and operating scenarios. Figures or maps should correspond to Section 3 NAAQS and Increment results.

[Paste here]

**Acronyms**

| | |
|---|---|
| $\mu g/m^3$ | Micrograms per cubic meter |
| AERMAP | AERMOD Terrain Preprocessor |
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | AMS/EPA Regulatory Model |
| AQ | Air Quality |
| AQDMP-01 | Air Quality Dispersion Modeling Protocol form |
| AQDMPS-01 | Air Quality Dispersion Modeling Protocol Spreadsheet |
| BPIP-PRIME | Building Profile Input Program for PRIME |
| CO | Carbon Monoxide |
| EPA | U.S. Environmental Protection Agency |
| FAC | 3-letter facility ID |
| MAAQS | Minnesota State Ambient Air Quality Standard |
| MPCA | Minnesota Pollution Control Agency |
| NAAQS | National Ambient Air Quality Standard |
| $NO_2$ | Nitrogen Dioxide |
| OU | Operable Unit |
| Pb | Lead |
| $PM_{10}$ | Particulate Matter less than 10 um in size |
| $PM_{2.5}$ | Particulate Matter less than 2.5 um in size |
| PRIME | Plume Rise Model Enhancements |
| PSD | Prevention of Significant Deterioration Program |
| SIL | Significant Impact Level |
| $SO_2$ | Sulfur Dioxide |
| SIP | State Implementation Plan |
| SMS | Standardized Mobile Source |
| UG/M3 | Micrograms per cubic meter ($\mu g/m^3$) |
| UTM | Universal Transverse Mercator |

Barr Footer: ArcGIS 10.0, 2012-05-22 14:41 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_1_PolyMet_MineSite_EISCumulative_NAAQS_INCREMENT_Receptors.mxd User: jjm



- Cumulative Receptors
- Mesabi Nugget
- NorthMet Plant Site
- NorthShore Mine
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records

**Northshore Peter Mitchell Mine on-site receptors based on St. Louis County tax property records.

N

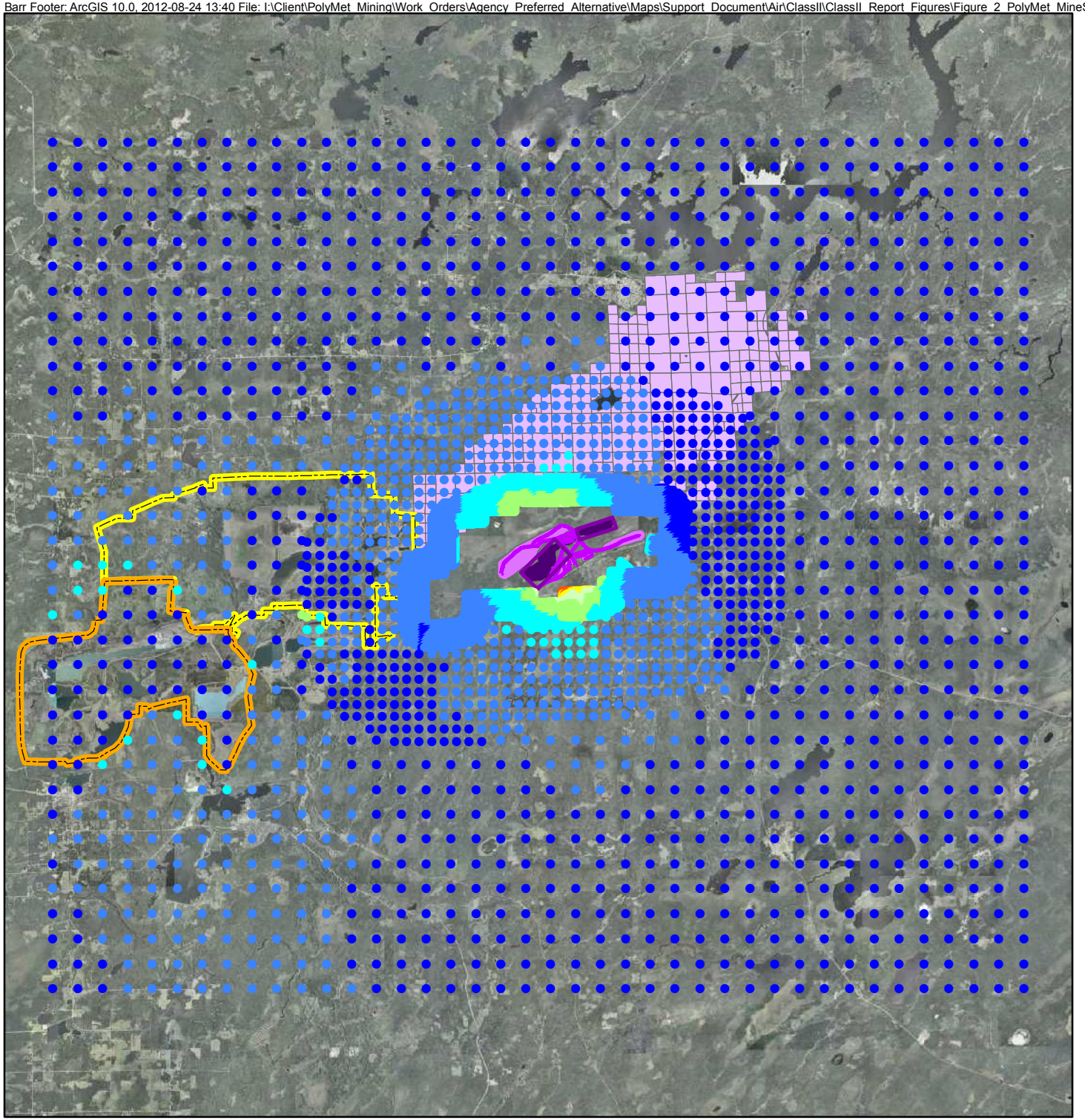
Kilometers

5 0 5

Figure 1

EIS CUMULATIVE NAAQS/INCREMENT
RECEPTOR GRID
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

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**H2H Concentration (ug/m$^3$)**

- 0 - 1
- 2 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 27

Mesabi Nugget AAB

NorthMet Plant Site AAB

St Louis County Tax Records

Open Pit Sources

Volume Sources

$PM_{10}$ 24 Hour Increment is 30 ug/m$^3$.

N

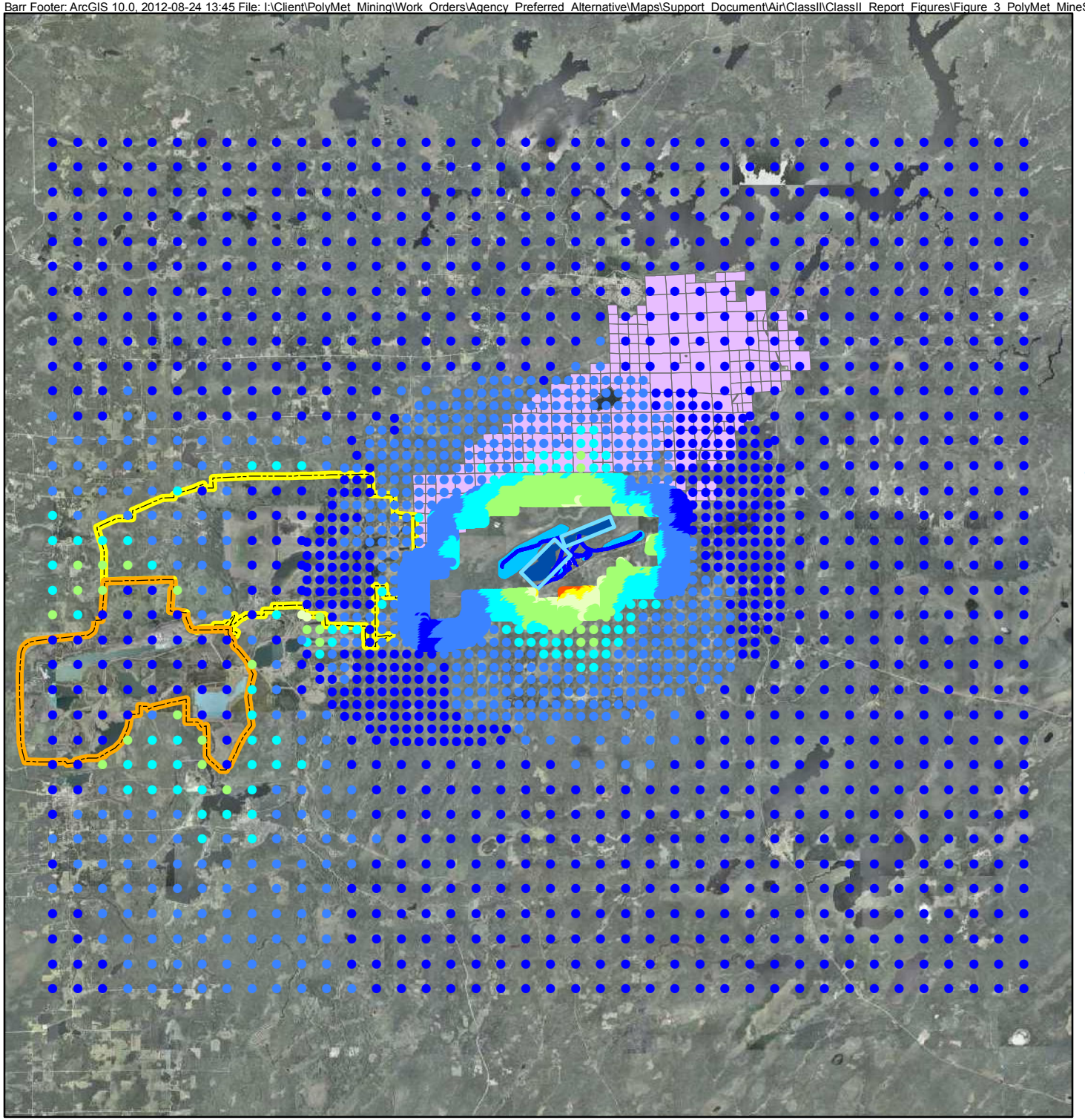
Kilometers

5 0 5

Figure 2

24 HOUR $PM_{10}$ INCREMENT
YEAR 8 RESULTS
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-08-24 13:45 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_3_PolyMet_MineSite_Year13_24hPM10_IncrementResults.mxd User: jjm



**H2H Concentration (ug/m$^3$)**

- 0 - 1
- 2 - 3
- 4 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records
- Open Pit Sources
- Volume Sources

$PM_{10}$ 24 Hour Increment is 30 ug/m$^3$.

N

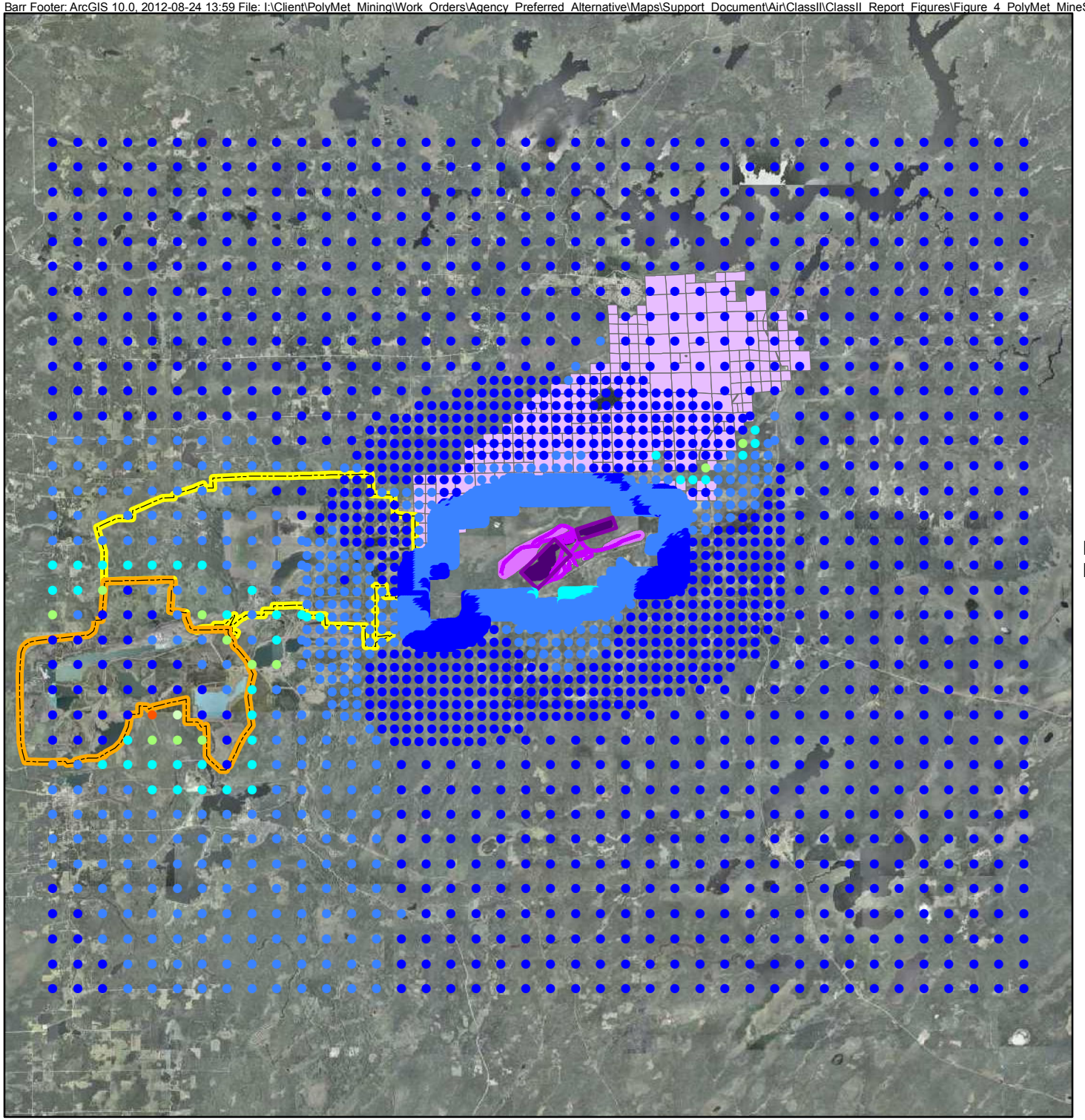
Kilometers

5 0 5

Figure 3

24 HOUR $PM_{10}$ INCREMENT
YEAR 13 RESULTS
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-08-24 13:59 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_4_PolyMet_MineSite_Year08_24hPM10_NAAQSResults.mxd User: jjm



**H6H Concentration (ug/m$^3$)**

- 37 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 84
- 85 - 88
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records
- Open Pit Sources
- Volume Sources

$PM_{10}$ 24 Hour NAAQS is 150 ug/m$^3$.
Background Concentration Included = 36 ug/m$^3$

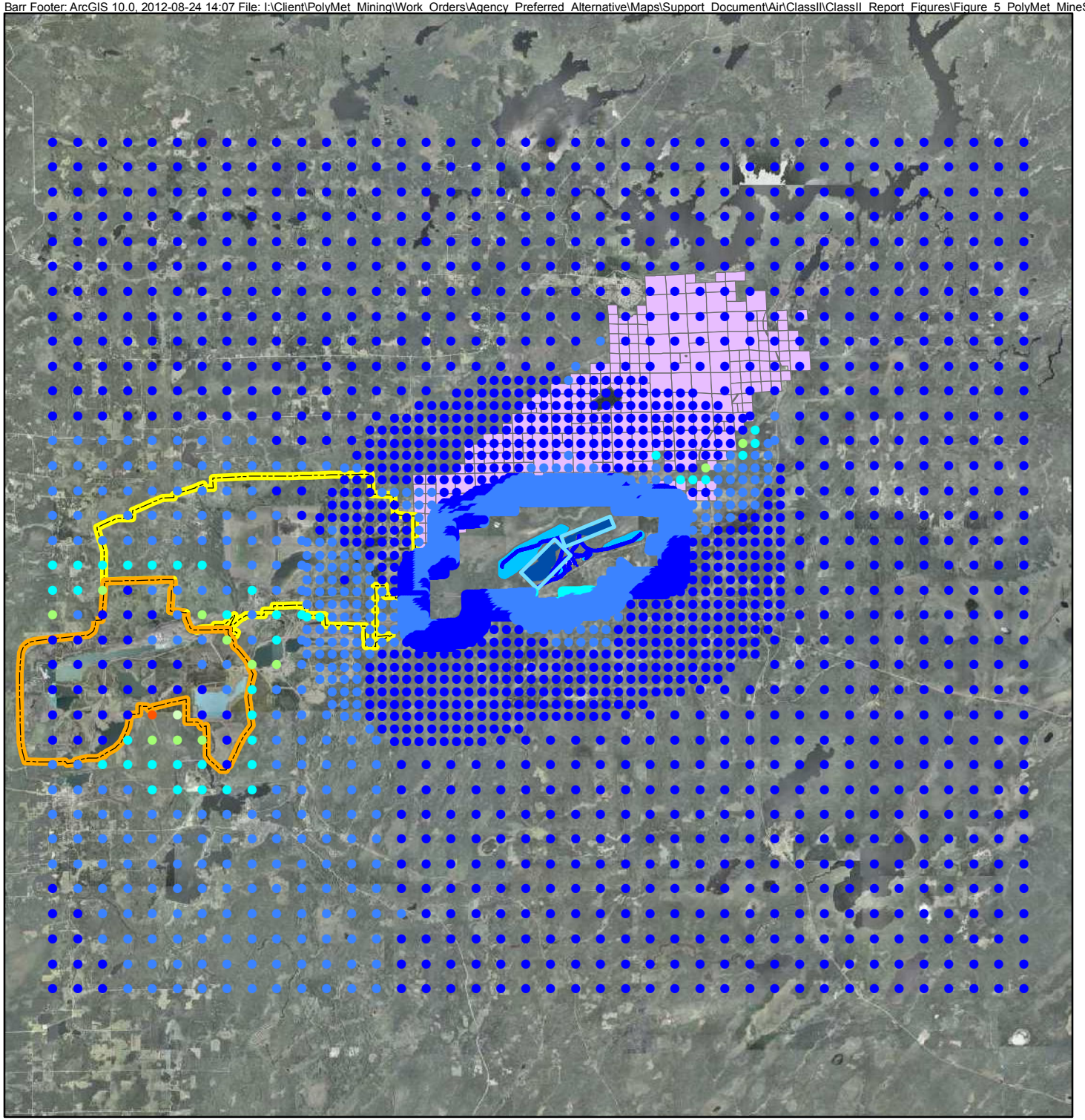
N

Kilometers
5 0 5

Figure 4

24 HOUR $PM_{10}$ NAAQS
YEAR 8 RESULTS
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-08-24 14:07 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_5_PolyMet_MineSite_Year13_24hPM10_NAAQSResults.mxd User: jjm



**H6H Concentration (ug/m$^3$)**

- 37 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 84
- 85 - 88
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records
- Open Pit Sources
- Volume Sources

$PM_{10}$ 24 Hour NAAQS is 150 ug/m$^3$.
Background Concentration Included = 36 ug/m$^3$.

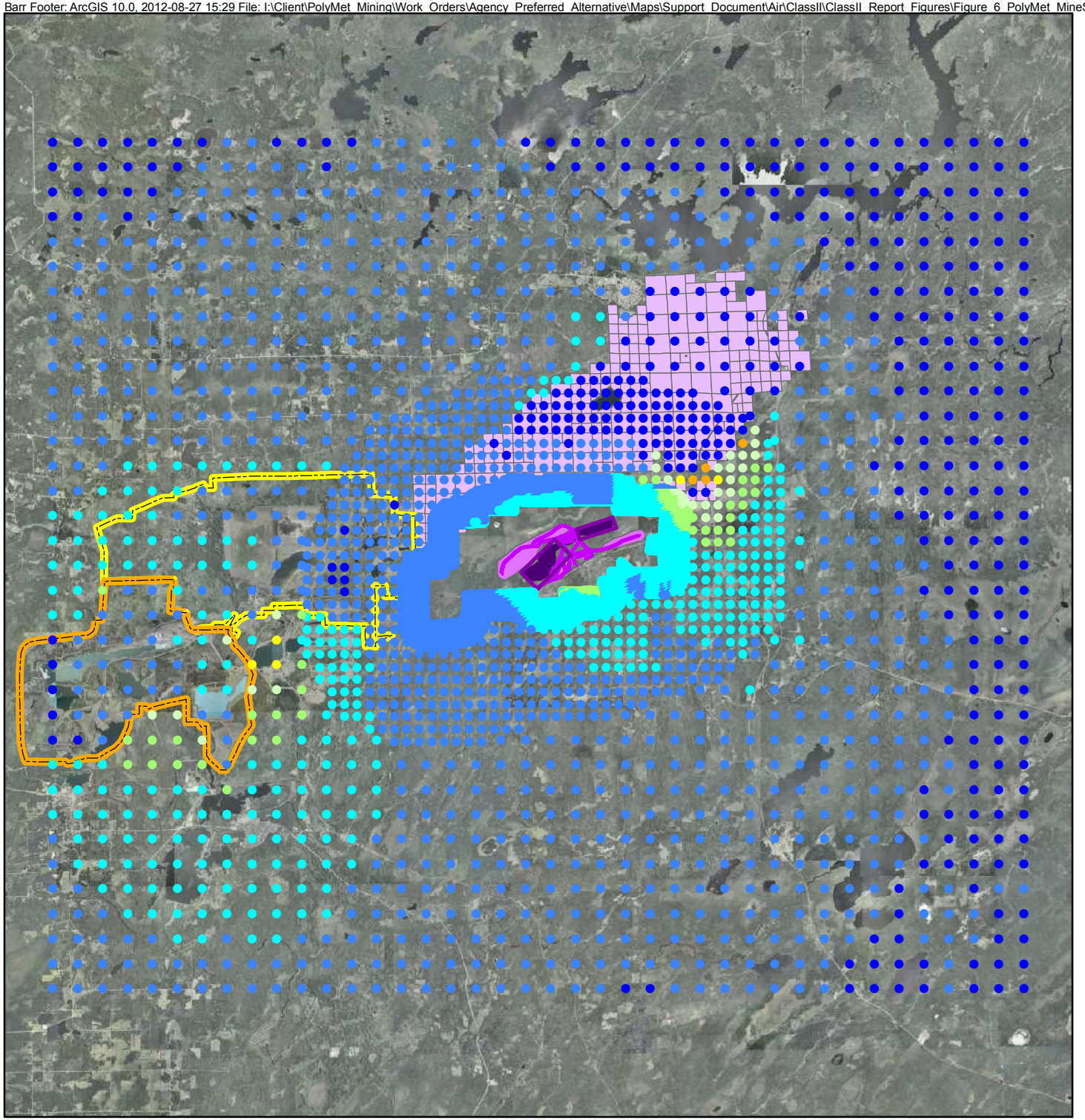
N

Kilometers
5 0 5

Figure 5

24 HOUR $PM_{10}$ NAAQS
YEAR 13 RESULTS
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-08-27 15:29 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_6_PolyMet_MineSite_Year08_24hPM25_NAAQSResults.mxd User: jjm



## H8H Concentration (ug/m$^3$)

- 17.2 - 18.0
- 18.1 - 20.0
- 20.1 - 23.0
- 23.1 - 25.0
- 25.1 - 28.0
- 28.1 - 30.0
- 30.1 - 32.5
- Open Pit Sources
- Volume Sources
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records

$PM_{2.5}$ 24 Hour NAAQS is 35 ug/m$^3$.
Background Concentration Included = 16.5 ug/m$^3$

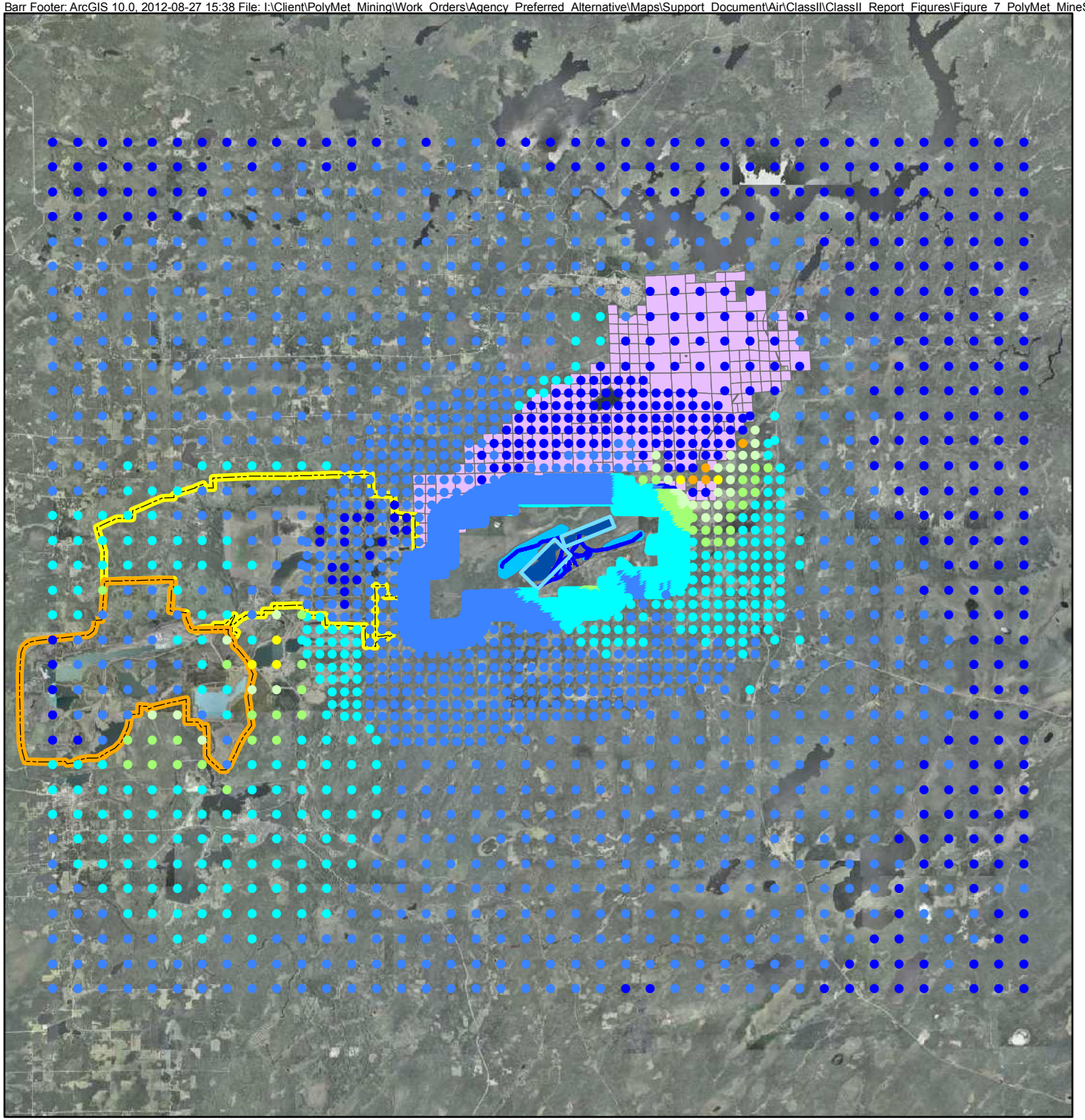
N

Kilometers
5 0 5

Figure 6

24 HOUR $PM_{2.5}$ NAAQS
YEAR 8 RESULTS
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-08-27 15:38 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_7_PolyMet_MineSite_Year13_24hPM25_NAAQSResults.mxd User: jjm



**H8H Concentration (ug/m$^3$)**

- 17.2 - 18.0
- 18.1 - 20.0
- 20.1 - 23.0
- 23.1 - 25.0
- 25.1 - 28.0
- 28.1 - 30.0
- 30.1 - 32.5
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records
- Open Pit Sources
- Volume Sources

$PM_{2.5}$ 24 Hour NAAQS is 35 ug/m$^3$.
Background Concentration Included = 16.5 ug/m$^3$.

N

Kilometers
5 0 5

Figure 7

24 HOUR $PM_{2.5}$ NAAQS
YEAR 13 RESULTS
PolyMet Mine Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

**Attachment G**

**Plant Site Class II Air Quality Dispersion Modeling Report**

# Plant Site Class II Air Quality Dispersion Modeling Report

**Version 2**

**November 2012**

## NorthMet Project

## PolyMet Mining Incorporated

## Hoyt Lakes, MN

This document provides the Class II dispersion modeling report for the Plant Site in the format requested by the Minnesota Pollution Control Agency (MPCA). This includes MPCA form AQDMR-01, four tables, two attachments and 33 figures. The AQDMR-01 did not have sufficient space to present the modeling results in Table 3 and Table 4, so tables with the required information were embedded into the form after Section 6. Tables 3 and 4 were also completed as requested by MPCA in their comments on version 1 of this report. The attachments, tables and figures are listed below.

### Attachments (name references corresponding section of the AQDMP-01 (protocol) form):

Section 3 Supplemental Information
Supplemental Information on Ozone NAAQS

### Tables (Embedded in AQDMR-01 Form after Section 6):

Table 3A NorthMet Plant Site Alone NAAQS/MAAQS Modeling Results
Table 3B Cumulative Impact NAAQS/MAAQS Modeling Results
Table 4A NorthMet Plant Site Alone Increment Modeling Results
Table 4B Cumulative Impact Increment Modeling Results

### Figures:

Figure 1 EIS Cumulative NAAQS-Increment Receptor Grid
Figure 2 24 Hour PM10 Increment Plant Boundary Results
Figure 3 24 Hour PM10 NAAQS Scenario 1 Plant Boundary Results
Figure 4 24 Hour PM10 NAAQS Scenario 2 Plant Boundary Results
Figure 5 24 Hour PM10 Increment Cumulative Impact Results
Figure 6 24 Hour PM10 NAAQS Scenario 1 Cumulative Impact Results
Figure 7 24 Hour PM10 NAAQS Scenario 2 Cumulative Impact Results
Figure 8 24 Hour PM25 NAAQS Scenario 1 Plant Boundary Results
Figure 9 24 Hour PM25 NAAQS Scenario 2 Plant Boundary Results
Figure 10 24 Hour PM25 NAAQS Scenario 1 Cumulative Impact Results
Figure 11 24 Hour PM25 NAAQS Scenario 2 Cumulative Impact Results
Figure 12 Annual NOX Increment Plant Boundary Results
Figure 13 1 Hour NO2 NAAQS Plant Boundary Results
Figure 14 Annual NOX NAAQS Plant Boundary Results
Figure 15 Annual NOX Increment Cumulative Impact Results
Figure 16 1 Hour NO2 NAAQS Cumulative Impact Results

Figure 17 1 Hour NO2 NAAQS Cumulative Impact PolyMet Plant Site Culpability
Figure 18 Annual NOX NAAQS Cumulative Impact Results
Figure 19 3 Hour SO2 Increment Plant Boundary Results
Figure 20 24 Hour SO2 Increment Plant Boundary Results
Figure 21 Annual SO2 Increment Plant Boundary Results
Figure 22 1 Hour SO2 NAAQS Plant Boundary Results
Figure 23 3 Hour SO2 NAAQS Plant Boundary Results
Figure 24 24 Hour SO2 MAAQS Plant Boundary Results
Figure 25 Annual SO2 MAAQS Plant Boundary Results
Figure 26 3 Hour SO2 Increment Cumulative Impact Results
Figure 27 24 Hour SO2 Increment Cumulative Impact Results
Figure 28 Annual SO2 Increment Cumulative Impact Results
Figure 29 1 Hour SO2 NAAQS Cumulative Impact Results
Figure 30 1 Hour SO2 NAAQS Cumulative Impact PolyMet Plant Site Culpability
Figure 31 3 Hour SO2 MAAQS Cumulative Impact Results
Figure 32 24 Hour SO2 MAAQS Cumulative Impact Results
Figure 33 Annual SO2 MAAQS Cumulative Impact Results

In addition to this document, requested electronic files will be provided via the Project Air FTP Site.

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

# AQDMR-01

## Air Quality Dispersion Modeling Report(AQDMR)

Protocol Form for Criteria Pollutant Modeling

*Doc Type: Air Dispersion Modeling*

**Acronym Information on Page 6**

**Instructions:** Permit applicants required to conduct air dispersion modeling should submit two paper copies of the completed Air Quality Dispersion Modeling Report form (AQDMR-01) and all accompanying files to:

Air Quality Permit Document Coordinator
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Applicants may also submit an electronic version in addition to the two paper copies.

Electronic copies of the forms and accompanying files should be sent to: AirModeling.PCA@state.mn.us.

## Facility Information

AQ tracking number: _____

AQ file no.: _____ AQ facility/permit ID no.: _____ Today's date (mm/dd/yyyy): 11/9/2012

Three-letter modeling facility ID (ex., XEK = Xcel Energy Allen S. King, MEC = Mankato Energy Center, etc.): PMP

Facility name: NorthMet Plant Site

Facility street address: 6500 County Road 666

City: Hoyt Lakes County: St. Louis

State: MN Zip code: 55750 Elevation at facility: 493 m

Facility contact: Kevin Pylka Protocol prepared by: Jennifer Koenen, Barr Engineering Co.

Facility contact phone: (218) 471 - 2162 Preparer phone: (952) 832 - 2682

Facility contact e-mail address: kpylka@polymetmining.com Preparer e-mail address: jkoenen@barr.com

Latitude, Longitude of facility (Decimal degrees to **four** decimal places): 47.5981 N, 92.1391 W

UTM coordinates of facility (NAD83, zone 15 extended **only**): x = 564,719.00 m East, y = 5,271,989.00 m North

**This report is associated with:**

- ☐ Permit application
- ☐ Permit requirement
- ☒ Other: EIS

## Project Description (50 words or less)

PolyMet plans to construct and operate a mine, to reactivate portions of the LTV Steel Mining Company facility and to build a hydrometallurgical concentrate processing facility at the former LTVSMC site (Plant Site is subject of this report). More detail is available in the NorthMet Project Description Version 4 Submitted October 31, 2012.

## Files to Accompany Modeling Report

Include the following files with the completed modeling report form. Use checkbox to indicate that all applicable files are included.

1. ☒ AERMOD input files (*.inp, *.adi, *.ami)
   ☒ AERMOD output files (*.out, *.ado, *.amo)
   ☒ AERMOD plot files (*.plt)
   ☒ AERMOD post files (*.pst) – If applicable
   ☒ AERMOD event files (*.evi, *.evo) – If applicable

☒ AERMOD miscellaneous/other files (MAXDCONT, ?, ?, etc.) – If applicable

2. AERMET files: ☒ *.sfc ☒*.pfl
3. BPIP-PRIME files: ☒ Input (*.bpi) ☒ Output (*.bpo, *.sum)
4. AERMAP files: ☒ Terrain (*.dem(s), *.tif (NED files)), ☐ Input (*.ami), ☒ Output (*.rou, *.sou, etc.)
5. Background data files: ☒ Background concentrations for applicable pollutants (seasonal, monthly, daily, hourly, etc.)
6. Modeling Results: ☒ Figures (*.jpeg, *.pdf), ☐ GIS Maps (*.shp)
7. AQDMPS-01 spreadsheet*: ☐
8. Other files and supporting documents (SMSv*.xls, Far sources, readme, etc.):

   Version 5 of the PolyMet Plant Site emission inventory was submitted on June 6, 2012 in lieu of the AQDMPS-01 spreadsheet as stated in the approved modeling protocol.

* *Provide the final spreadsheet (i.e. AQDMPS-01) and indicate/highlight changes.*

## Section 1. Modeling Protocol

1. The Air Dispersion Modeling presented in this report is based on a Protocol that has been:

   ☒ Approved ☐ Conditionally approved ☒ *MPCA approval date (mm/dd/yyyy): 06/12/2012

   **This is the date given on AQDM PAN-01 form*
2. Does this Modeling submittal **completely** follow the Approved Protocol? ☐ Yes ☒ No

   If yes, proceed to Section 3.

   If no, proceed to Section 2.

## Section 2. Changes to Modeling Protocol

**Table 1: Protocol Changes** (Please indicate which sections in Approved Protocol contain changes.)

**Modeling protocol by sections**

| **Section and section name** | **Change/No change** |
|---|---|
| Files to accompany protocol | No Change |
| Section A<br>*Purpose for Air Dispersion Modeling and Related Information* | No Change |
| Section B<br>*EPA Pre-Processors and EPA Post-Processors* | No Change |
| Section C<br>*Model Selection and Options (Key CO Pathway Inputs)* | Change |
| Section D<br>*Emission Source Characterizations and Parameters (Key SO Pathway Inputs)* | No Change |
| Section E<br>*Paved Roads Fugitive Dust (as per MPCA April 25, 2011 Policy)* | No Change |
| Section F<br>*Receptors (RE Pathway)* | Change |
| Section G<br>*Meteorological Data (ME Pathway)* | Change |
| Section H<br>*SIL Analysis and Results* | No Change |
| Section I<br>*Background Values* | Change |
| Section J<br>*Nearby Sources* | Change |
| Section K<br>*Anticipated Outputs (OU Pathway)* | No Change |

## Section 2.1: Detailed Changes to Modeling Protocol

Please provide specific information corresponding to those sections in Table 1 where changes are indicated.

### Section A. Purpose for air dispersion modeling and related information

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section B. EPA pre-processors and EPA post-processors

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section C. Model selection and options (Key CO pathway inputs)

MPCA approved change: ☒ Yes ☐ No Date (mm/dd/yyyy): 11/7/2012

Describe changes and/or indicate section item number(s):

5c. MPCA processed hourly ozone .dat files are no longer allowed, so user processed hourly ozone files were developed and submitted as part of response to report comments received on version 1 of this report.

### Section D. Emission source characterizations and parameters (Key SO pathway inputs)

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section E. Paved roads fugitive dust

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section F. Receptors (RE pathway)

MPCA approved change: ☒ Yes ☐ No Date (mm/dd/yyyy): 8/2/2012

Describe changes and/or indicate section item number(s):

NO2 1hour and NOX Annual Significant Impact Analysis was re-run with the updated NO2 emission rates and a revised Cumulative NAAQS and Increment receptor grid specific to NO2/NOX modeling was created. The SIL modeling analysis files are included with the supplemental files attached to this report.

### Section G. Meteorological data (ME pathway)

MPCA approved change: ☐ Yes ☒ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

7b. Wind speed dependent calculation spreadsheet had an incorrect value for the minimum wind speed category value, which resulted in the number of events per wind speed category to be incorrect. This value was corrected and incorporated into final modeling. The methodology for how the wind speed dependent emission rates were determined was not changed.

### Section H. SIL analysis and results

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

### Section I. Background values

MPCA approved change: ☒ Yes ☐ No Date (mm/dd/yyyy): 11/7/2012

Describe changes and/or indicate section item number(s):

2a. The MPCA generated single value 1 hour SO2 and NO2 background concentrations are no longer acceptable, therefore, the 1 hour NO2 and SO2 background concentrations were calculated using the 2008-2010 monitor values from the same monitors used for the Annual NOX background and the 3-hr, 24-hr, and annual SO2 background.

### Section J. Nearby sources

MPCA approved change: ☒ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

3. The nearby source inputs spreadsheet has been updated to reflect changes to nearby facility inputs after review and discussions by MPCA. An updated nearby source input spreadsheet has been included and these values are incorporated into the final modeling.

### Section K. Anticipated outputs (OU pathway)

MPCA approved change: ☐ Yes ☐ No Date (mm/dd/yyyy): _____

Describe changes and/or indicate section item number(s):

## Section 3. Paved Roads Fugitive Dust (Optional)

Facilities that have indicated in AQDMP-01 form the exclusion of paved roads in the air dispersion modeling should provide the results of that modeling in Table 1. (See the AQDMP-01 form for details.)

**Table 1: Paved Road Dust modeling results**

| | Averaging Period | NAAQS ($\mu g/m^3$) | Total Modeled NAAQS Concentration (includes Background and Nearby Sources) ($\mu g/m^3$) | % of NAAQS | PSD Class II Increments ($\mu g/m^3$) | Modeled Class II Increment Impact Concentrations ($\mu g/m^3$) | % of Class II Increments |
|---|---|---|---|---|---|---|---|
| $PM_{10}$ | 24-hour | 150 | | 0.00% | 30 | | 0.00% |
| | Annual | 50 | | 0.00% | 17 | | 0.00% |
| $PM_{2.5}$ | 24-hour | 35 | | 0.00% | 9 | | 0.00% |
| | Annual | 15 | | 0.00% | 4 | | 0.00% |

## Section 4. Modeling Results

**Table 2: Pollutants and averaging periods** (Indicate with an "X" all pollutant and averaging period(s) modeled.)

| Pollutant | Averaging Period | Standard | | Increment |
|---|---|---|---|---|
| | | NAAQS | MAAQS | |
| **CO** | 1-hr | | | |
| | 8-hr | | | |
| **Lead** | Rolling 3 mo. Avg | | | |
| | Quarterly Avg | | | |
| **$NO_2$** | 1-hr | X | X | |
| | Annual | X | X | X |
| **$SO_2$** | 1-hr | X | X | |

| | | | | |
|---|---|---|---|---|
| | 3-hr | X | X | X |
| | 24-hr | X | X | X |
| | Annual | X | X | X |
| **$PM_{10}$** | 24-hr | X | X | X |
| | Annual | X | X | X |
| **$PM_{2.5}$** | 24-hr | X | X | |
| | Annual | X | X | |

**Table 3: NAAQS/MAAQS modeling results** (Enter modeling results along with the percent of standard.)

| Pollutant | Averaging period | NAAQS standard ($ug/m^3$) | MAAQS standard ($ug/m^3$) | Total modeled concentration (includes background and nearby sources) ($ug/m^3$) | Percent of standard (%) | |
|---|---|---|---|---|---|---|
| | | | | | NAAQS | MAAQS |
| **CO** | 1-hr | 40,000 | 35,000 | | | |
| | 8-hr | 10,000 | 10,000 | | | |
| **Lead** | Rolling 3 mo. Avg | 0.15 | *** | | | |
| | Quarterly Avg | 1.5 | 1.5 | | | |
| **$NO_2$** | 1-hr | 188 | *** | 292 | 155 | NA |
| | Annual | 100 | 100 | 23 | 23 | 23 |
| **$SO_2$** | 1-hr | 196 | 1300 | 893 | 456 | 69 |
| | 3-hr | *** | 1300/*915 | 784 | NA | 86 |
| | 24-hr | 365 | 365 | 255 | NA | 70 |
| | Annual | 80 | 60 | 24 | NA | 40 |
| **$PM_{10}$** | 24-hr | 150 | 150 | 77 | 51 | 51 |
| | Annual | *** | 50 | 19 | NA | 38 |
| **$PM_{2.5}$** | 24-hr | 35 | 65 | 34 | 96 | 52 |
| | Annual | 15 | 15 | 12 | 63 | 63 |

**SO2 3-hr for Northern Minnesota is 915 ug/m3.*

**Table 4: Increment modeling results** (Provide the increment modeling results along with the percent of standard.)

| Pollutant | Averaging Period | Class II Increment ($ug/m^3$) | Total Modeled Concentration (includes other increment sources) ($ug/m^3$) | Percent of Standard (%) |
|---|---|---|---|---|
| **$NO_2$** | 1-hr | *** | | |
| | Annual | 25 | 0.86 | 3.5 |
| **$SO_2$** | 1-hr | *** | | |
| | 3-hr | 512 | 11 | 2.1 |
| | 24-hr | 91 | 1.9 | 2.1 |
| | Annual | 20 | 0.17 | 0.8 |
| **$PM_{10}$** | 24-hr | 30 | 18 | 59 |
| | Annual | 17 | 3.0 | 18 |
| **$PM_{2.5}$** | 24-hr | 9 | | |
| | Annual | 4 | | |

## Section 5. Discussion

Enter any discussion comments:

The Results in Tables 3 and 4 are for the Cumulative Results at the LTV ambient air boundary. Section 6 below includes more detailed modeling results tables which include the PolyMet plant site only results at the PolyMet ambient air boundary and results tables incorporating culpability. A detailed discussion of the modeled results is included in the Section 3 Supplemental Information included after the report forms.

## Section 6. Modeling Results Figures/Maps

Insert a figure or map showing the facility emission sources, receptors, and the location of the modeled maximum concentration(s) for each applicable pollutant, corresponding averaging periods, and operating scenarios. Figures or maps should correspond to Section 3 NAAQS and Increment results.

[Paste here]

**Attachment to Form AQDMR-01 - Table 3A**

**NorthMet Plant Site Alone NAAQS/MAAQS Modeling Results**

| Pollutant | Averaging Period | NAAQS ($ug/m^3$) | MAAQS ($ug/m^3$) | Modeled Result ($ug/m^3$) [1] | Background Concentration ($ug/m^3$) [2] | Total Result ($ug/m^3$) | % of NAAQS | % of MAAQS |
|---|---|---|---|---|---|---|---|---|
| $NO_2$ | 1 Hour | 188 | NA | 88 | 89.6 | 177 | 94 | NA |
| $NO_X$ | Annual | 100 | 100 | 3.2 | 17.6 | 21 | 21 | 21 |
| SO2 | 1 Hour | 196 | 1300 | 103 | 6.1 | 109 | 56 | 8 |
| | 3 Hour | NA | 915 | 85 | 12.1 | 97 | NA | 11 |
| | 24 Hour | NA | 365 | 35 | 5.5 | 40 | NA | 11 |
| | Annual | NA | 60 | 5.9 | 0.63 | 7 | NA | 11 |
| $PM_{10}$ | 24 Hour | 150 | 150 | 44 | 36 | 80 | 53 | 53 |
| | Annual | NA | 50 | 12 | 14 | 26 | NA | 53 |
| $PM_{2.5}$ | 24 Hour | 35 | 65 | 17 | 16.5 | 33 | 94 | 51 |
| | Annual | 15 | 15 | 5.8 | 5.8 | 12 | 77 | 77 |

[1] The modeled results follow the form of the standard described in the modeling protocol.
NO2 (1-hr): 5 year average High 8th High Concentration
NOX (annual): Maximum Annual Concentration out of 5 years
SO2 (1-hr): 5 year average High 4th High Concentration
SO2 (3,24-hr): Maximum High 2nd High Concentration out of 5 years
SO2 (annual): Maximum Annual Concentration out of 5 years
PM10 (24-hr): 5 year High 6th High Concentration
PM10 (annual): Maximum Annual Concentration out of 5 years
PM2.5 (24-hr): 5 year average High 8th High Concentration
PM2.5 (annual): Maximum Annual Concentration out of 5 years

[2] The background concentration value descriptions are as follows:
NO2 (1-hr): 2008-2010 Maximum Daily 1 hour 98th percentile average NOX Concentration from Blaine-Anoka Airport Monitor
NOX (annual): 2008-2010 Maximum Annual NOX Concentration from Blaine-Anoka Airport Monitor
SO2 (1-hr): 2008-2010 Maximum Daily 1 hour 99th percentile SO2 Concentration from Rosemount, MN Site 443 Monitor
SO2 (3,24-hr): 2008-2010 Maximum High 2nd High SO2 Concentration from Rosemount, MN Site 443 Monitor
SO2 (annual): 2008-2010 Maximum Annual SO2 Concentration from Rosemount, MN Site 443 Monitor
PM10 (24-hr): 2008-2010 Average High 2nd High PM10 Concentration from Virginia, MN Monitor
PM10 (annual): 2008-2010 Maximum Annual PM10 Concentration from Virginia, MN Monitor
PM2.5 (24-hr): 2008-2010 Average High 2nd High PM2.5 Concentration from Virginia, MN Monitor
PM2.5 (annual): 2008-2010 Maximum Annual PM2.5 Concentration from Virginia, MN Monitor

**Attachment to Form AQDMR-01 - Table 3B**

**Cumulative Impact NAAQS/MAAQS Modeling Results**

| Pollutant | Averaging Period | NAAQS ($ug/m^3$) | MAAQS ($ug/m^3$) | Modeled Result ($ug/m^3$) [1] | PolyMet Plant Site Contribution to Modeled Results ($ug/m^3$) | SIL ($ug/m^3$) | Background Concentration ($ug/m^3$) [2] | Total Result ($ug/m^3$) | % of NAAQS | % of MAAQS |
|---|---|---|---|---|---|---|---|---|---|---|
| $NO_2$ | 1 Hour | 188 | NA | 202 | 0.00167 | 7.52 | 89.6 | 292 | 155 | NA |
| $NO_X$ | Annual | 100 | 100 | 5.6 | NAAQS Attainment | 1 | 17.6 | 23 | 23 | 23 |
| SO2 | 1 Hour | 196 | 1300 | 887 | 0.0024 | 7.83 | 6.1 | 893 | 456 | 69 |
| | 3 Hour | NA | 915 | 772 | MAAQS Attainment | 25 | 12.1 | 784 | NA | 86 |
| | 24 Hour | NA | 365 | 249 | MAAQS Attainment | 5 | 5.5 | 255 | NA | 70 |
| | Annual | NA | 60 | 24 | MAAQS Attainment | 1 | 0.63 | 24 | NA | 40 |
| $PM_{10}$ | 24 Hour | 150 | 150 | **41** | NAAQS Attainment | 5 | 36 | 77 | 51 | 51 |
| | Annual | NA | 50 | **4.9** | MAAQS Attainment | 1 | 14 | 19 | NA | 38 |
| $PM_{2.5}$ | 24 Hour | 35 | 65 | **17** | NAAQS Attainment | 1.2 | 16.5 | 34 | 96 | 52 |
| | Annual | 15 | 15 | **3.7** | NAAQS Attainment | 0.3 | 5.8 | 10 | 63 | 63 |

[1] The modeled results follow the form of the standard described in the modeling protocol.
NO2 (1-hr): 5 year average High 8th High Concentration
NOX (annual): Maximum Annual Concentration out of 5 years
SO2 (1-hr): 5 year average High 4th High Concentration
SO2 (3,24-hr): Maximum High 2nd High Concentration out of 5 years
SO2 (annual): Maximum Annual Concentration out of 5 years
PM10 (24-hr): 5 year High 6th High Concentration
PM10 (annual): Maximum Annual Concentration out of 5 years
PM2.5 (24-hr): 5 year average High 8th High Concentration
PM2.5 (annual): Maximum Annual Concentration out of 5 years

[2] The background concentration value descriptions are as follows:
NO2 (1-hr): 2008-2010 Maximum Daily 1 hour 98th percentile average NOX Concentration from Blaine-Anoka Airport Monitor
NOX (annual): 2008-2010 Maximum Annual NOX Concentration from Blaine-Anoka Airport Monitor
SO2 (1-hr): 2008-2010 Maximum Daily 1 hour 99th percentile SO2 Concentration from Rosemount, MN Site 443 Monitor
SO2 (3,24-hr): 2008-2010 Maximum High 2nd High SO2 Concentration from Rosemount, MN Site 443 Monitor
SO2 (annual): 2008-2010 Maximum Annual SO2 Concentration from Rosemount, MN Site 443 Monitor
PM10 (24-hr): 2008-2010 Average High 2nd High PM10 Concentration from Virginia, MN Monitor
PM10 (annual): 2008-2010 Maximum Annual PM10 Concentration from Virginia, MN Monitor
PM2.5 (24-hr): 2008-2010 Average High 2nd High PM2.5 Concentration from Virginia, MN Monitor
PM2.5 (annual): 2008-2010 Maximum Annual PM2.5 Concentration from Virginia, MN Monitor

**Attachment to Form AQDMR-01 - Table 4A**
**NorthMet Plant Site Alone Increment Modeling Results**

| Pollutant | Averaging Period | Increment ($ug/m^3$) | Modeled Result ($ug/m^3$) [1] | % of Increment |
|---|---|---|---|---|
| $NO_X$ | Annual | 25 | 3.2 | 13 |
| $SO_2$ | 3 Hour | 512 | 85 | 17 |
| | 24 Hour | 91 | 35 | 38 |
| | Annual | 20 | 5.9 | 29 |
| $PM_{10}$ | 24 Hour | 30 | 27 | 91 |
| | Annual | 17 | -0.14 | -0.82 |

[1] The modeled results follow the form of the standard described in the modeling protocol.
NOX (annual): Maximum Annual Concentration out of 5 years
SO2 (3,24-hr): Maximum High 2nd High Concentration out of 5 years
SO2 (annual): Maximum Annual Concentration out of 5 years
PM10 (24-hr): Increment - Maximum High 2nd High Concentration out of 5 years
PM10 (annual): Maximum Annual Concentration out of 5 years

**Attachment to Form AQDMR-01 - Table 4B**
**Cumulative Impact Increment Modeling Results**

| Pollutant | Averaging Period | Increment ($ug/m^3$) | Modeled Result ($ug/m^3$) [1] | % of Increment |
|---|---|---|---|---|
| $NO_X$ | Annual | 25 | 0.86 | 3.5 |
| $SO_2$ | 3 Hour | 512 | 11 | 2.1 |
| | 24 Hour | 91 | 1.9 | 2.1 |
| | Annual | 20 | 0.17 | 0.8 |
| $PM_{10}$ | 24 Hour | 30 | **18** | 59 |
| | Annual | 17 | **3.0** | 18 |

[1] The modeled results follow the form of the standard described in the modeling protocol.
NOX (annual): Maximum Annual Concentration out of 5 years
SO2 (3,24-hr): Maximum High 2nd High Concentration out of 5 years
SO2 (annual): Maximum Annual Concentration out of 5 years
PM10 (24-hr): Maximum High 2nd High Concentration out of 5 years
PM10 (annual): Maximum Annual Concentration out of 5 years

**Acronyms**

| | |
|---|---|
| $\mu g/m^3$ | Micrograms per cubic meter |
| AERMAP | AERMOD Terrain Preprocessor |
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | AMS/EPA Regulatory Model |
| AQ | Air Quality |
| AQDMP-01 | Air Quality Dispersion Modeling Protocol form |
| AQDMPS-01 | Air Quality Dispersion Modeling Protocol Spreadsheet |
| BPIP-PRIME | Building Profile Input Program for PRIME |
| CO | Carbon Monoxide |
| EPA | U.S. Environmental Protection Agency |
| FAC | 3-letter facility ID |
| MAAQS | Minnesota State Ambient Air Quality Standard |
| MPCA | Minnesota Pollution Control Agency |
| NAAQS | National Ambient Air Quality Standard |
| $NO_2$ | Nitrogen Dioxide |
| OU | Operable Unit |
| Pb | Lead |
| $PM_{10}$ | Particulate Matter less than 10 um in size |
| $PM_{2.5}$ | Particulate Matter less than 2.5 um in size |
| PRIME | Plume Rise Model Enhancements |
| PSD | Prevention of Significant Deterioration Program |
| SIL | Significant Impact Level |
| $SO_2$ | Sulfur Dioxide |
| SIP | State Implementation Plan |
| SMS | Standardized Mobile Source |
| UG/M3 | Micrograms per cubic meter ($\mu g/m^3$) |
| UTM | Universal Transverse Mercator |

# Section 3 Supplemental Information

The Plant Site Class II modeling analysis focused on two impacts: Plant Site impacts at PolyMet's ambient air boundary and the combined impacts of the Plant Site with nearby facilities at a cumulative impacts boundary encompassing the shared properties of the NorthMet Plant Site (Plant Site), Mesabi Nugget, and Cliffs Erie Pellet Yard using the former LTV Steel Mining Company (LTVSMC) property boundary as the ambient air boundary. The modeling results discussion is arranged by pollutant and reference the modeling results tables and figures included with the Class II Plant Site Modeling Report.

Note: in comments provided by MPCA on the Mesabi Nugget modeling inputs used for cumulative assessments, they recommended excluding the sources from the Mesabi Nugget Phase II (Mesabi Mining) EIS, because MPCA does not have a current project description or permit application for this project. PolyMet elected not to rerun the particulate modeling without the Phase II sources, because the modeling with them produced acceptable results and these results would reflect higher total emissions than the approach recommended by MPCA (i.e. the reported cumulative results are conservative).

**$PM_{10}$: 24 Hour and Annual Increment and NAAQS**

The $PM_{10}$ Analysis included two different wind erosion Tailings Basin scenarios for the Plant Site called Scenario 1 and Scenario 2. In the initial stages of modeling the Tailings Basin, it was determined that it was overly conservative to assume the entire beach area as erodible because only a portion of the total beach acreage would be active and erodible while the remainder would be vegetated or otherwise stabilized. The active acreages were evaluated along the entire beach area and the locations that provided the maximum impacts to the PolyMet receptors were assumed as the worst case. These locations tended to be at the south end, closest to the southern ambient air boundary. Figure 5 in the Plant Site protocol showed the entire erodible beach area and the Plant Site only $PM_{10}$ 24-hour NAAQS results in Figures 3 and 4 of this document show the erodible beach areas represented by Scenarios 1 and 2 in red.

As stated in the Plant Site protocol, "Final results will be used to determine need for inclusion of paved roads in submitted modeling". The MPCA paved road guidance policy indicates that $PM_{10}$ and $PM_{2.5}$ NAAQS results greater than 95% or $PM_{10}$ Increment results greater than 75% of the standard require the inclusion of paved roads in the modeling analysis. The Plant Site only $PM_{10}$ Increment results are below their respective increments of 30 and 17 $\mu g/m^3$ as shown in Table 4A and the maximum impacts are at the boundary due south of the tailings basin as shown in Figure 2. However, the 24 hour $PM_{10}$ Increment result is greater than 75% of the Increment, which would require the paved road to be included in the analysis.

The Plant Site paved road was present at the baseline date and used during operations of the LTVSMC plant. PolyMet is proposing to use this paved road for the same types of activities, so there would be no net increment consumption along the paved road. Traffic on paved roads for LTVSMC and the Project would include employee vehicles, company owned light trucks and service vehicles and deliveries of

goods by over-the-road trucks (i.e. 80,000 pounds maximum weight). LTVSMC shipped taconite pellets predominantly by rail and the Project will also ship large volume products (i.e. flotation concentrates) primarily by rail and the lower volume products (Nickel/Cobalt hydroxide and PGM concentrate) primarily by over-the-road truck. The truck traffic from Project product shipping will be relatively low at an average rate of 2-3 trucks per day for Ni/Co hydroxide and 1 to 2 trucks per month for PGM concentrate. Most Project process consumables used in large quantities will be shipped by rail - lime will have the highest volume routinely shipped by truck at an approximate rate of 22 over-the-road trucks per month. Overall, traffic at the baseline date for LTVSMC would be expected to be greater than for the Project due to the higher operating capacity of the plant (100,000 tons per day versus 32,000 tons per day) and the associated higher staffing levels (approximately 1,400 versus 360 full time employees).

The 24-hour and annual $PM_{10}$ NAAQS results for the Plant Site are around 50% of their respective NAAQS/MAAQS as shown in Table 3A. Figures 3 and 4 show the 24 hour $PM_{10}$ NAAQS results for the Plant Site only. The maximum results are located at the ambient air boundary south of the Tailings Basin.

$PM_{10}$ cumulative impact results for the 24 hour Increment were 59% of the 30 $\mu g/m^3$ standard and the annual increment results were 18% of the standard as shown in Table 4B. Figure 5 shows the maximum concentration is located south of the NorthMet Mine Site in that scenario.

$PM_{10}$ cumulative Impact results for the 24 hour NAAQS were 51% the 150 $\mu g/m^3$ standard and the annual MAAQS results were 38% of the standard as shown in Table 3B. Figures 6 and 7 show the maximum concentrations located at Mesabi Nugget's ambient air boundary west of the proposed Mesabi Mining Phase II tailings basin.

The above cumulative results did not include the paved roads at the Mesabi Nugget facility and the results are below the level that would require them to be added per MPCA policy.

**$PM_{2.5}$: 24 Hour and Annual NAAQS**

The $PM_{2.5}$ Analysis included the same two wind erosion Tailings Basin scenarios for the Plant Site as the $PM_{10}$ analysis: Scenario 1 and Scenario 2. The $PM_{2.5}$ 24-hour NAAQS results in Figures 8 and 9 show the erodible beach areas represented for Scenarios 1 and 2 in red.

As stated in the Plant Site protocol, "Final results will be used to determine need for inclusion of paved roads in submitted modeling". The MPCA paved road guidance policy requires that $PM_{10}$ and $PM_{2.5}$ NAAQS results greater than 95% or $PM_{10}$ Increment results greater than 75% of the standards require the inclusion of paved roads in the modeling analysis. The Plant Site only $PM_{2.5}$ NAAQS results are below their respective NAAQS of 35 and 15 $\mu g/m^3$ as shown in Table 3A and the maximum impacts are at the boundary due south of the tailings basin as shown in Figures 8 and 9. Both of these results are less than 95% of the NAAQS which does not require the paved road to be included.

$PM_{2.5}$ Cumulative Impact results for the 24 hour and annual NAAQS were below the 35 and 15 $\mu g/m^3$ standard as shown in Table 3B. Figures 10 and 11 show the maximum impacts are located at the boundary of Mesabi Nugget due west of the proposed tailings basin.

**$NO_2$: 1 Hour NAAQS and Annual Increment and NAAQS**

The annual $NO_X$ Increment modeling results for the Plant Site at its own ambient air boundary were 13% of the increment of 25 $\mu g/m^3$ as shown in Table 4A. Figure 12 shows the maximum impact is at the boundary next to the new administration building. The most likely culpable $NO_X$ source near that area is the administration building boiler. The Plant Site NAAQS results in Table 3A show the 1-hour and annual impacts are 94% and 21% of their respective standards. Figure 13 shows the 1-hour $NO_2$ maximum impacts at the boundary west of the Area 1 Shop due to space heater emissions emitted from its associated building vent. The annual $NO_X$ NAAQS results shown in Figure 14 indicate the Administration Building Boiler is also the culpable source as was the case in the annual increment results.

The annual $NO_X$ Cumulative Increment results are 3.5% of the standard of 25 $\mu g/m^3$ as shown in Table 4B. Figure 15 shows the maximum impacts occurring in two areas: west of the Mesabi Nugget Phase I plant and southeast of the Plant Site.

Cumulative impacts for 1-hour $NO_2$ NAAQS were modeled as a single 5 year run using the Ozone Limiting Method (OLM) in AERMOD. The maximum concentration was 155% of the NAAQS of 188 $\mu g/m^3$ as shown in Table 3B. Figure 16 shows the maximum impacts occurring throughout the western half of the receptor grid due to the nearby facilities (Arcelor Mittal, Virginia Public Utilities, Laskin Energy, and Minntac) that were included in the cumulative modeling. Figure 17 shows the Plant Site contribution to the 1-hour modeled concentrations shown in Figure 16. The Plant Site contributes 0.002 $\mu g/m^3$ to the maximum modeled 1-hour concentration and less than the SIL of 7.52 $\mu g/m^3$ for the receptors exceeding the NAAQS in Figure 16. The spreadsheet "NOX_results.xlsx" included with this report lists the contributions by facility for the 1-hour $NO_2$ modeled NAAQS concentrations. The annual $NO_X$ results were 23% of the 100 $\mu g/m^3$ NAAQS and the maximum impacts shown in Figure 18 were at the western edge of the receptor grid indicating the previously mentioned nearby facilities being the culpable sources.

NAAQS and MAAQS are applicable requirements. MPCA will evaluate any exceedences as part of the air permitting process.

**$SO_2$: 1 Hour NAAQS and 3 Hour, 24 Hour, and Annual Increment and NAAQS**

The 3-hour, 24-hour, and annual $SO_2$ increment modeling results for the Plant Site at its own ambient air boundary are all substantially below their respective Increments (<50%) as shown in Table 4A. Figures 19, 20, and 21 show the maximum impacts at the boundary due south of the Plant Site. The Plant Site NAAQS results in Table 3A show that the 1-hour, 24-hour, and annual NAAQS impacts are all below the respective standards with 1-hour $SO_2$ having the lowest margin with 56% of its NAAQS of 196 $\mu g/m^3$. Figures 22, 23, 24, and 25 show the 1 hour $SO_2$ maximum impacts in the same location as the increment results; due south of the Plant Site at the ambient air boundary.

The 3-hour, 24-hour, and annual $SO_2$ Cumulative Increment results are all less than 5% of the standards as shown in Table 4B. Figures 26, 27, and 28 show the short term maximum impacts occurring west of the Mesabi Nugget Phase I plant and the annual maximum impacts occur there as well as southeast of the Plant Site.

Cumulative impacts for 1-hour $SO_2$ NAAQS were modeled as a single 5 year run in AERMOD. The maximum concentration was 456% of the NAAQS of 196 $\mu g/m^3$ as shown in Table 3B. Figure 29 shows the maximum impacts occurring at the southern edge of the Mesabi Nugget ambient air boundary and the western edge of the receptor grid due to nearby facilities Laskin Energy and Virginia Public Utilities that were included in the cumulative modeling. Figure 30 shows the Plant Site contribution to the 1-hour modeled concentrations shown in Figure 29. The Plant Site contributes 0.002 $\mu g/m^3$ to the maximum modeled 1-hour concentration and less than the 7.83 $\mu g/m^3$ SIL for the receptors exceeding the NAAQS in Figure 29. The spreadsheet "SO2_ results.xlsx" included with this report lists the contributions by facility for the 1-hour $SO_2$ modeled NAAQS concentrations. The 3-hour MAAQS is 915 $\mu g/m^3$ and the model results are 86% of this MAAQS. The 24-hour $SO_2$ results were 70% of their 365 $\mu g/m^3$ Minnesota Ambient Air Quality Standard (MAAQS). The Annual $SO_2$ results were 40% of their 60 $\mu g/m^3$ Minnesota Ambient Air Quality Standard (MAAQS). Figures 31, 32, and 33 show the maximum impacts were at the western edge of the receptor grid indicating the nearby facility Virginia Public Utilities being the culpable source.

As noted above, NAAQS and MAAQS are applicable requirements that will be addressed by MPCA in permitting.

# Supplemental Information on Ozone NAAQS

Modeling for the NorthMet Project (Project) is being conducted and reported separately for the Mine Site and the Plant Site. In response to comments received on the Class II modeling protocol for the Plant Site, the following information on ozone formation is being included with the Plant Site Class II modeling results. However, the emission values referenced for the Project include both the Mine Site and Plant Site stationary source emissions, so the analysis applies to the entire project.

One of the primary differences in this ozone impacts analysis as compared to the other pollutants for which air quality impacts have been assessed is that dispersion modeling of ozone impacts is not technically or practically feasible[1] for determining an individual project's contribution to ground-level ozone concentrations either near the facility or at a long distance from the facility.

## Ozone Formation, Fate and Transport

Ozone is formed through complex photochemical reactions between $NO_X$, VOC, other non-regulated compounds (e.g., $OH^-$), sunlight, and meteorological conditions of wind speed, wind direction, temperature, and humidity. Elevated ozone concentrations occur primarily during stable / stagnant atmospheric conditions in urban airsheds.[2] Minnesota generally does not experience long duration stagnation periods due to its geographic location and climate.

Ozone transport can be an important contributor to a region's ozone concentrations[3], however, due to its distance from metropolitan areas and prevailing winds, northern Minnesota is not typically affected by long range ozone transport.

Ozone concentrations from 2008-2010 for Voyageurs National Park (VNP) are shown in Table 1 and are below the applicable standard. VNP is located approximately 82 miles northwest of the Plant Site and is the only year-round ozone monitoring station in northern Minnesota.[4]

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[1] 40 CFR Part 51 Appendix W – Guideline on Air Quality Models - Section 5.2.1.a.
[2] MPCA, 2011. Air Quality in Minnesota. 2011 Report to the Legislature. *Ozone concentrations tend to be highest just outside urban areas, since other pollutants emitted in urban centers actually destroy ground level ozone. As a result, MPCA does not monitor ozone in urban centers such as Minneapolis and St. Paul, but does in surrounding suburban areas.*
[3] See for example the Clean Air Interstate Rule (CAIR) replacement, called the Transport Rule, modifying 40 CFR Parts 51, 72, 73, 74, 77, 78, 96.

**Table 1: Voyageurs National Park 8 Hour Ozone NAAQS Monitor**

| YEAR | 8 Hour High 4th High Concentration (ppm) | NAAQS (ppm) | % NAAQS | Data Source |
|---|---|---|---|---|
| 2008 | 0.059 | 0.08 | 74% | EPA Airdata website |
| 2009 | 0.062 | 0.08 | 77% | EPA Airdata website |
| 2010 | 0.067 | 0.08 | 84% | EPA Airdata website |
| AVERAGE | 0.063 | 0.08 | 78% | |

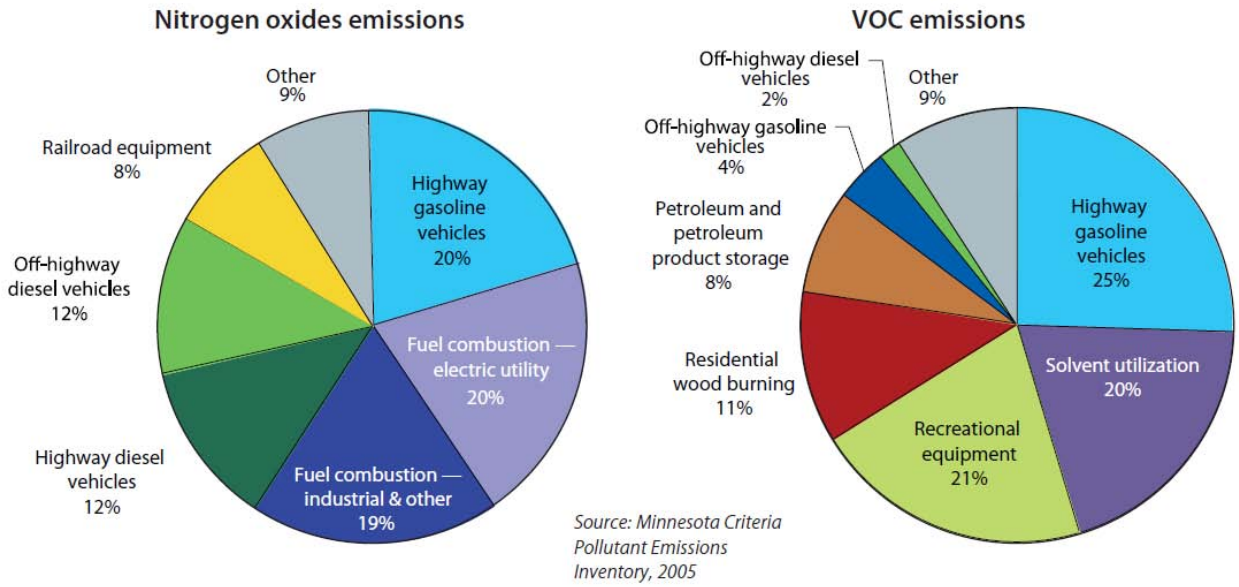
To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm (80 ppb).

## Ozone Precursor Emission Levels

$NO_X$ and VOC emissions are both ozone precursors. $NO_X$ emissions are primarily anthropogenic, whereas VOCs are emitted both from biogenic and anthropogenic sources (http://www.epa.gov/ord/sciencenews/scinews_trees-and-air-pollution.htm). Figure 1 shows the primary anthropogenic emission source types for $NO_X$ and VOCs in Minnesota.

[4] The MPCA conducts ozone monitoring at other stations in northern Minnesota from April through September.

**Figure 1: Minnesota Ozone Precursor Emissions by Source Type[5]**




*Ozone concentrations are dependent on sunlight, heat and emissions of $NO_X$ and VOCs. The main source of $NO_X$ is emissions from burning fuels. Stationary sources such as electric utilities account for nearly 40 percent of $NO_X$ emissions. Another 32 percent comes from gasoline and diesel highway vehicles. Major sources of VOCs include evaporation from and combustion of gasoline in highway and recreational vehicles (46 percent), use of solvents (20 percent) and residential wood burning (11 percent).*

## Project $NO_X$ and VOC Emissions Analysis

The emission inventory spreadsheets submitted with version 2 of the Class I Modeling results list controlled potential emissions for the Project (Plant Site and Mine Site) stationary sources of 49 tpy VOC and 95 tpy $NO_X$.

Table 2 compares reported actual statewide emissions in 2008 with emissions increases that would result from the Project and with changes associated with reasonably foreseeable projects in northeastern Minnesota (as reported in Table 1 of the Cumulative Visibility Report (version 3, January 2012)).

---

[5] Source: MPCA. Air Quality in Minnesota: Emerging Trends. 2009 Report to the Legislature

Statewide VOC emissions from 1999 are also included in Table 2[6]. The table illustrates that proposed Project emissions would be negligible compared to statewide emissions.

**Table 2. Statewide Actual Emissions Compared with Proposed and Reasonably Foreseeable Emissions**

| $NO_X$ | 2008 Actuals | Proposed Project | Reasonably Foreseeable Changes in NE MN |
|---|---|---|---|
| Stationary sources (tons/yr) | 129,000 | 95 | -3,292 |
| All sources (tons/yr) | 391,000 | -- | -- |
| % 2008, stationary | -- | 0.07% | -11.6% |
| % 2008, total | -- | 0.02% | -3.8% |
| **VOC** | **1999 Actuals** | **Proposed ESMM Project** | **Reasonably Foreseeable Changes in NE MN** |
| Stationary sources (tons/yr) | 32,500 | 49 | -- |
| All sources (tons/yr) | 397,000 | -- | -- |
| % 1999, stationary | -- | 0.2% | -- |
| % 1999, total | -- | 0.01% | -- |

## Summary

In conclusion, while ozone formation is complex and not directly linear with respect to emissions, given the low Project $NO_X$ and VOC emissions relative to statewide emissions, as well as the generally uniform ozone concentrations in northern Minnesota and its favorable location (relative to ozone formation), there is no reason to believe that the Project would have an impact on ozone concentrations either near to or far from the facility. Because ozone concentrations at the nearest receptor (VNP) are currently 78% of the standard (Table 1), there is no reason to expect emissions from the Project would alter compliance status at VNP with respect to the ozone standard.

[6] 1999 VOC emissions from MPCA website. http://www.pca.state.mn.us/index.php/topics/environmental-data/eda-environmental-data-access/eda-air-quality-searches/eda-air-quality-search-pollutant-data.html

Barr Footer: ArcGIS 10.0, 2012-05-29 13:09 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_1_PolyMet_PlantSite_EISCumulative_NAAQS_INCREMENT_Receptors.mxd User: jjm



- Cumulative Receptors
- Mesabi Nugget
- NorthMet Mine Site
- NorthShore Mine
- Mesabi Nugget AAB
- NorthMet Plant Site AAB
- St Louis County Tax Records

**Northshore Peter Mitchell Mine on-site receptors based on St. Louis County tax property records.

N

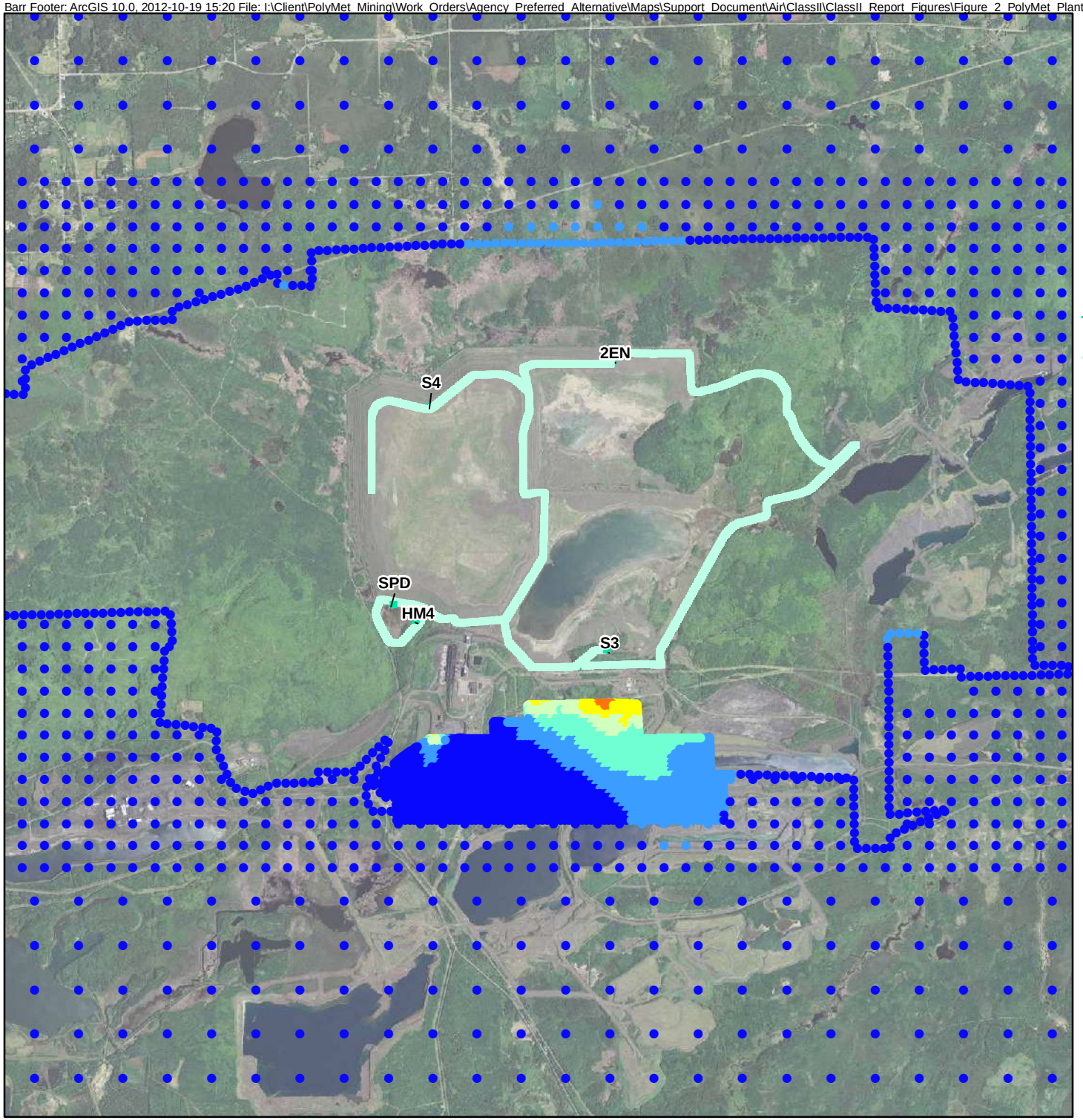
Kilometers

5 0 5 10

Figure 1

EIS CUMULATIVE NAAQS/INCREMENT
RECEPTOR GRID
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-10-19 15:20 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_2_PolyMet_PlantSite_24hPM10_IncrementResults.mxd User: jjm




**H2H Concentration (ug/m$^3$)**

- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 27
- Tailings Construction Handling
- Tailings Construction Roads

$PM_{10}$ 24 Hour Increment is 30 ug/m$^3$.

N

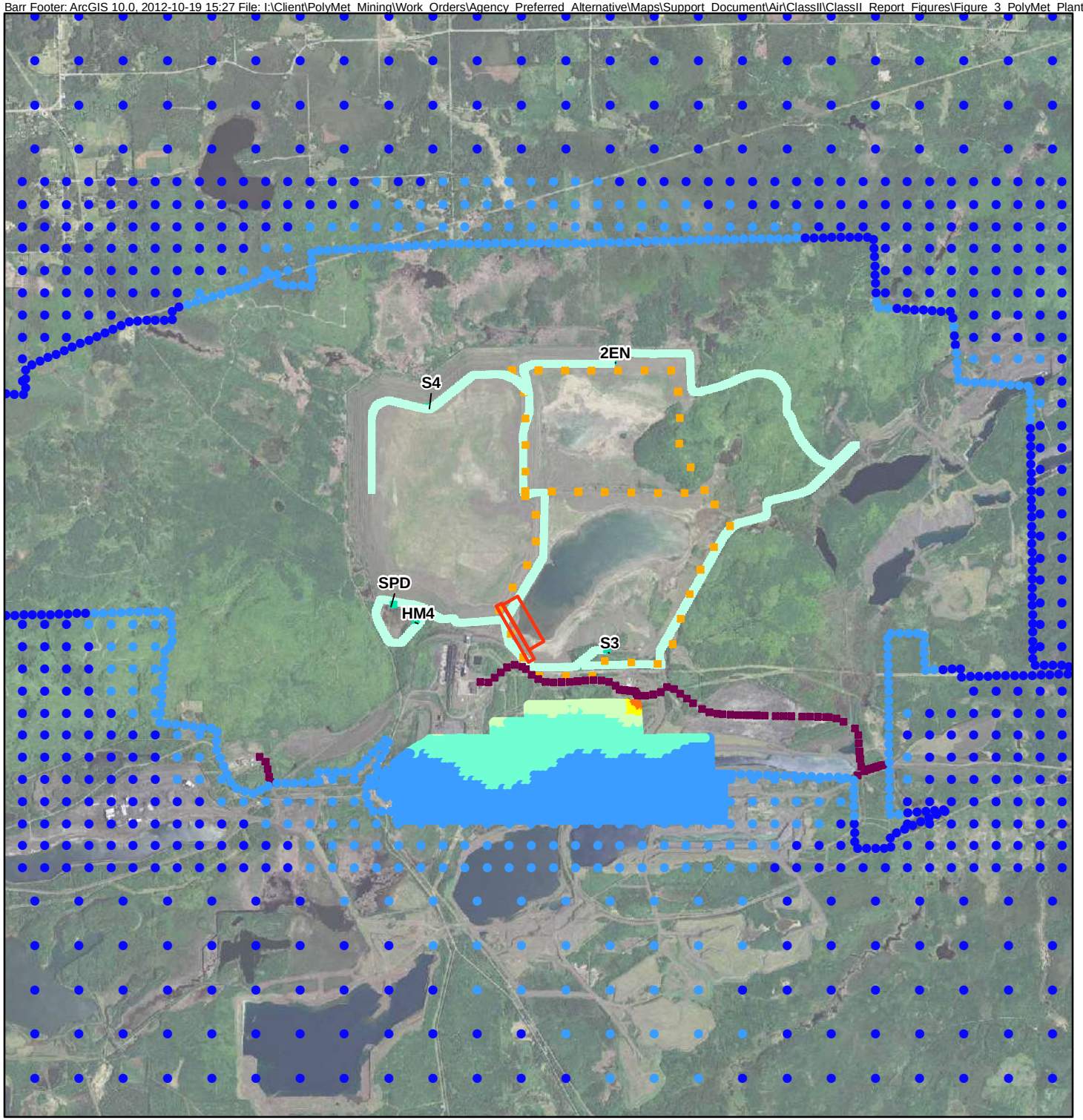
Meters

1,000 0 1,000

Figure 2

24 HOUR $PM_{10}$ INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-10-19 15:27 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_3_PolyMet_PlantSite_24hPM10_NAAQS1Results.mxd User: jjm




**H6H Concentration ug/m$^3$**

- 36 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 75
- 76 - 80
- Tailings Basin Erodible Beach Area
- Dunka Road Traffic
- Tailings Construction Handling
- Tailings Construction Roads
- Tailings Maintenance Traffic

$PM_{10}$ 24 Hour NAAQS is 150 ug/m$^3$.
Background Concentration Included = 36 ug/m$^3$

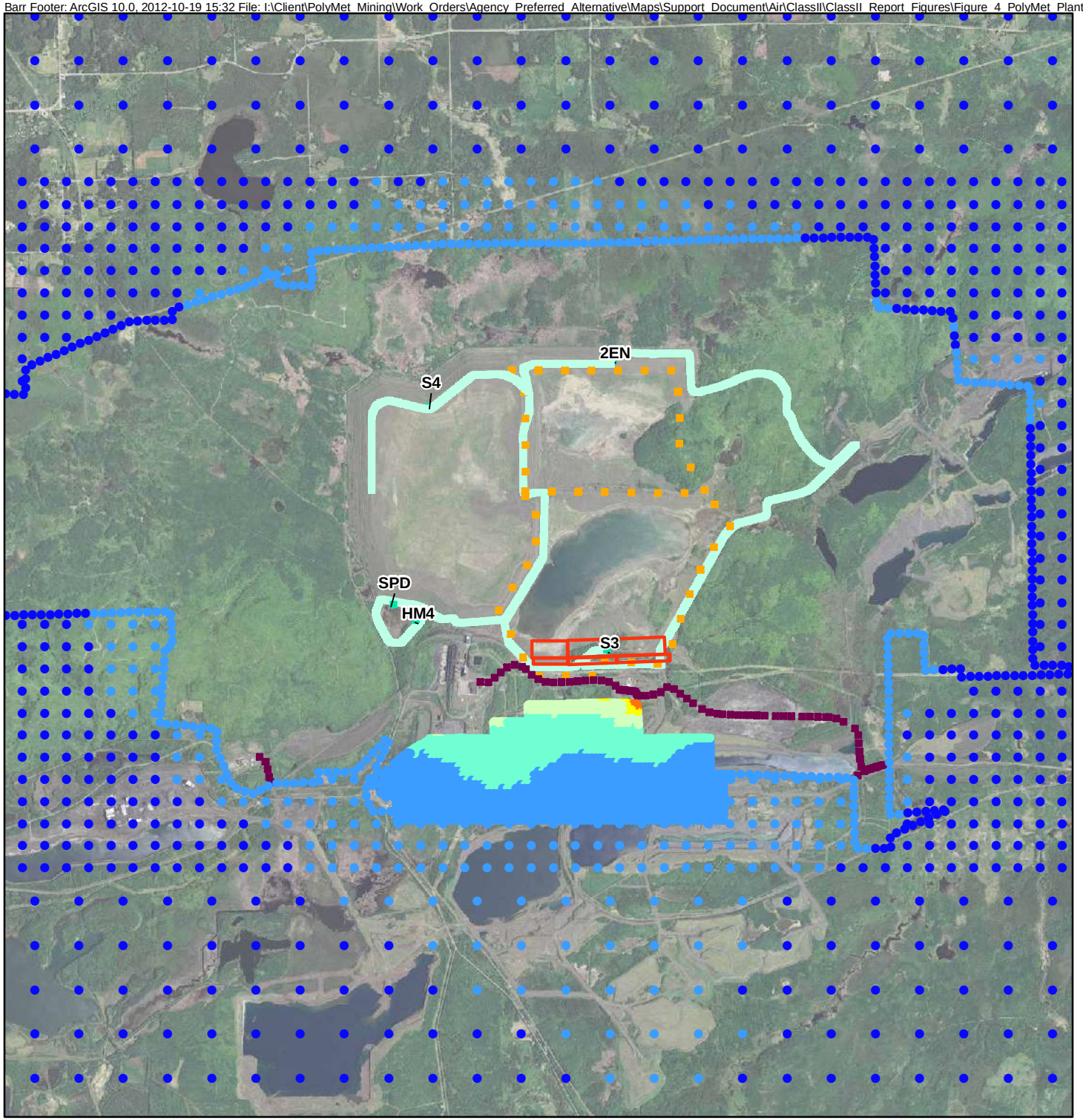
N

Meters
1,000 0 1,000

Figure 3

24 HOUR $PM_{10}$ NAAQS RESULTS
TAILINGS BASIN SCENARIO 1
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-10-19 15:32 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_4_PolyMet_PlantSite_24hPM10_NAAQS2Results.mxd User: jjm




**H6H Concentration ug/m$^3$**

- 36 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 75
- 76 - 80
- Tailings Basin Erodible Beach Area
- Dunka Road Traffic
- Tailings Construction Handling
- Tailings Construction Roads
- Tailings Maintenance Traffic

$PM_{10}$ 24 Hour NAAQS is 150 ug/m$^3$.
Background Concentration Included = 36 ug/m$^3$

N

Meters
1,000 0 1,000

Figure 4

24 HOUR $PM_{10}$ NAAQS RESULTS
TAILINGS BASIN SCENARIO 2
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 14:17 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_5_PolyMet_PlantSite_24hPM10_Nopavedroad_IncrementCIResults.mxd User: jjm

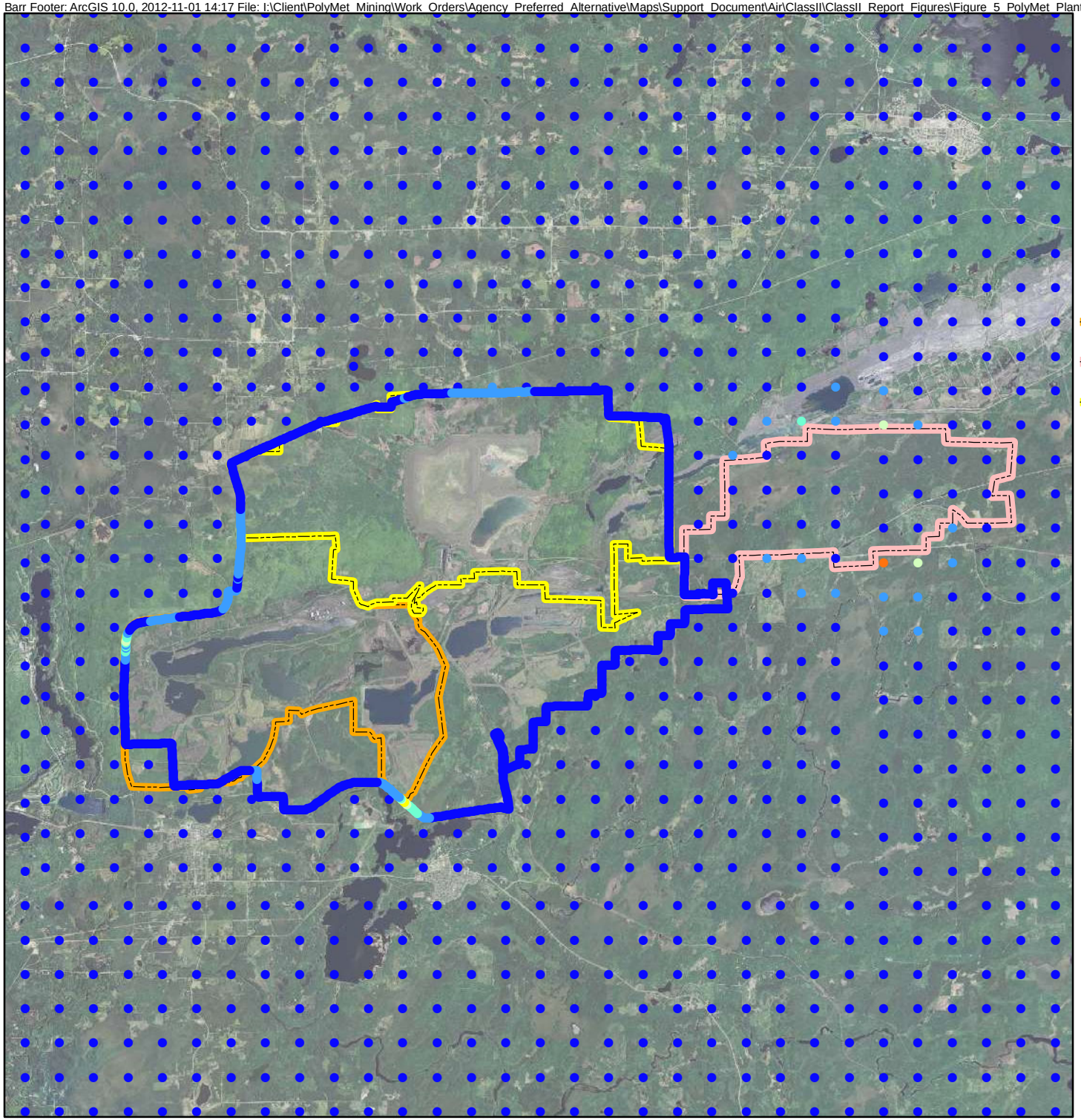
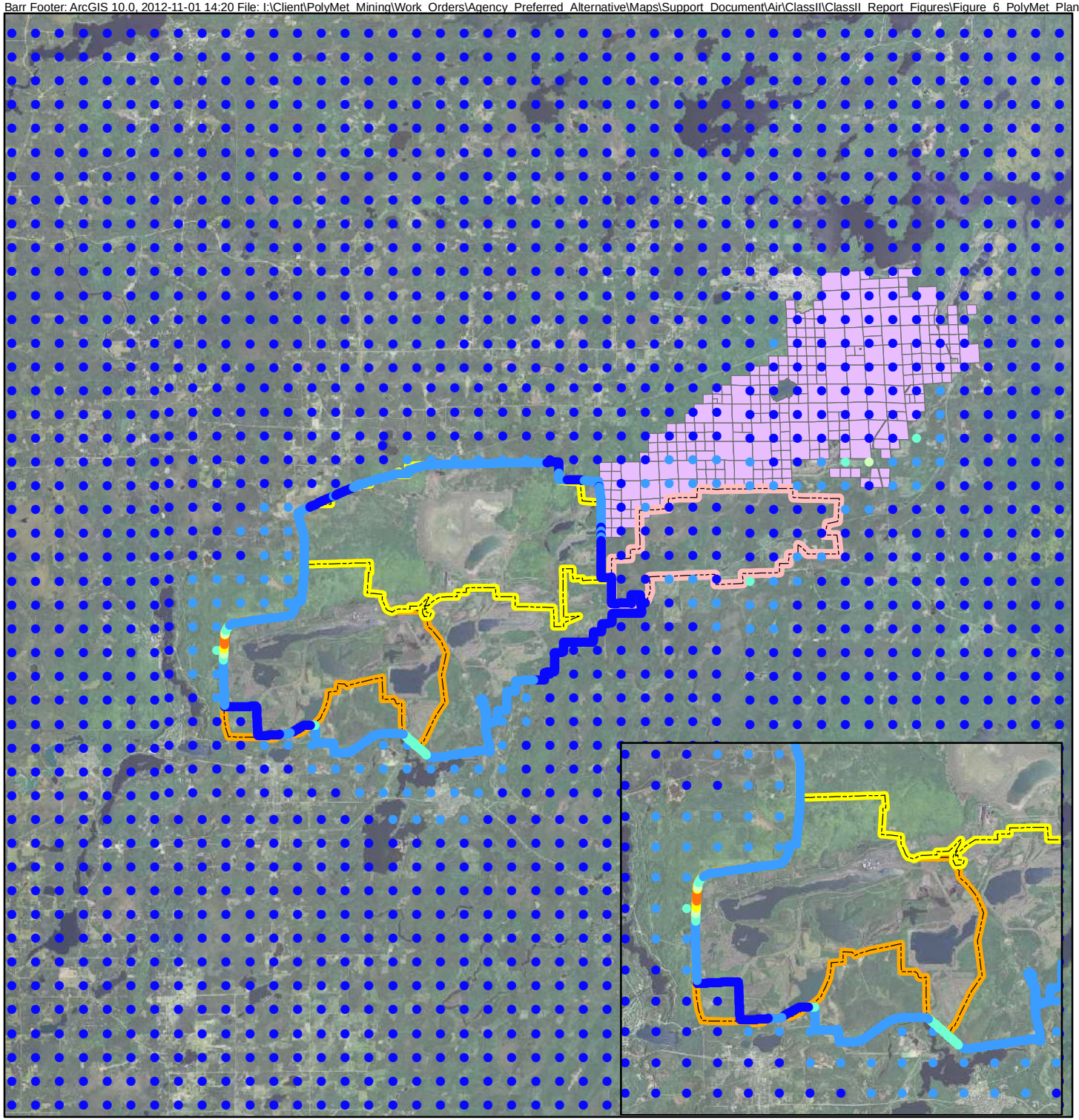



Figure 5

24 HOUR $PM_{10}$ CUMULATIVE IMPACT INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 14:20 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_6_PolyMet_PlantSite_24hPM10_nopavedroadNAAQS1CIResults.mxd User: jjm



**H6H Concentration ug/m$^3$**

- 36 - 40
- 41 - 50
- 51 - 60
- 61 - 65
- 66 - 70
- 71 - 77
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$PM_{10}$ 24 Hour NAAQS is 150 ug/m$^3$.
Background Concentration Included = 36 ug/m$^3$.

N

Kilometers
5 0 5

Figure 6

24 HOUR $PM_{10}$ CUMULATIVE IMPACT NAAQS RESULTS
TAILINGS BASIN SCENARIO 1
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 14:24 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_7_PolyMet_PlantSite_24hPM10_nopavedroadNAAQS2CIResults.mxd User: jjm

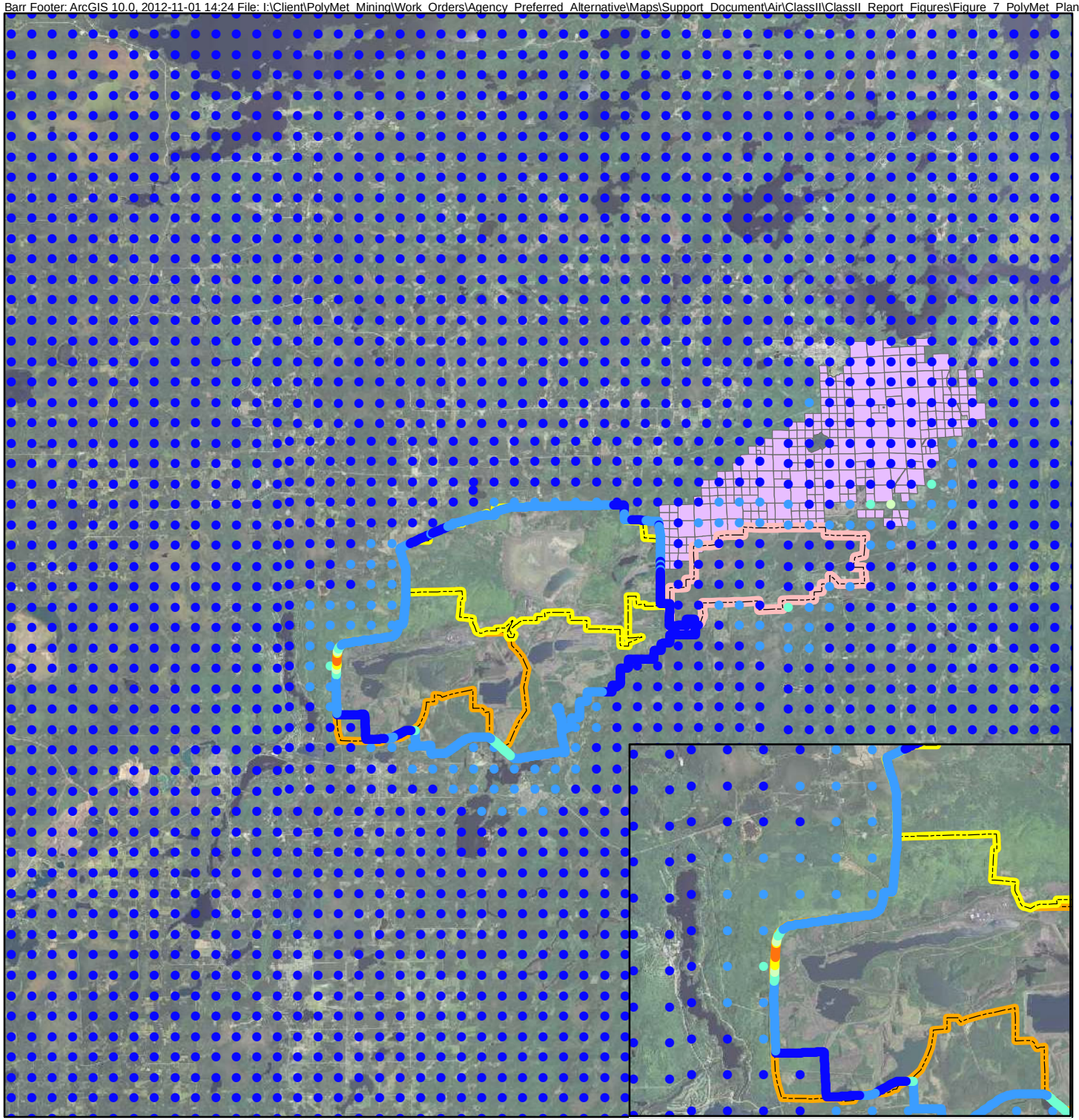
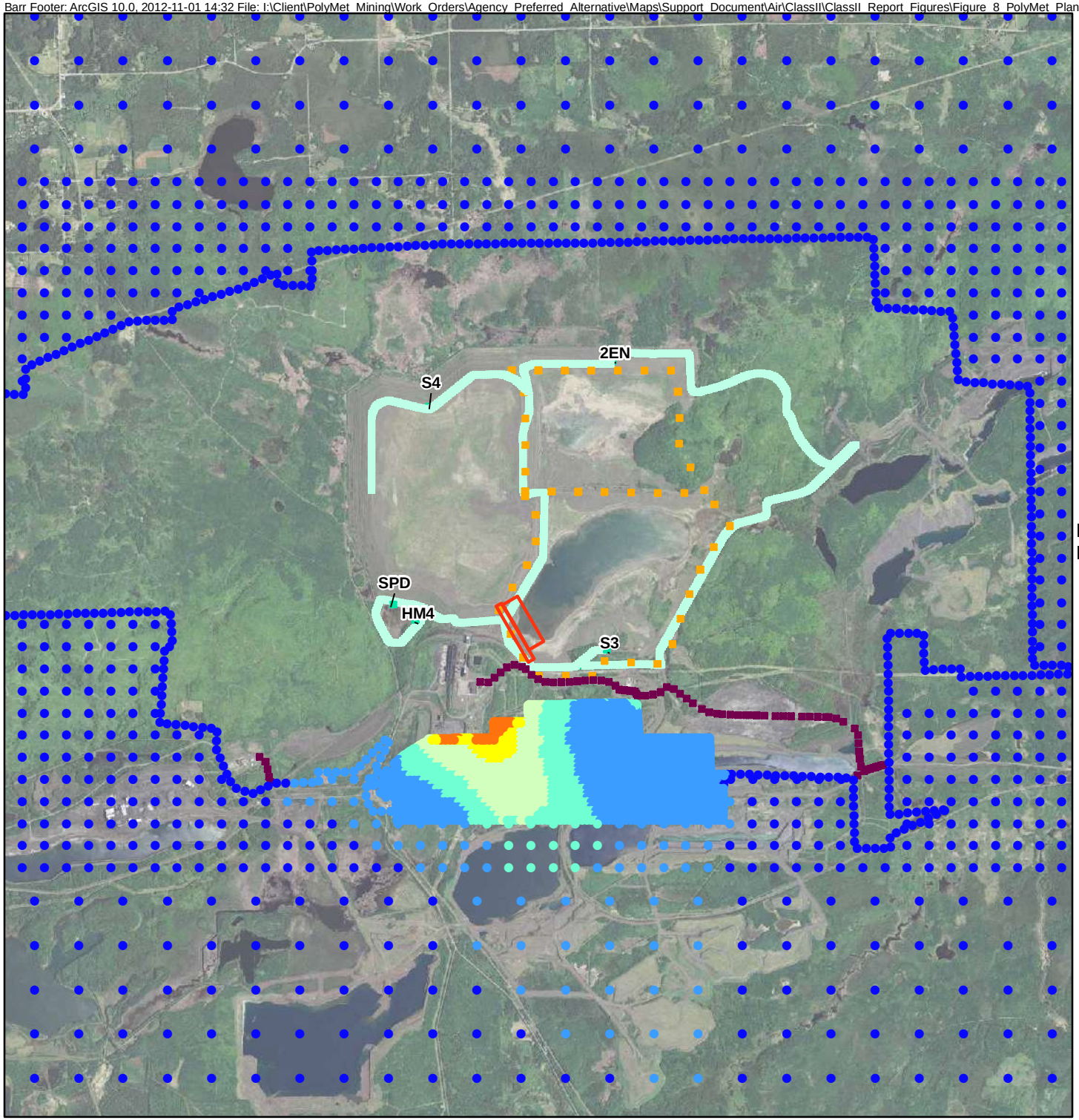



Figure 7

24 HOUR $PM_{10}$ CUMULATIVE IMPACT NAAQS RESULTS
TAILINGS BASIN SCENARIO 2
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 14:32 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_8_PolyMet_PlantSite_24hPM25_NAAQS1Results.mxd User: jjm




**H8H Concentration ug/m$^3$**

- 17 - 20
- 21 - 23
- 24 - 25
- 26 - 28
- 29 - 30
- 31 - 33
- Tailings Basin Erodible Beach Area
- Dunka Road Traffic
- Tailings Construction Handling
- Tailings Construction Roads
- Tailings Maintenance Traffic

$PM_{2.5}$ 24 Hour NAAQS is 35 ug/m$^3$.
Background Concentration Included = 16.5 ug/m$^3$

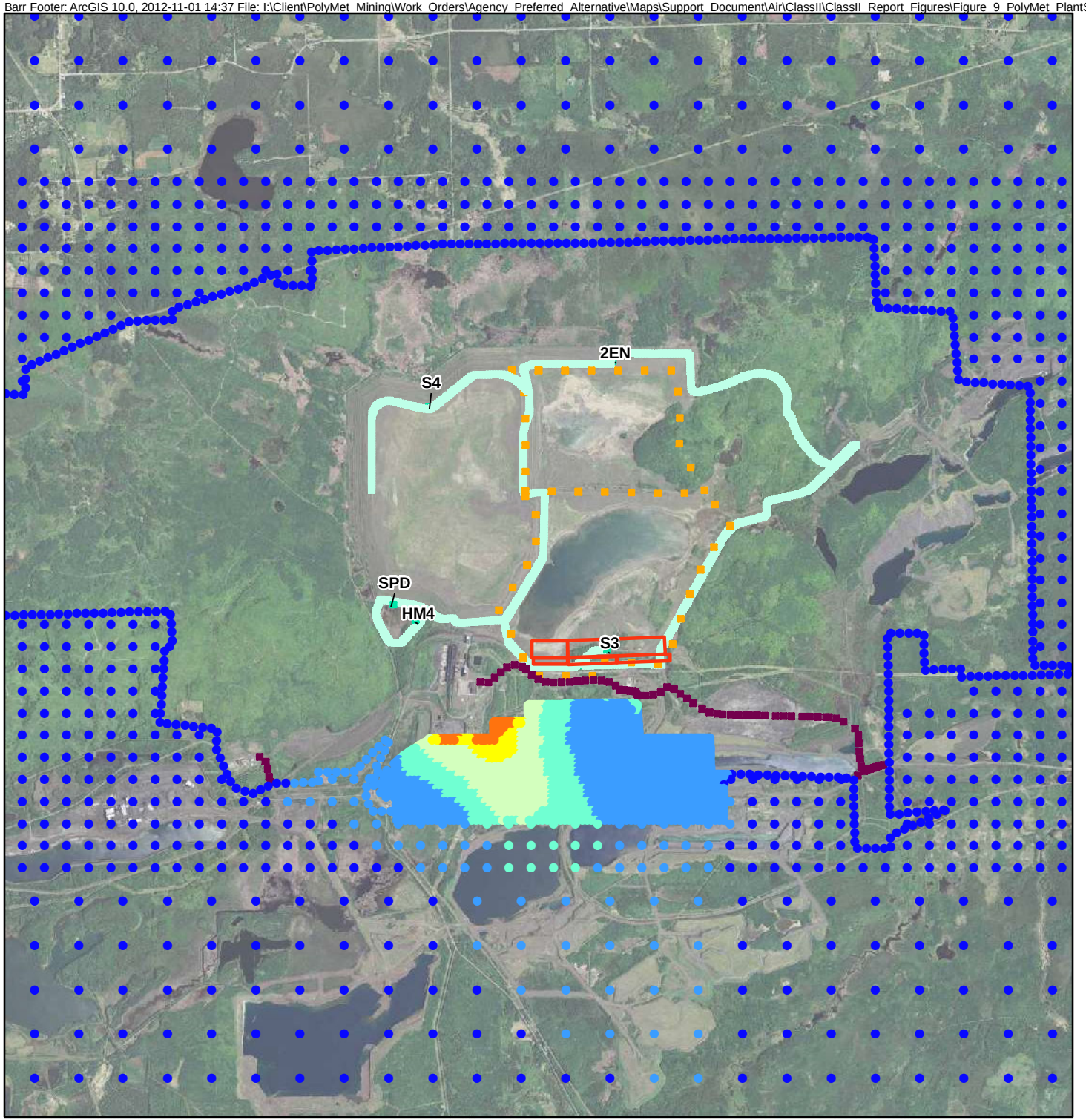
N

Meters
1,000 0 1,000

Figure 8

24 HOUR $PM_{2.5}$ NAAQS RESULTS
TAILINGS BASIN SCENARIO 1
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 14:37 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_9_PolyMet_PlantSite_24hPM25_NAAQS2Results.mxd User: jjm




**H8H Concentration ug/m$^3$**

- 17 - 20
- 21 - 23
- 24 - 25
- 26 - 28
- 29 - 30
- 31 - 33
- Tailings Basin Erodible Beach Area
- Dunka Road Traffic
- Tailings Construction Handling
- Tailings Construction Roads
- Tailings Maintenance Traffic

$PM_{2.5}$ 24 Hour NAAQS is 35 ug/m$^3$.
Background Concentration Included = 16.5 ug/m$^3$

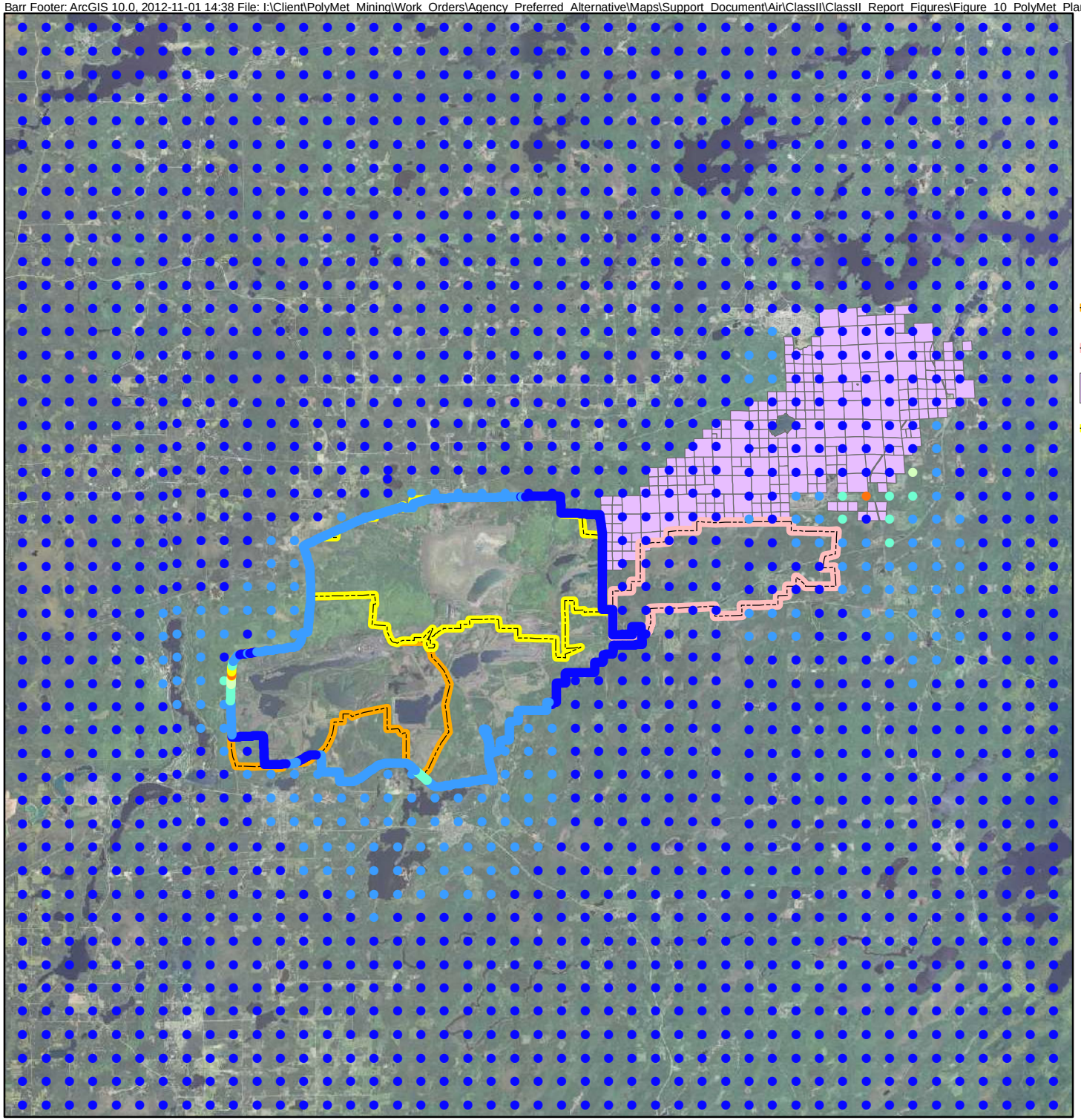
N

Meters
1,000 0 1,000

Figure 9

24 HOUR $PM_{2.5}$ NAAQS RESULTS
TAILINGS BASIN SCENARIO 2
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 14:38 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_10_PolyMet_PlantSite_24hPM25CI_NAAQS1Results.mxd User: jjm



**H8H Concentration ug/m$^3$**

- 17 - 20
- 21 - 24
- 25 - 28
- 29 - 30
- 31 - 32
- 33 - 34
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$PM_{2.5}$ 24 Hour NAAQS is 35 ug/m$^3$.
Background Concentration Included = 16.5 ug/m$^3$

N

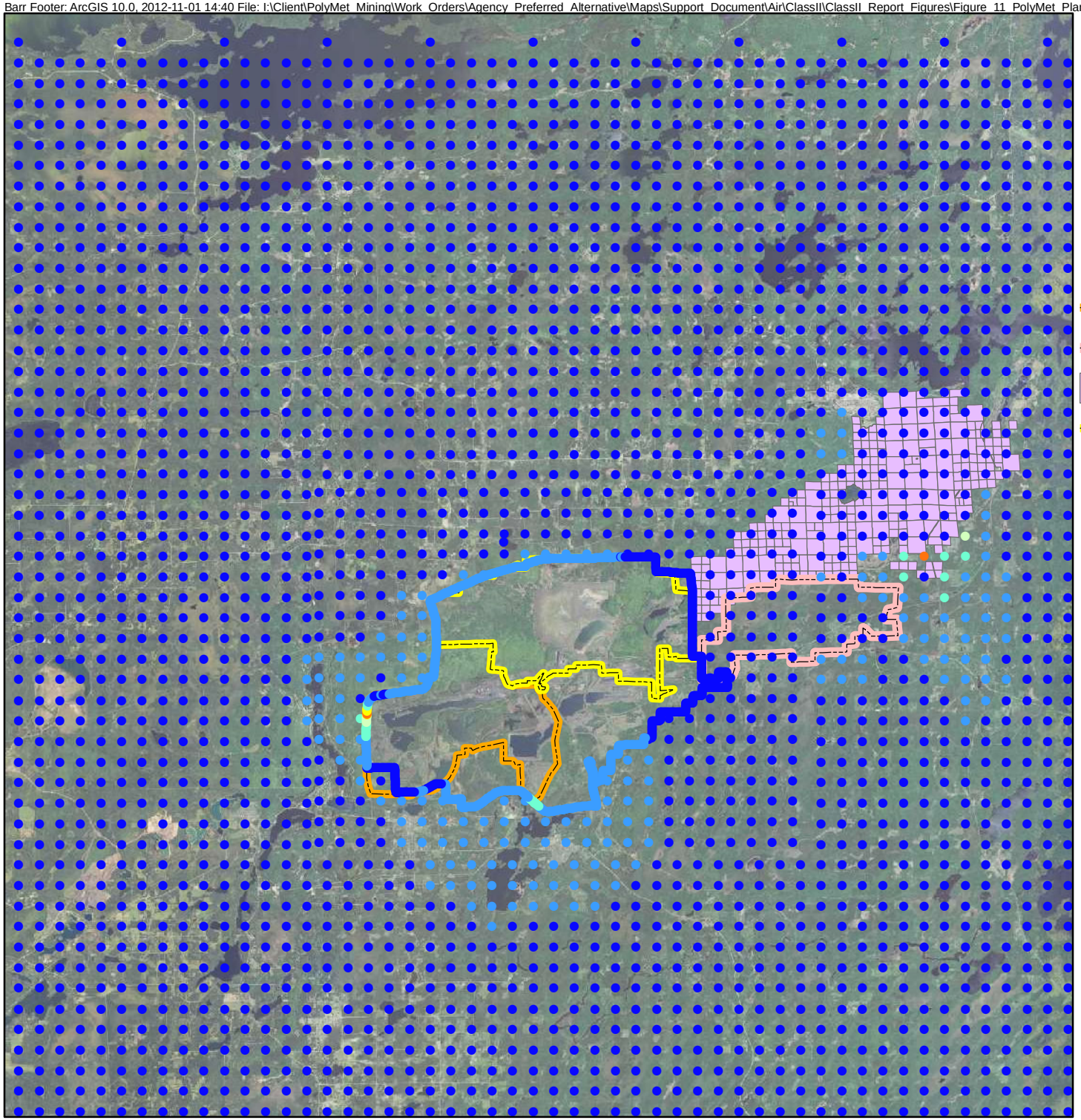
Kilometers

5 0 5

Figure 10

24 HOUR $PM_{2.5}$ CUMULATIVE IMPACT NAAQS RESULTS
TAILINGS BASIN SCENARIO 1
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

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**H8H Concentration ug/m$^3$**

- 17 - 20
- 21 - 24
- 25 - 28
- 29 - 30
- 31 - 32
- 33 - 34
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$PM_{2.5}$ 24 Hour NAAQS is 35 ug/m$^3$.
Background Concentration Included = 16.5 ug/m$^3$

N

Kilometers

5 0 5

Figure 11

24 HOUR $PM_{2.5}$ CUMULATIVE IMPACT NAAQS RESULTS
TAILINGS BASIN SCENARIO 2
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

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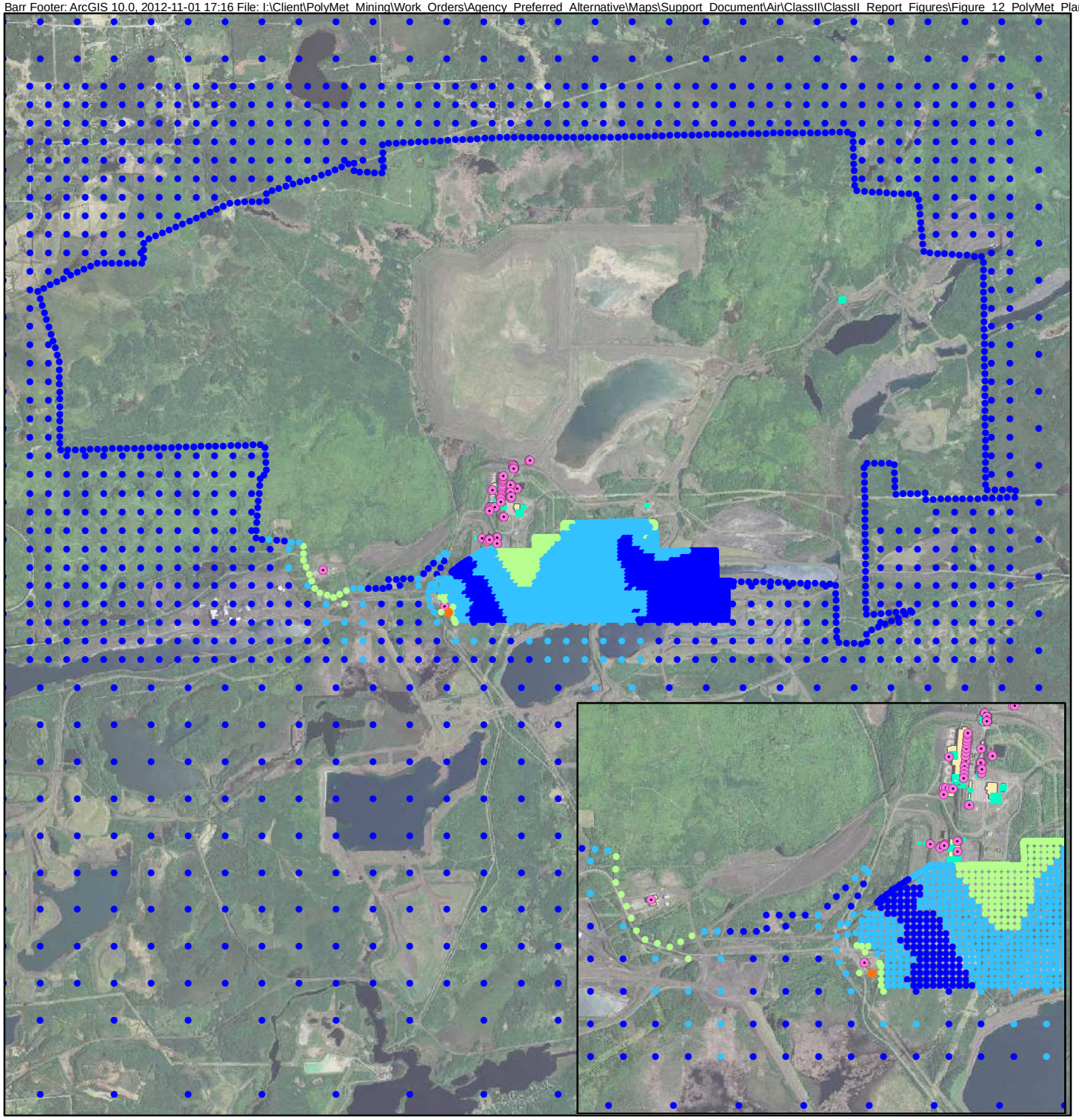
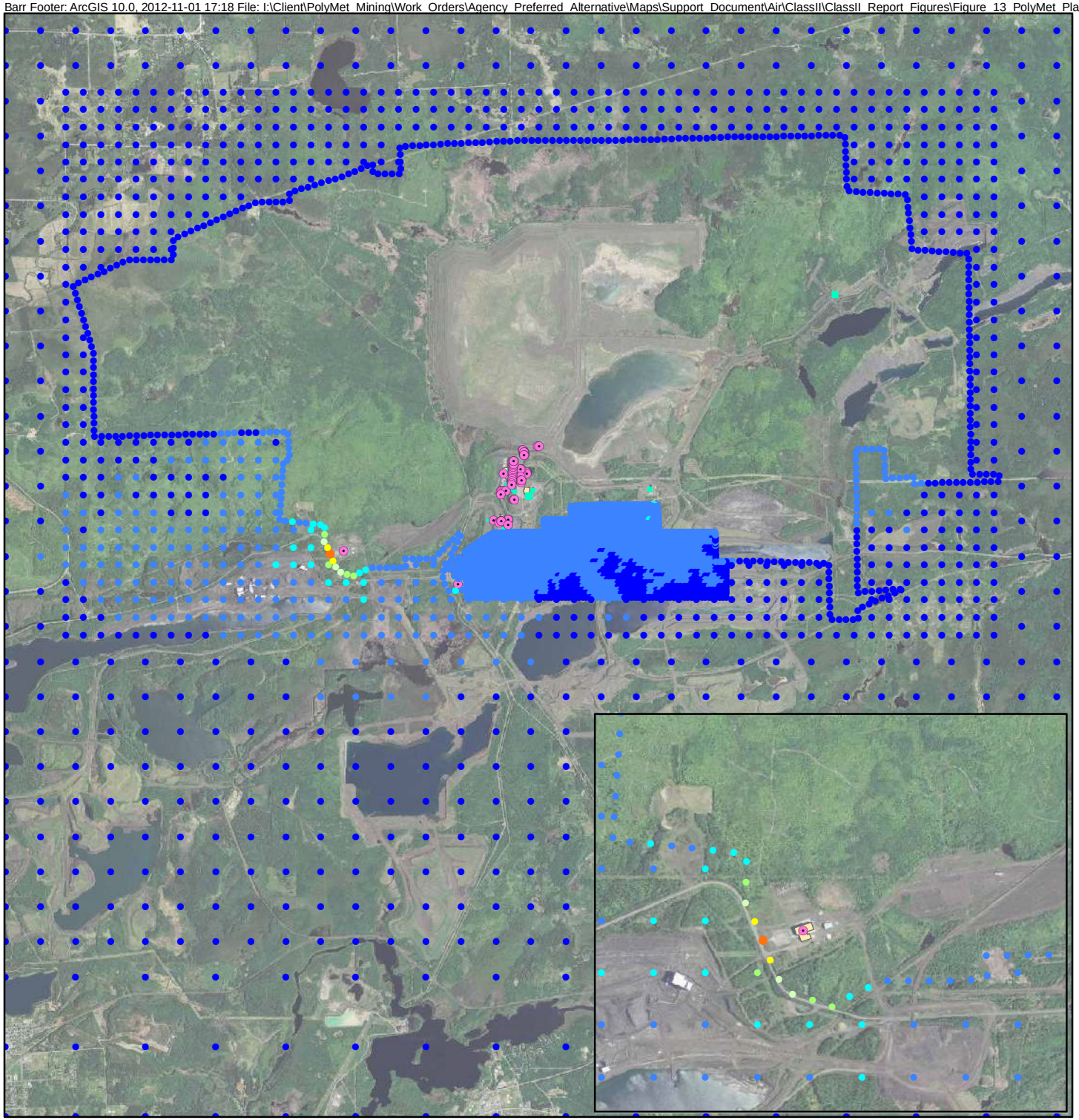



Figure 12

ANNUAL $NO_X$ INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 17:18 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_13_PolyMet_PlantSite_1hNOX_NAAQSResults.mxd User: jjm



**H8H Concentration ug/m$^3$**

- 91 - 100
- 101 - 120
- 121 - 140
- 141 - 150
- 151 - 160
- 161 - 170
- 171 - 177
- Point Sources
- Volume Sources

$NO_2$ 1 Hour NAAQS is 188 ug/m$^3$.
Background Concentration Included = 89.6 ug/m$^3$

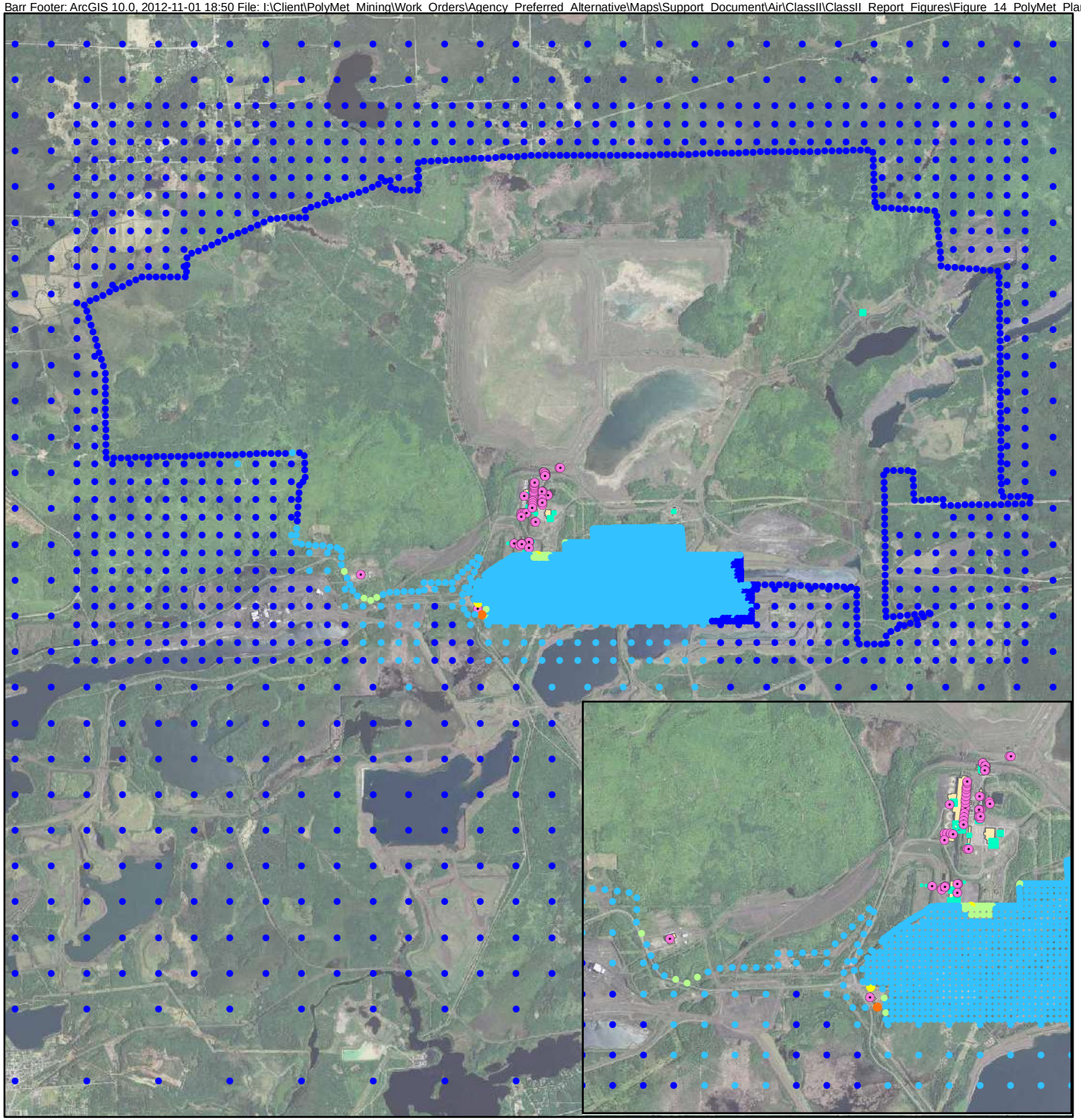
N

Meters
1,000 0 1,000

Figure 13

1 HOUR $NO_2$ NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 18:50 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_14_PolyMet_PlantSite_AnnNOX_NAAQSResults.mxd User: jjm



**Max Concentration ug/m$^3$**

- 17.6 - 18.0
- 18.1 - 19.0
- 19.1 - 19.5
- 19.6 - 20.5
- 20.6 - 20.8
- Point Sources
- Volume Sources
- BPIP Structures

$NO_X$ Annual NAAQS is 100 ug/m$^3$.
Background Concentration Included = 17.6 ug/m$^3$

N

Meters
1,000 0 1,000

Figure 14

ANNUAL $NO_X$ NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 11:33 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_15_PolyMet_PlantSite_AnnNOXCI_IncrementResults.mxd User: jjm

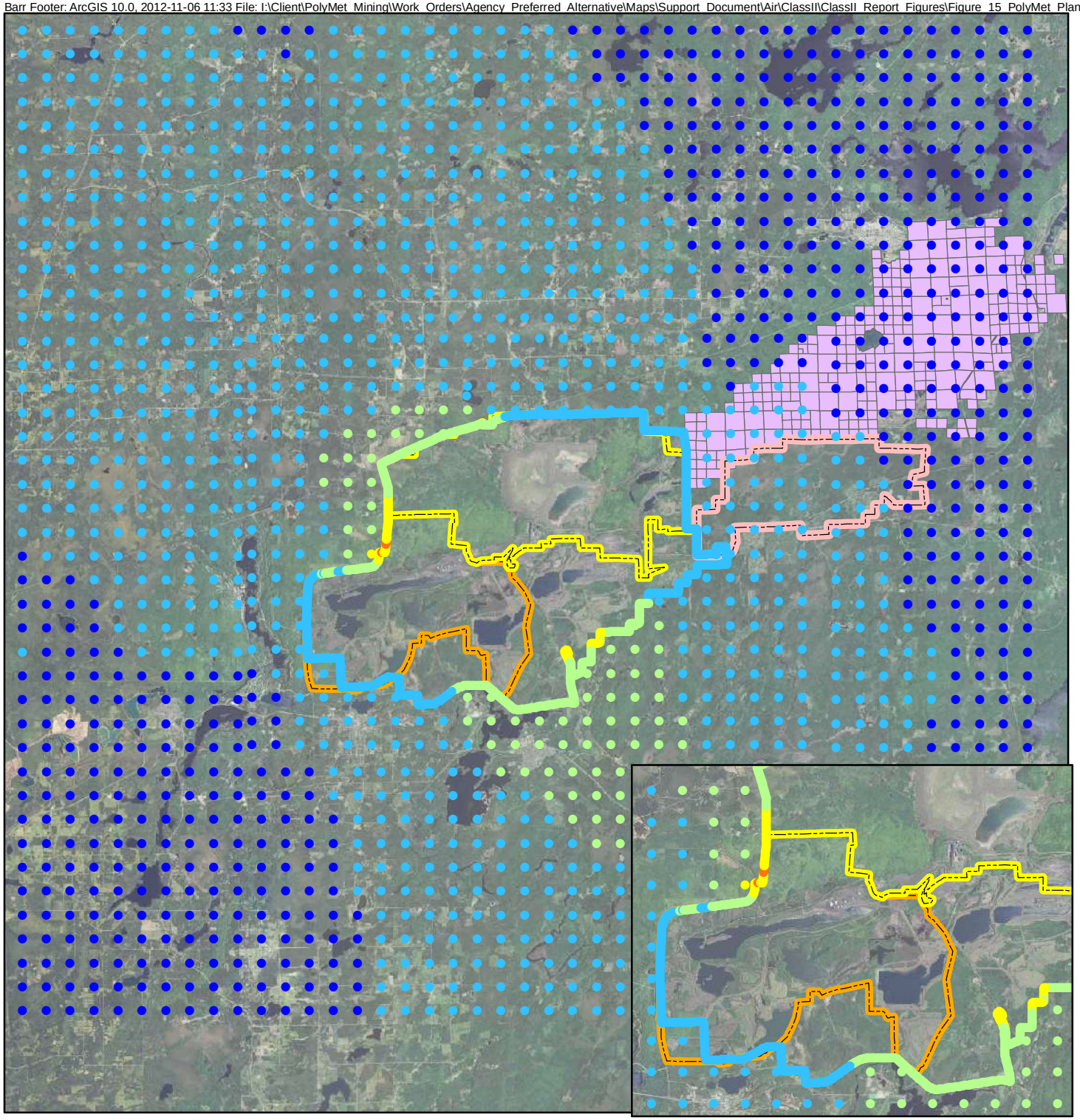
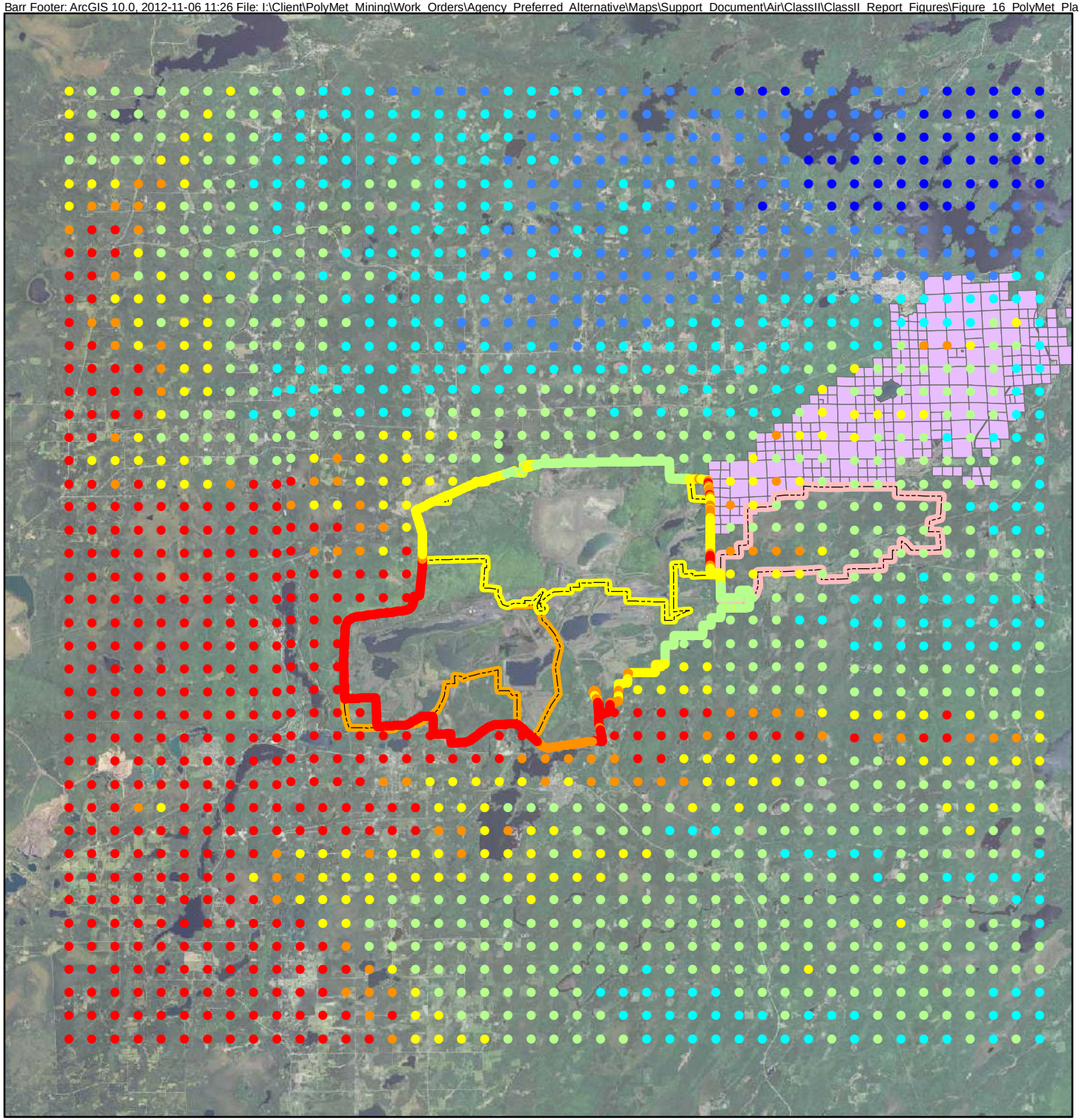



Figure 15

Annual $NO_X$ CUMULATIVE
IMPACT INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 11:26 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_16_PolyMet_PlantSite_1hNO2CI_NAAQSResults.mxd User: jjm



**H8H Concentration ug/m$^3$**

- 142 - 149
- 150 - 159
- 160 - 169
- 170 - 179
- 180 - 185
- 186 - 188
- 189 - 292
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- PolyMet Plant Site AAB
- St Louis County Tax Records

$NO_2$ 1 Hour NAAQS is 188 ug/m$^3$.
Background Concentration Included = 89.6 ug/m$^3$

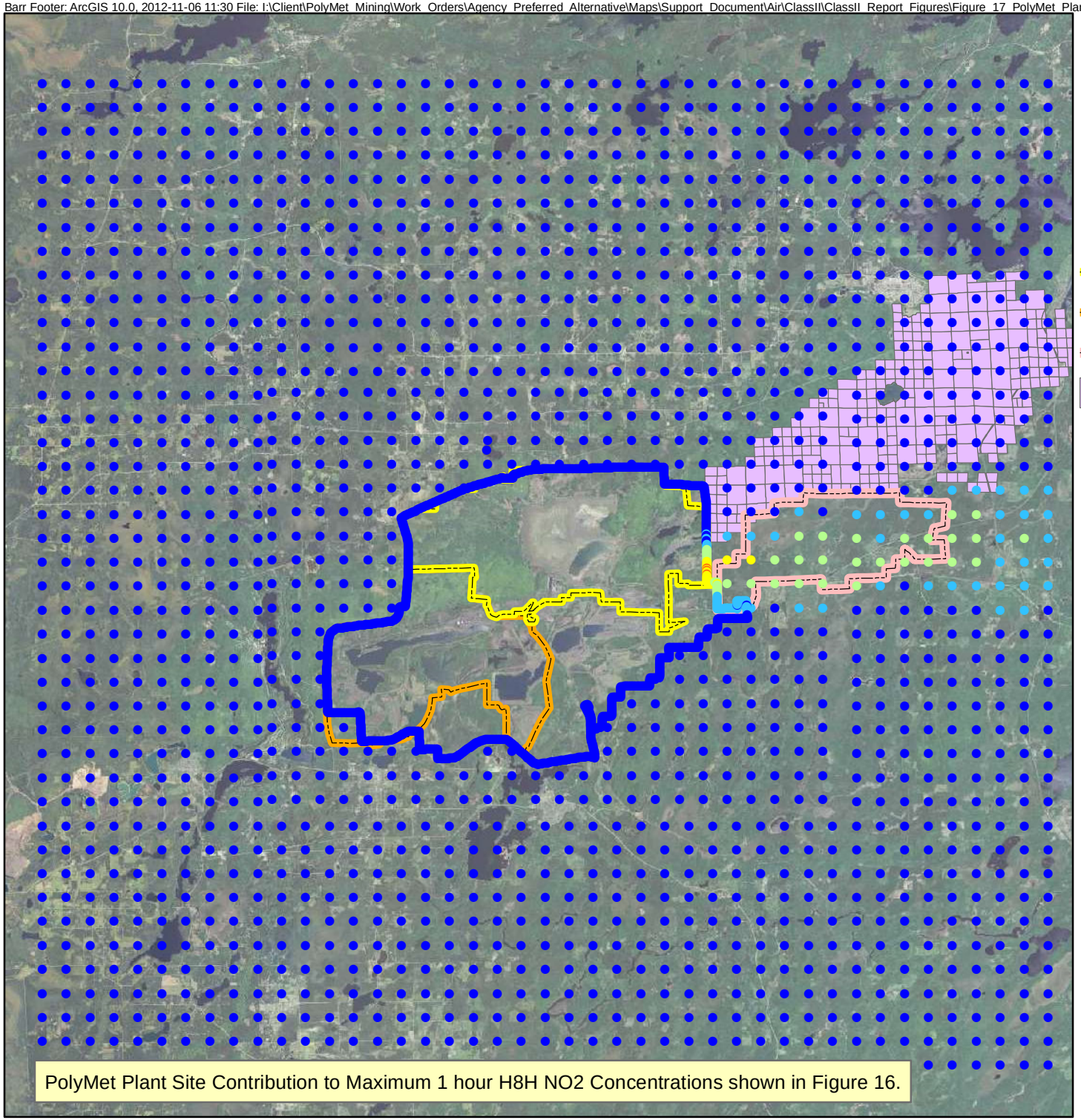
N

Kilometers
5 0 5

Figure 16

1 HOUR $NO_2$ CUMULATIVE IMPACT NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 11:30 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_17_PolyMet_PlantSiteCulpability_1hNO2CI_NAAQSResults.mxd User: jjm




PolyMet Plant Site Contribution to Maximum 1 hour H8H NO2 Concentrations shown in Figure 16.

Figure 17

1 HOUR $NO_2$ CUMULATIVE
IMPACT NAAQS
POLYMET PLANT SITE CULPABILITY
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

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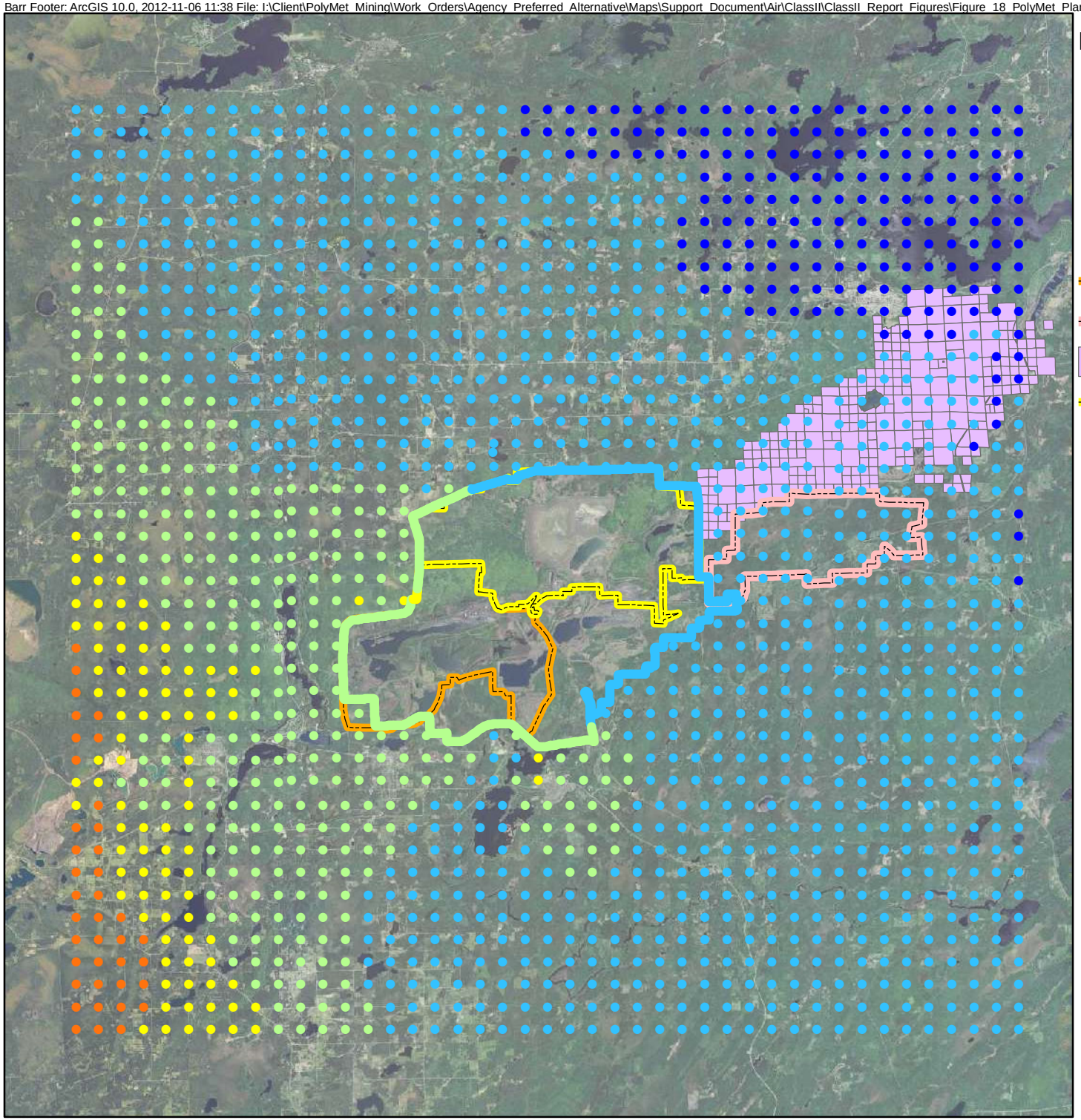



Figure 18

Annual $NO_X$ CUMULATIVE IMPACT NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

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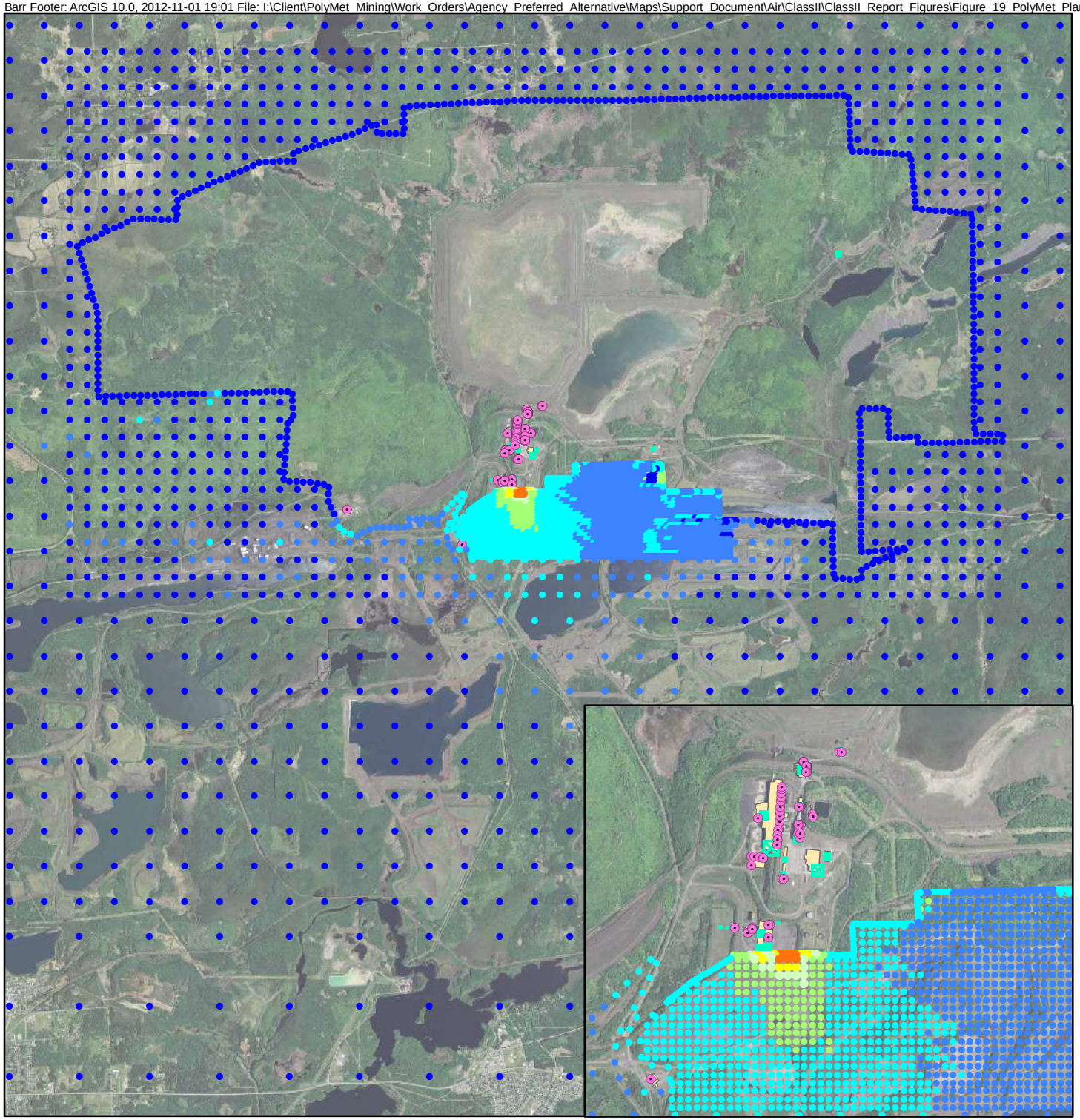



Figure 19

3 HOUR $SO_2$ INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:02 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_20_PolyMet_PlantSite_24hSO2_IncrementResults.mxd User: jjm

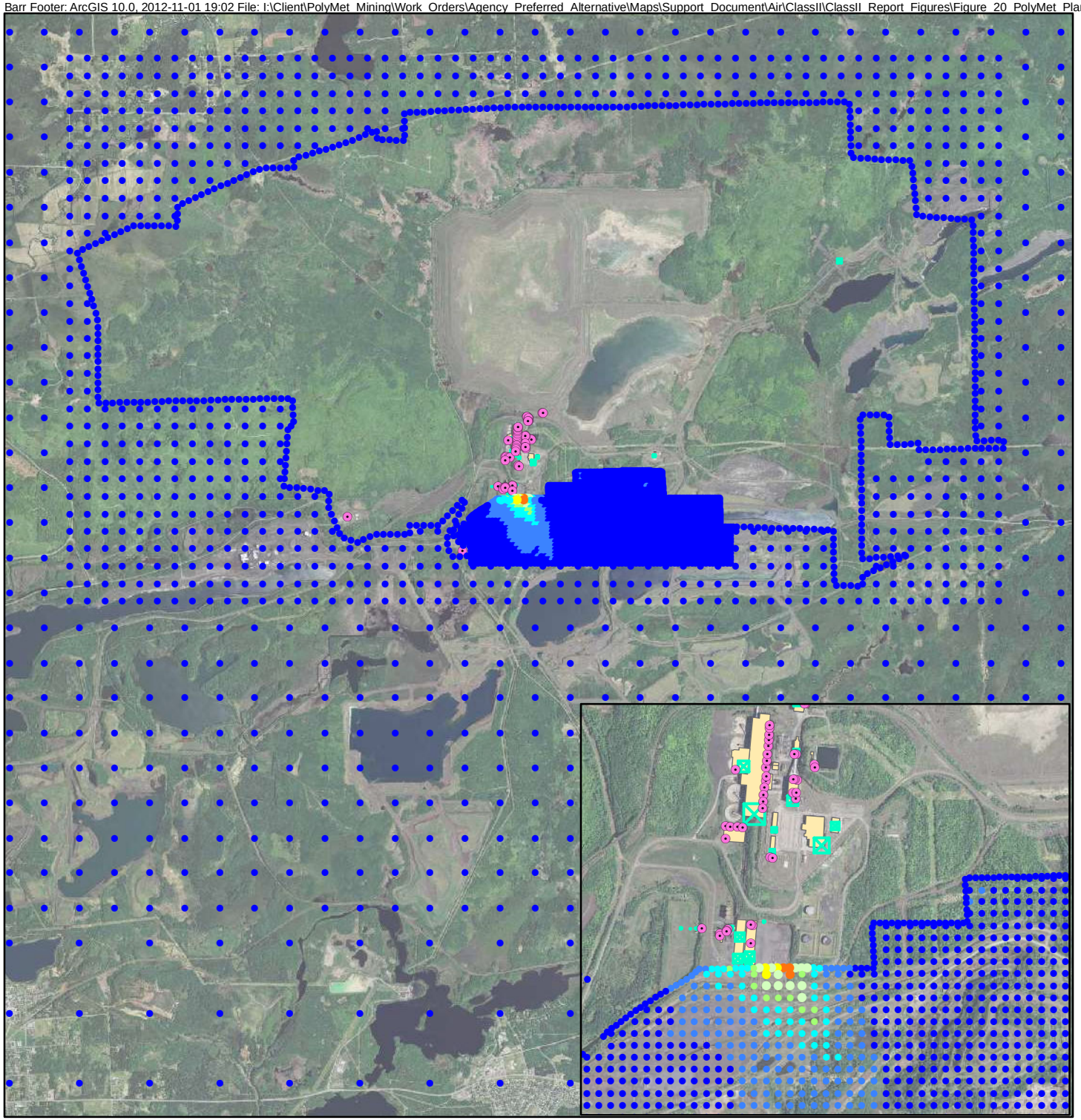



Figure 20

24 HOUR $SO_2$ INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:04 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_21_PolyMet_PlantSite_AnnSO2_IncrementResults.mxd User: jjm

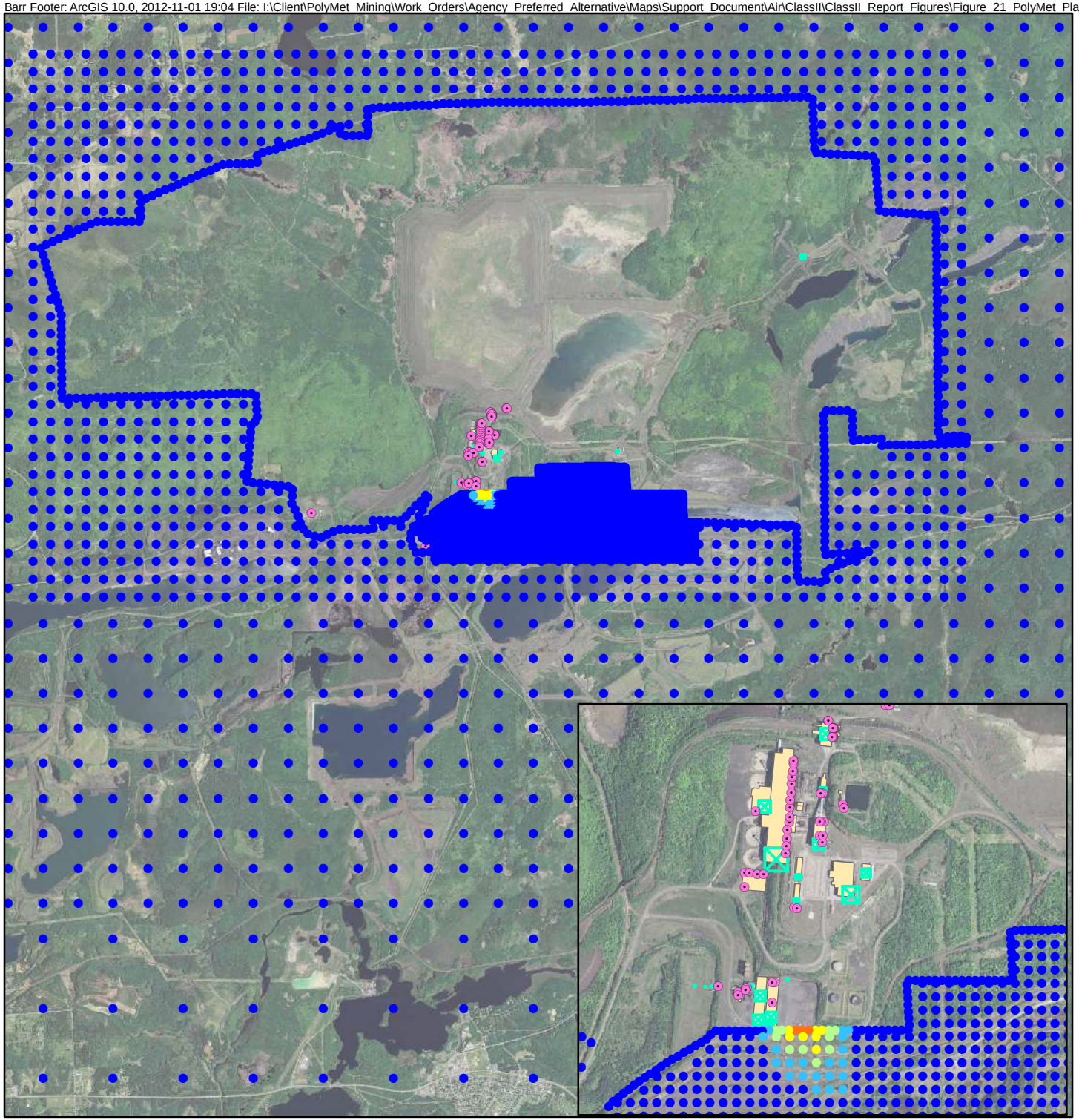



Figure 21

ANNUAL $SO_2$ INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

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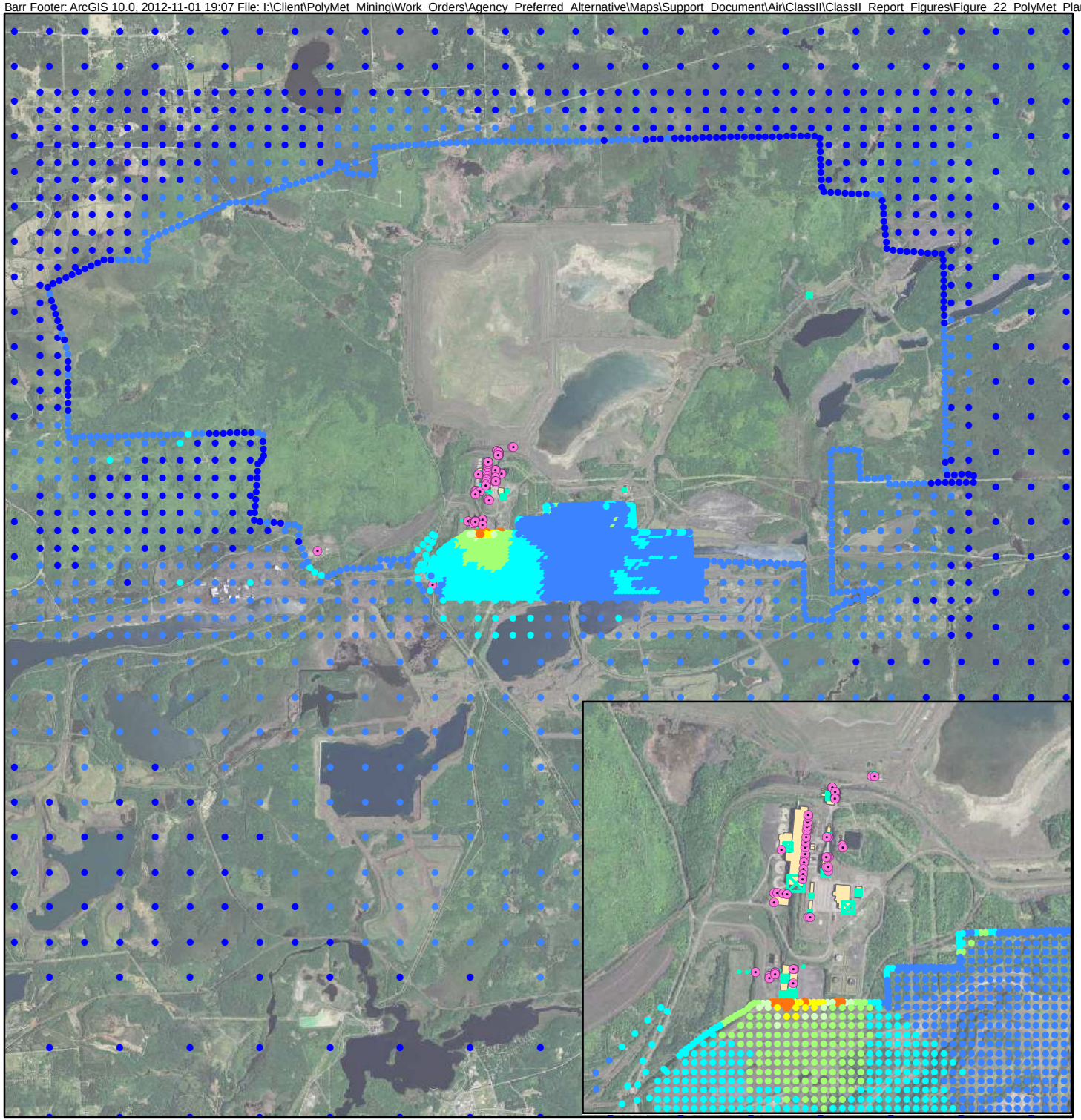
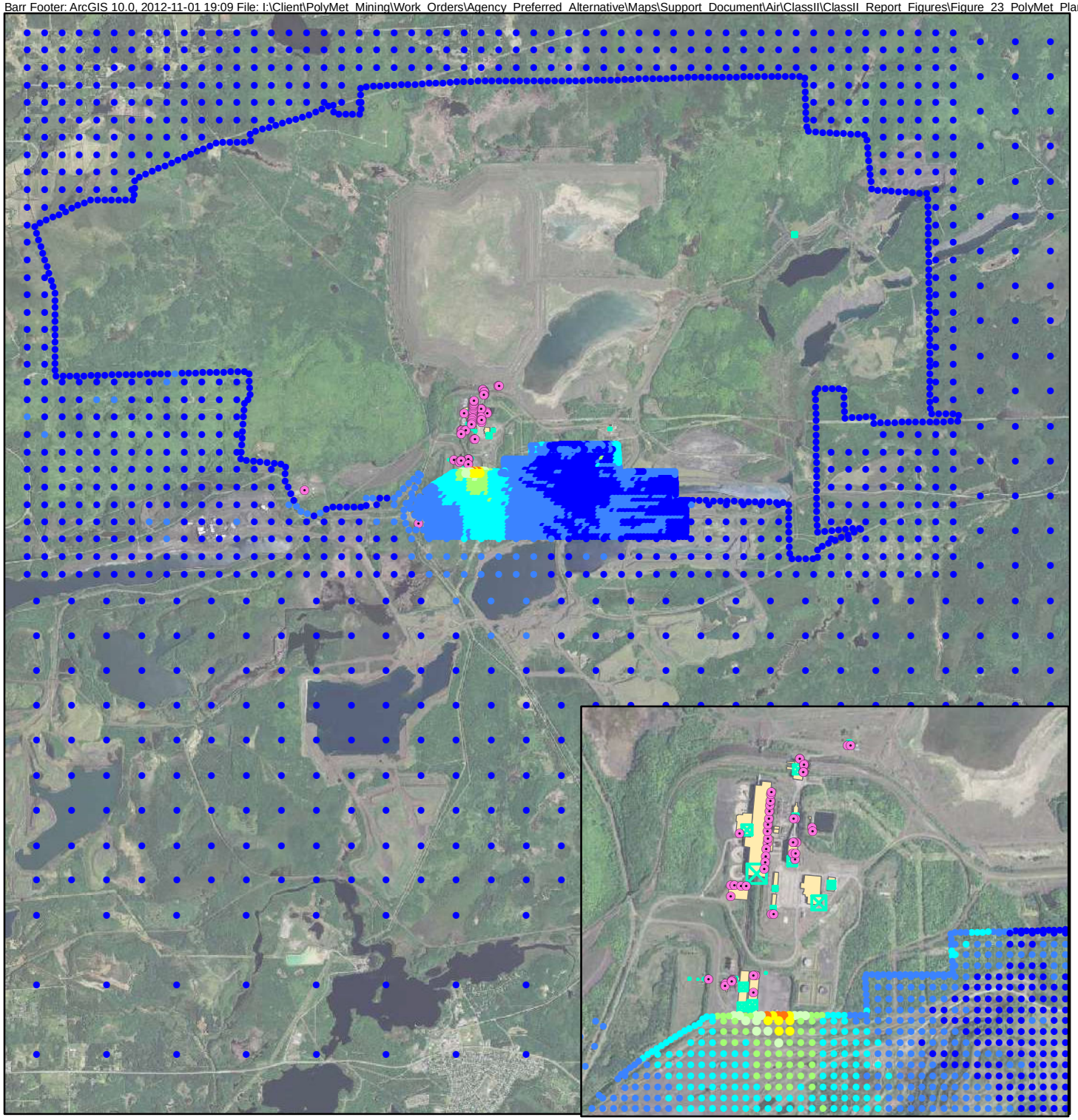



Figure 22

1 HOUR $SO_2$ NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:09 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_23_PolyMet_PlantSite_3hSO2_NAAQSResults.mxd User: jjm



**H2H Concentration ug/m$^3$**

- 12 - 20
- 21 - 30
- 31 - 50
- 51 - 70
- 71 - 80
- 81 - 90
- 91 - 97
- Point Sources
- Volume Sources
- BPIP Structures

$SO_2$ 3 Hour NAAQS is 915 ug/m$^3$.
Background Concentration Included = 12 ug/m$^3$.

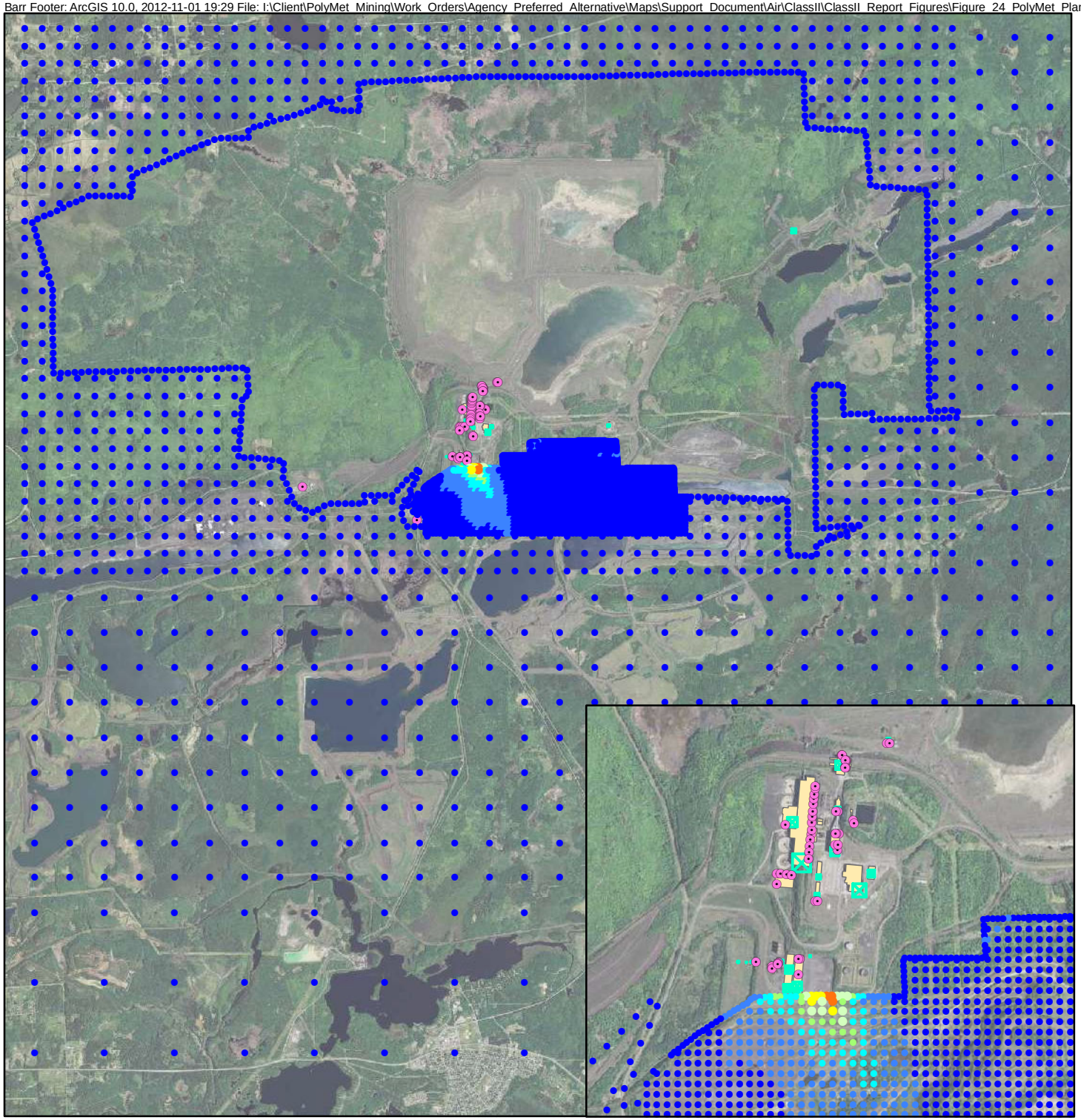
N

Meters
1,000 0 1,000

Figure 23

3 HOUR $SO_2$ NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:29 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_24_PolyMet_PlantSite_24hSO2_MAAQSResults.mxd User: jjm



**H2H Concentration ug/m$^3$**

- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- Point Sources
- Volume Sources
- BPIP Structures

$SO_2$ 24 Hour NAAQS is 365 ug/m$^3$.
Background Concentration Included = 5.5 ug/m$^3$.

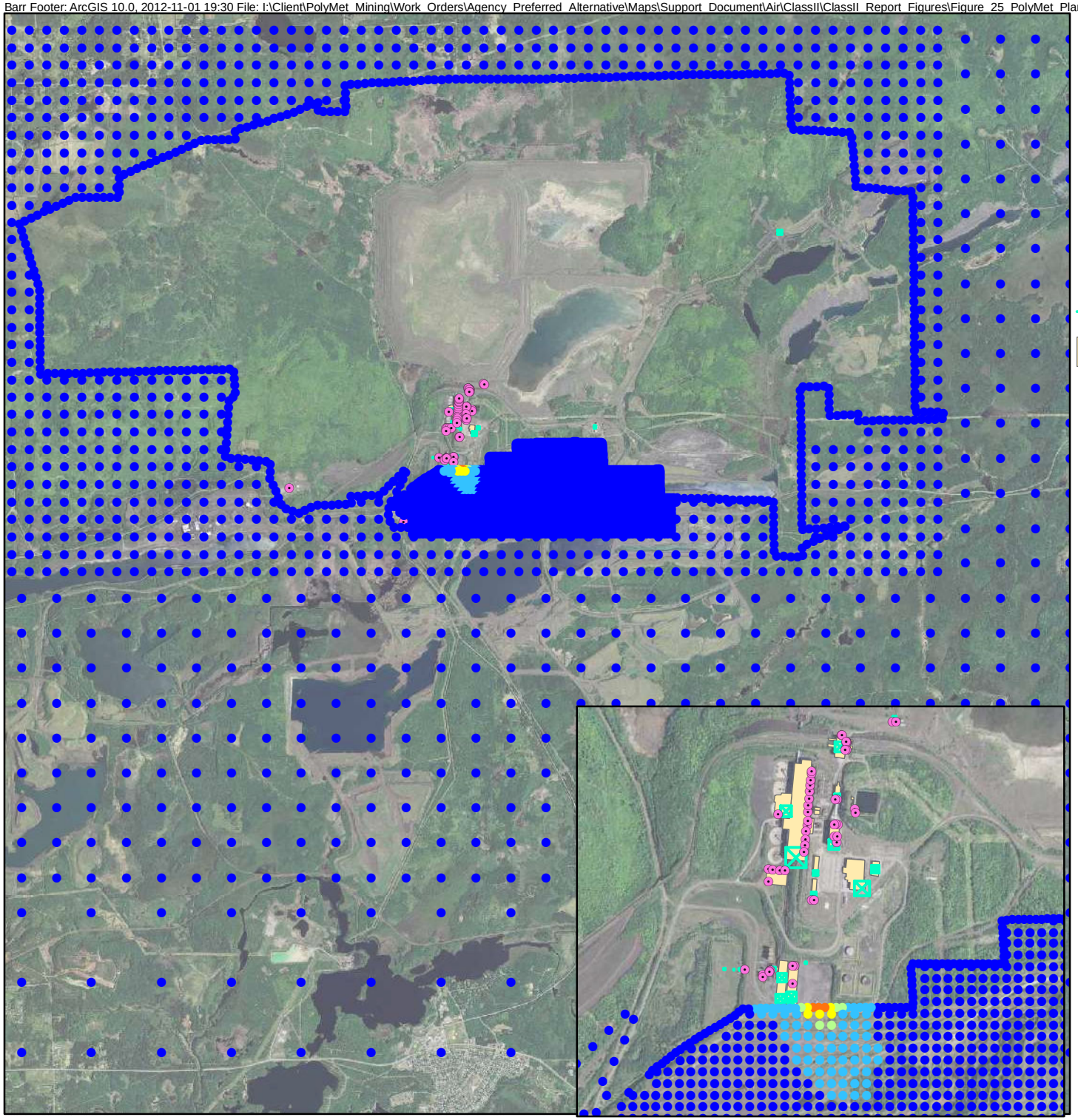
N

Meters
1,000 0 1,000

Figure 24

24 HOUR $SO_2$ MAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:30 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_25_PolyMet_PlantSite_AnnSO2_MAAQSResults.mxd User: jjm




$SO_2$ Annual NAAQS is 60 ug/$m^3$.
Background Concentration Included = 0.63 ug/$m^3$.

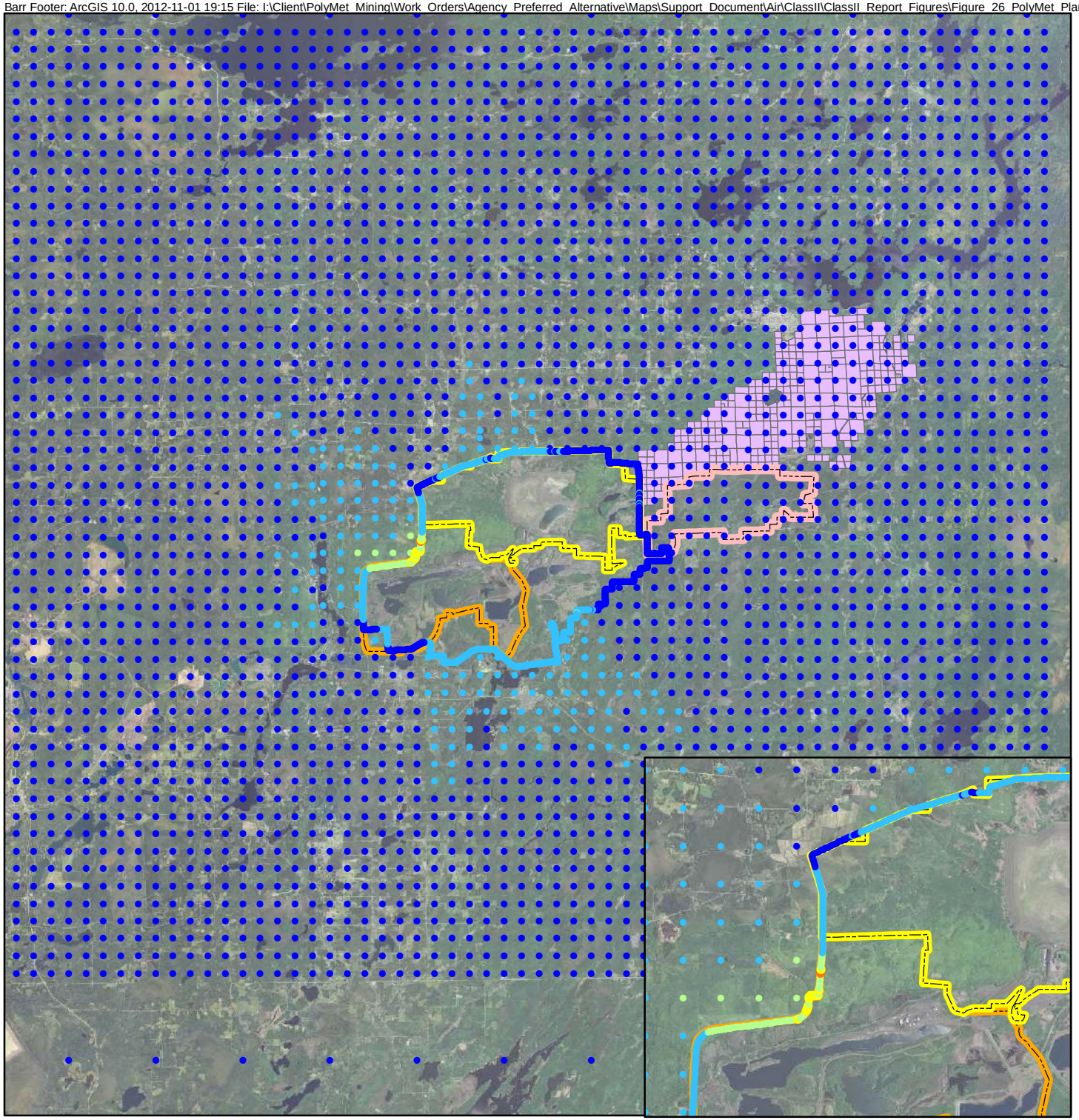
N

Meters
1,000 0 1,000

Figure 25

ANNUAL $SO_2$ MAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:15 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_26_PolyMet_PlantSite_3hSO2CI_IncrementResults.mxd User: jjm



**H2H Concentration ug/m$^3$**

- 1 - 3
- 4 - 5
- 6 - 7
- 8 - 9
- 10 - 11
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$SO_2$ 3 Hour Increment is 512 ug/m$^3$.

N

Kilometers

5 0 5

Figure 26

3 Hour $SO_2$ CUMULATIVE IMPACT INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:15 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_27_PolyMet_PlantSite_24hSO2CI_IncrementResults.mxd User: jjm

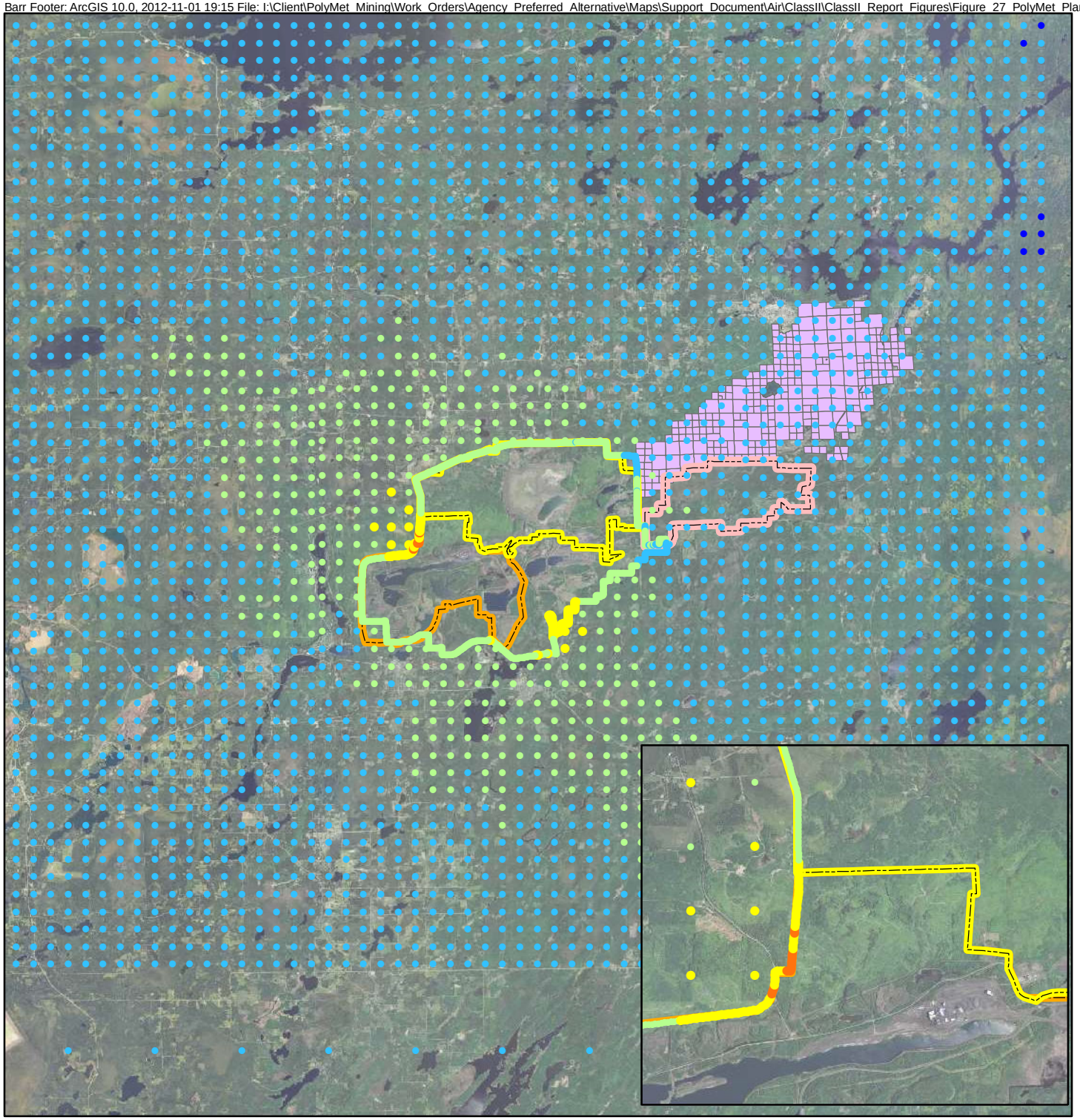
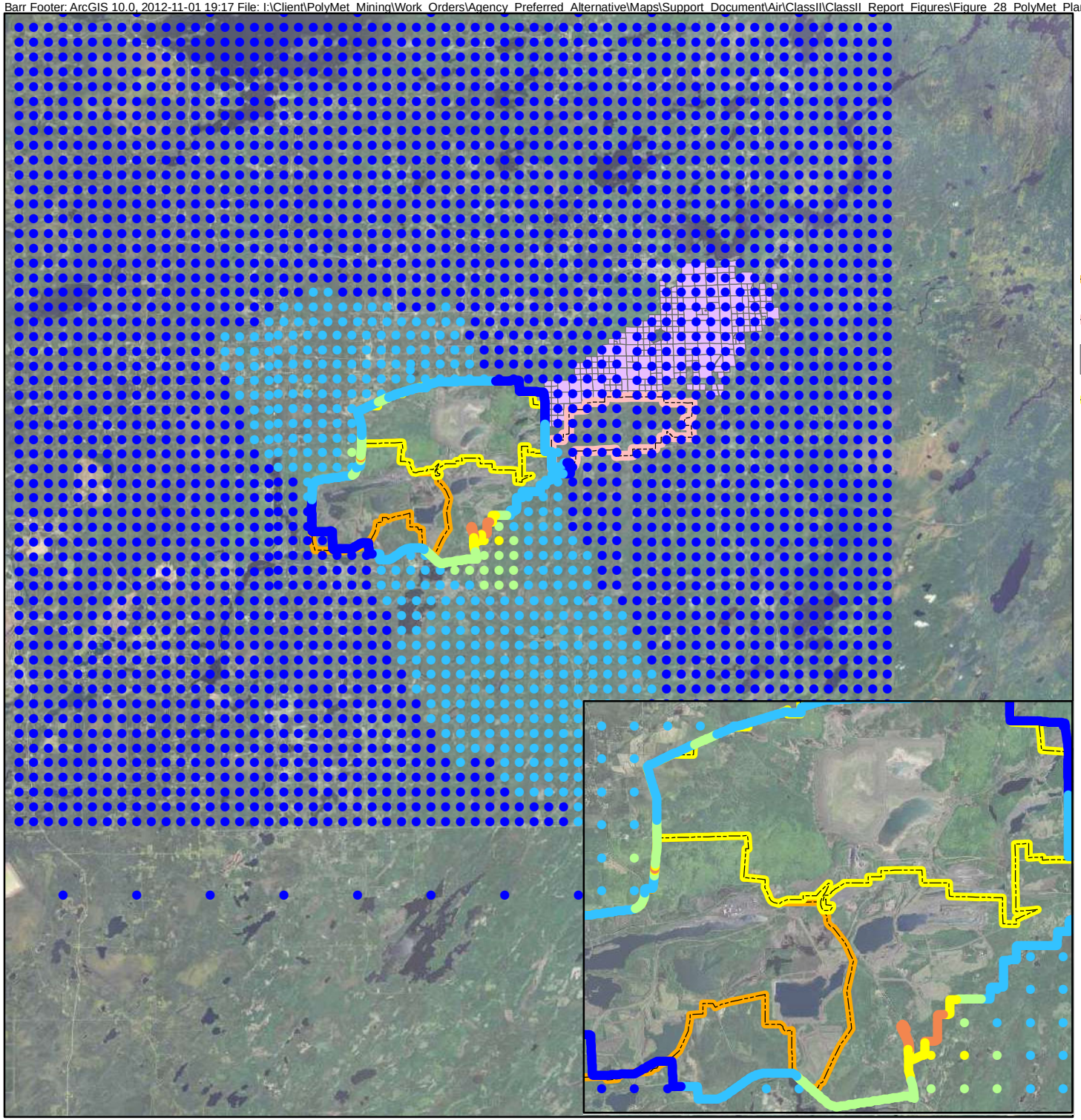



Figure 27

24 Hour $SO_2$ CUMULATIVE
IMPACT INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-01 19:17 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_28_PolyMet_PlantSite_AnnSO2CI_IncrementResults.mxd User: jjm



**Max Concentration ug/m$^3$**

- 0.01 - 0.05
- 0.06 - 0.10
- 0.11 - 0.13
- 0.14 - 0.15
- 0.16 - 0.17
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$SO_2$ Annual Increment is 20 ug/m$^3$.

N

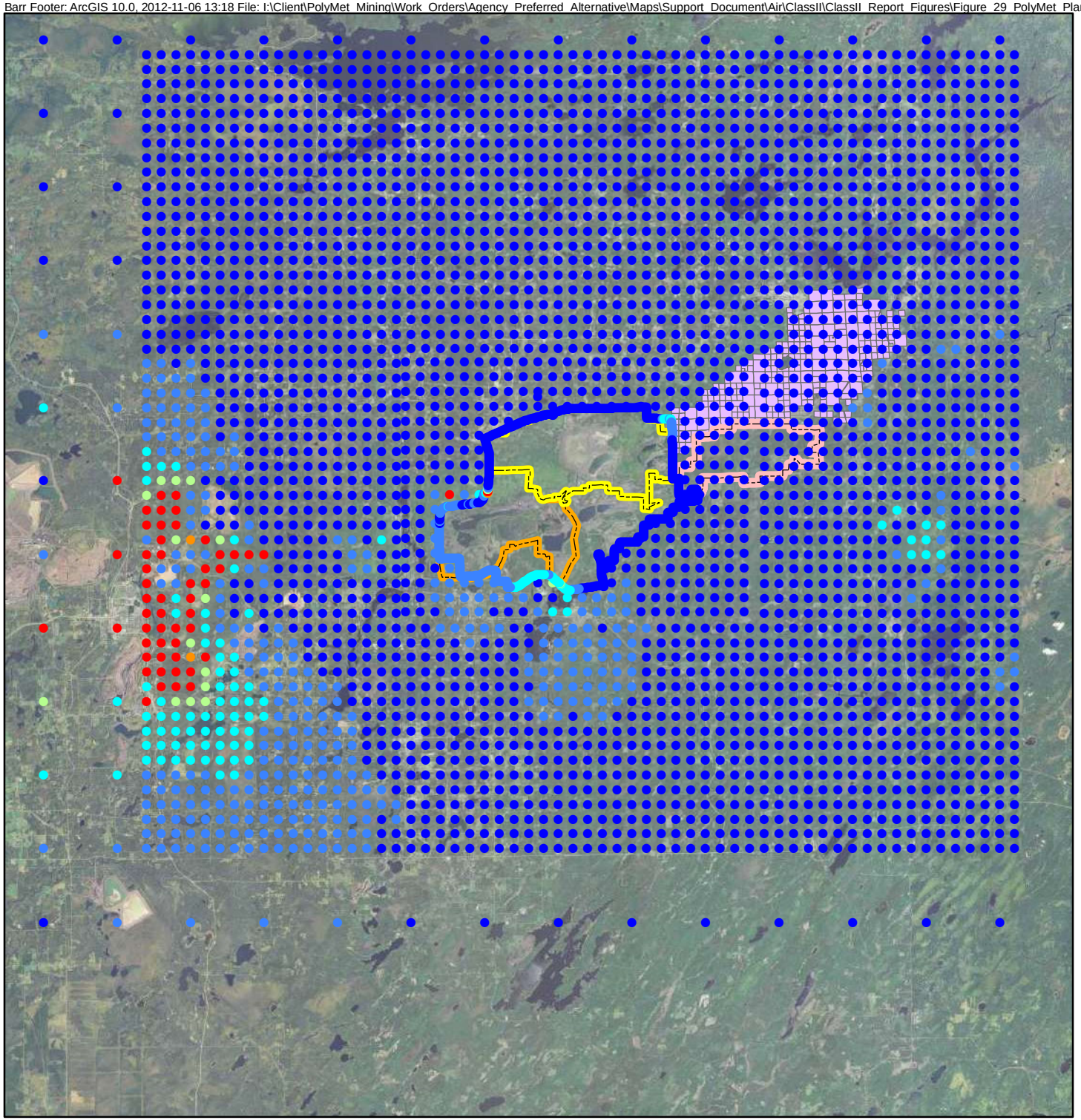
Kilometers

5 0 5

Figure 28

Annual $SO_2$ CUMULATIVE IMPACT INCREMENT RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 13:18 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_29_PolyMet_PlantSite_1hSO2CI_NAAQSResults.mxd User: jjm



**H4H Concentration ug/m$^3$**

- 61 - 100
- 101 - 130
- 131 - 160
- 161 - 180
- 181 - 190
- 191 - 196
- 197 - 925
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$SO_2$ 1 Hour NAAQS is 196 ug/m$^3$.
Background Concentration Included = 6.1 ug/m$^3$.

N

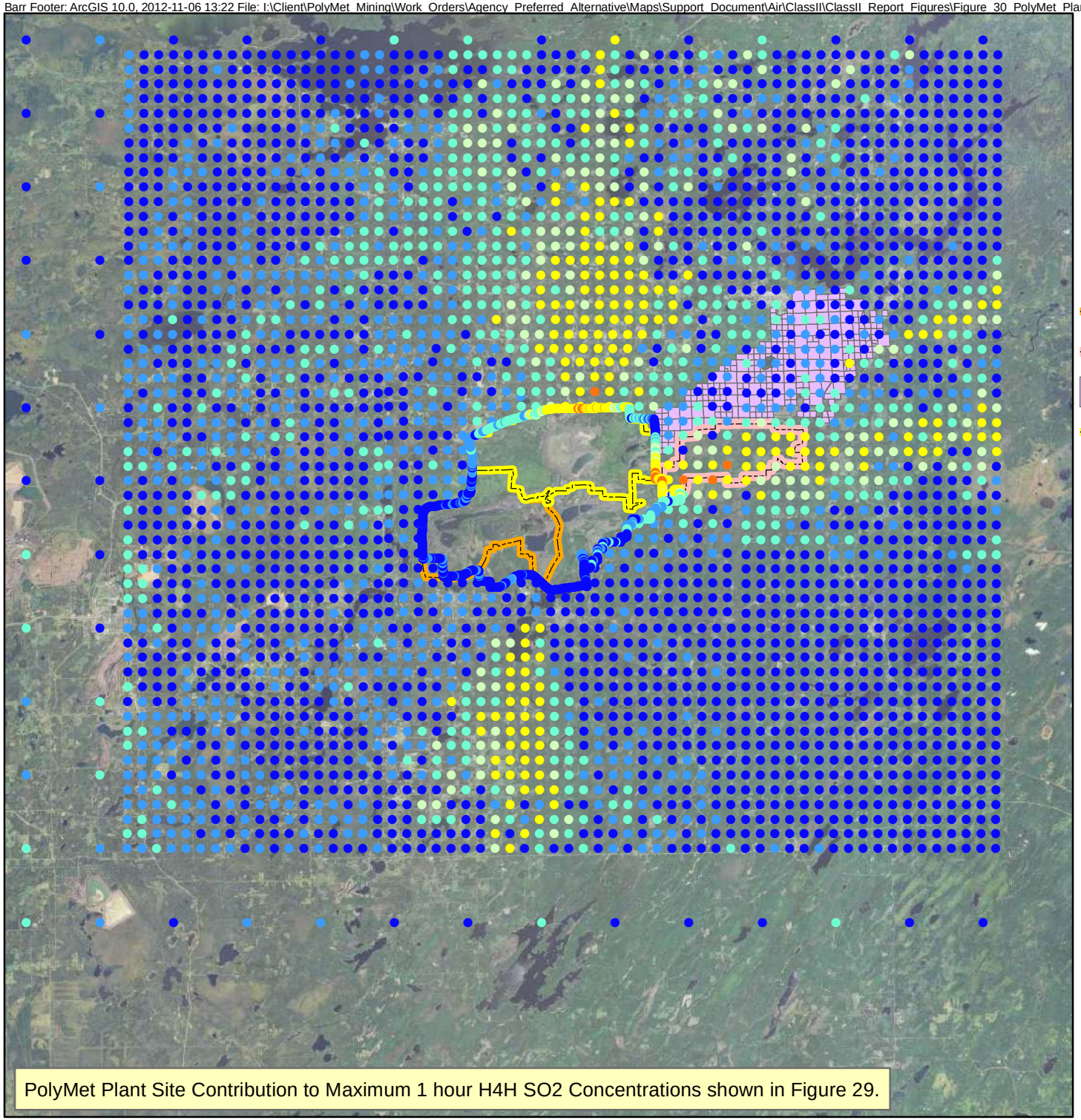
Kilometers

5 0 5

Figure 29

1 HOUR $SO_2$ CUMULATIVE IMPACT NAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 13:22 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_30_PolyMet_PlantSiteCulpability_1hSO2CI_NAAQSResults.mxd User: jjm

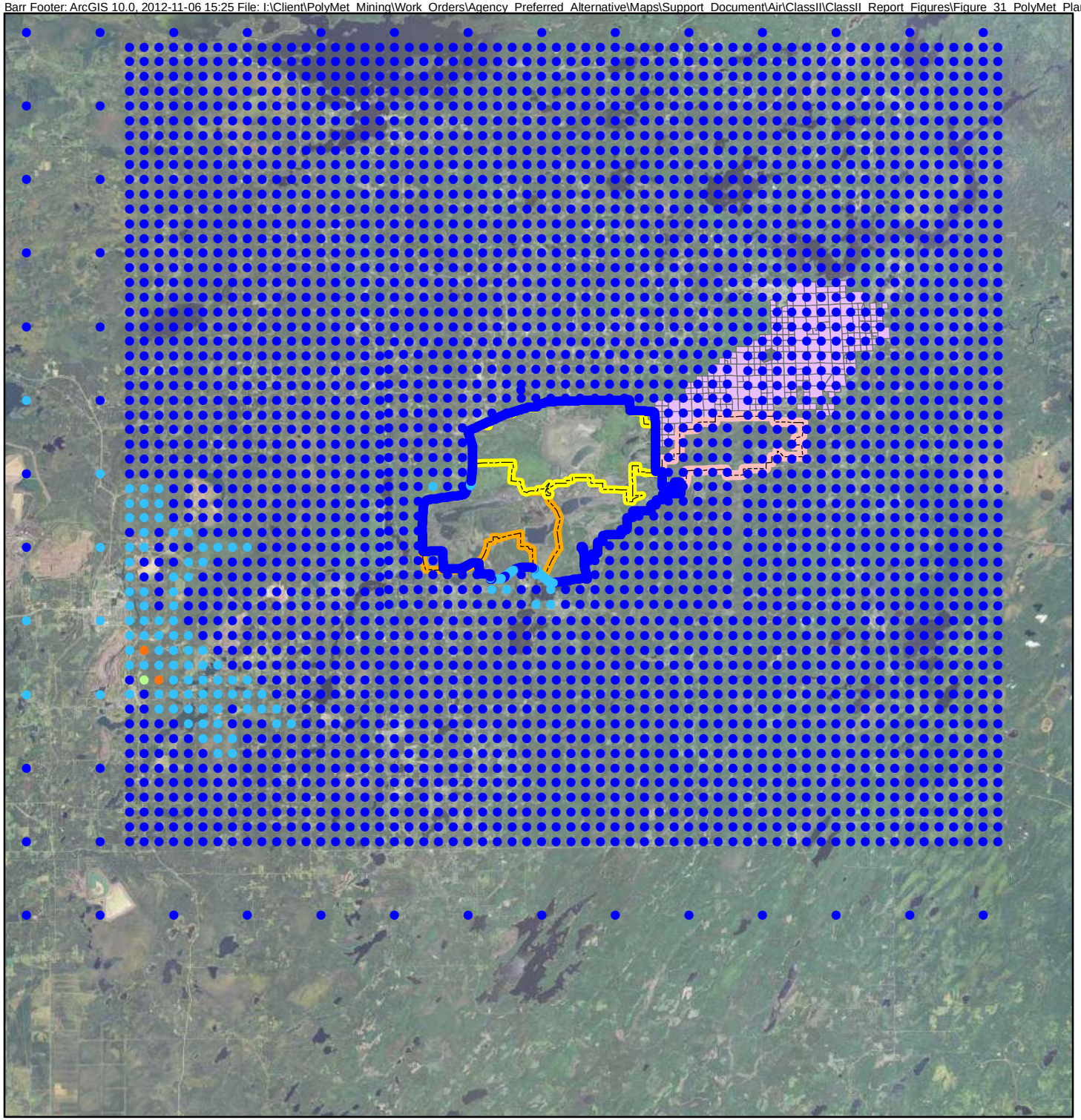



PolyMet Plant Site Contribution to Maximum 1 hour H4H SO2 Concentrations shown in Figure 29.

Figure 30

1 HOUR $SO_2$ CUMULATIVE
IMPACT NAAQS
POLYMET PLANT SITE CULPABILITY
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 15:25 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_31_PolyMet_PlantSite_3hSO2CI_MAAQSResults.mxd User: jjm



**H2H Concentration ug/m$^3$**

- 27 - 100
- 101 - 500
- 501 - 600
- 601 - 700
- 701 - 784
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$SO_2$ 3 Hour MAAQS is 915 ug/m$^3$.
Background Concentration Included = 12 ug/m$^3$.

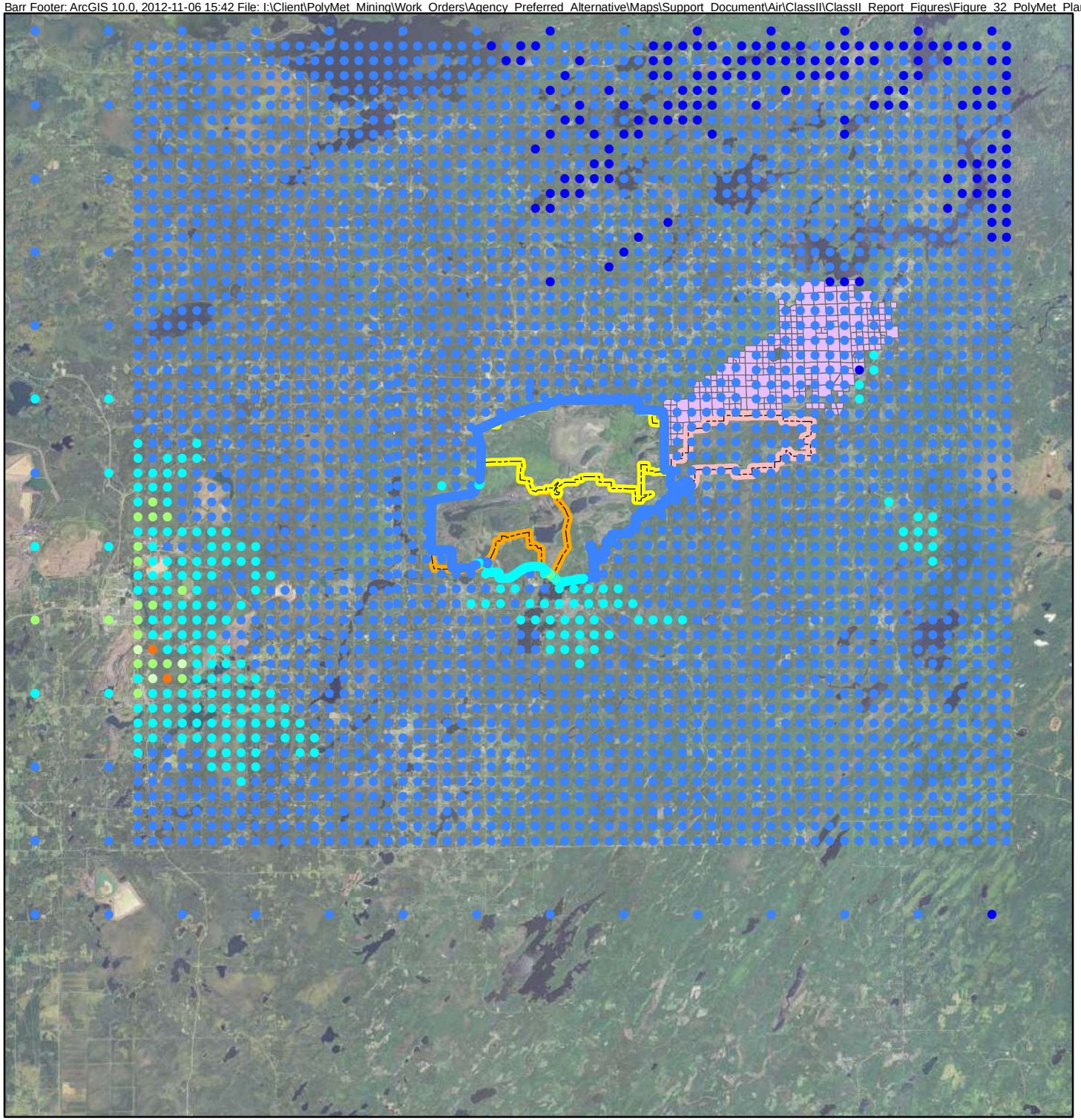
N

Kilometers
5 0 5

Figure 31

3 Hour $SO_2$ CUMULATIVE IMPACT MAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 15:42 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_32_PolyMet_PlantSite_24hSO2CI_MAAQSResults.mxd User: jjm



**H2H Concentration ug/m$^3$**

- 9 - 10
- 11 - 20
- 21 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 255
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$SO_2$ 24 Hour NAAQS is 365 ug/m$^3$.
Background Concentration Included = 5.5 ug/m$^3$.

N

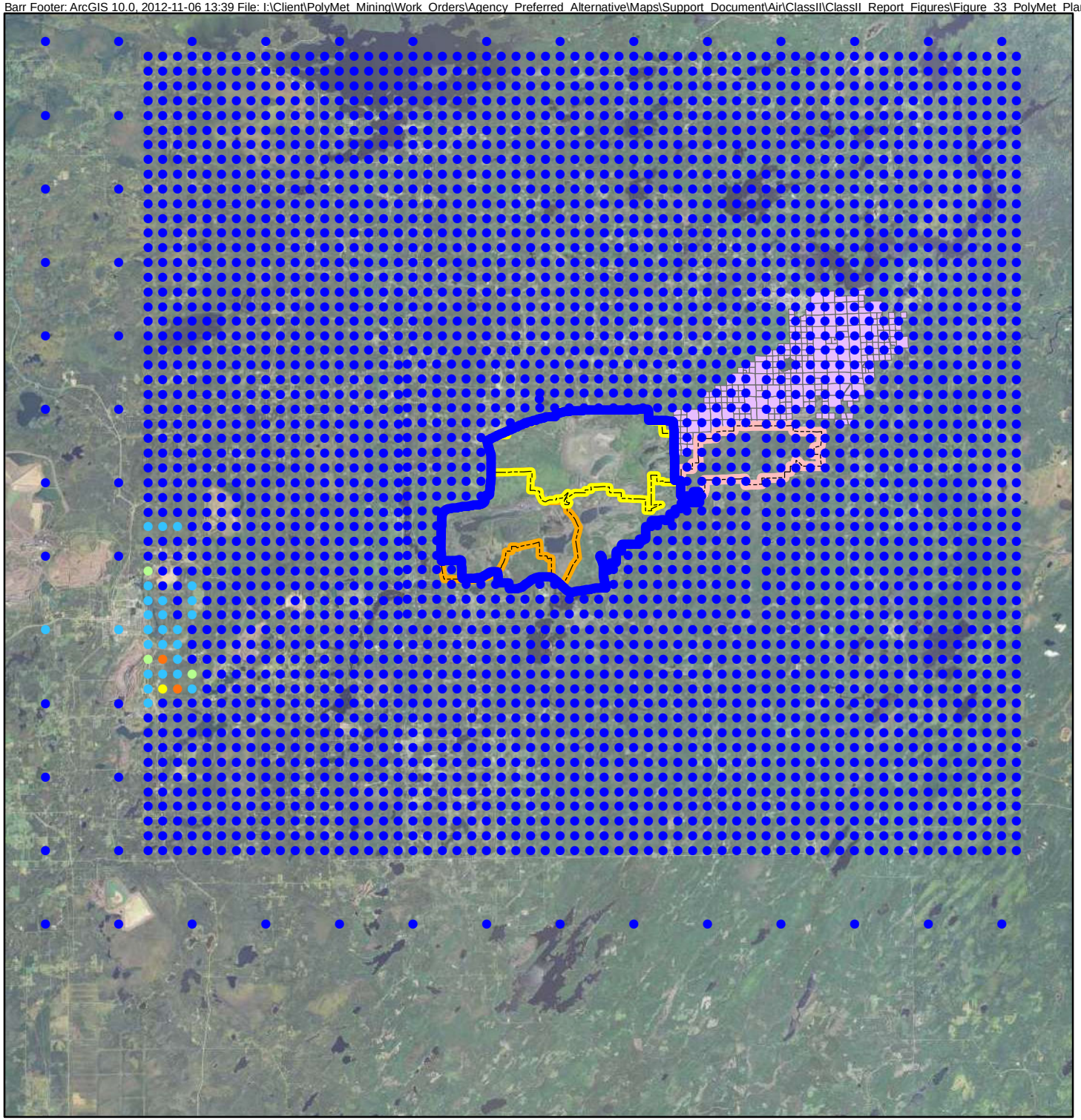
Kilometers

5 0 5

Figure 32

24 Hour $SO_2$ CUMULATIVE IMPACT MAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-11-06 13:39 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\ClassII\ClassII_Report_Figures\Figure_33_PolyMet_PlantSite_AnnSO2CI_MAAQSResults.mxd User: jjm



**Max Concentration ug/m$^3$**

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 24
- Mesabi Nugget AAB
- PolyMet Mine Site AAB
- St Louis County Tax Records
- PolyMet Plant Site AAB

$SO_2$ Annual NAAQS is 60 ug/m$^3$.
Background Concentration Included = 0.63 ug/m$^3$.

N

Kilometers
5 0 5

Figure 33

ANNUAL $SO_2$ CUMULATIVE IMPACT MAAQS RESULTS
PolyMet Plant Site EIS
Class II Modeling Report
NorthMet Project
Hoyt Lakes, MN

**Attachment H**

**Emission Control Technology Review for NorthMet Project Processing Plant: Revised Addendum 01 Version 3**

# *Emission Control Technology Review for NorthMet Project Processing Plant*

## *Revised Addendum 01*

***Prepared for***
***PolyMet Mining Inc.***

***Version 3***

***February 2012***

BARR

***4700 West 77***th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

# Emission Control Technology Review for NorthMet Project Processing Plant

# Revised Addendum 01

# Version 3 – February 2012

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## List of Attachments

Attachment 1 Results of RBLC Search for $PM_{2.5}$ determinations

Attachment 2 MPCA August 16, 2010 Memorandum - PolyMet Mining Company Plant Site Refinement Proposal, Venting Emission Control Exhaust Air Indoors

# 1.0 Introduction and Summary

## 1.1 Background

PolyMet is proposing to permit the NorthMet Project (Project) as a synthetic minor source with respect to Prevention of Significant Deterioration (PSD) regulations. Therefore a Best Available Control Technology (BACT) determination is not required. However, the Minnesota Pollution Control Agency (MPCA) has expressed concerns about the potential for adverse health effects from fine particulate matter emissions from the crushing of ore from the NorthMet deposit. As a result, PolyMet has agreed to install emission controls in the crushing plant which are consistent with the best controls currently used in the metallic ore processing industries for fine particulates. This will ensure that emissions of fine particulate matter from ore crushing and related sources are controlled by state of the art emission controls achieving controlled particulate emission rates consistent with recent BACT determinations for the metallic ore processing industry.

The particulate matter which raises concerns for potential adverse health effects is in the same size range as EPA's fine particulate matter designation for $PM_{2.5}$ (particles with an aerodynamic diameter less than or equal to 2.5 microns). Since information on control of $PM_{2.5}$ is available in the literature, $PM_{2.5}$ will be used as a surrogate for evaluating the effectiveness of various emission control technologies on the materials of concern.

As discussed above the Project is not subject to PSD regulations for $PM_{2.5}$ because of the proposed synthetic minor permitting approach. Potential emission of $PM_{2.5}$ are above the major source level, but emissions will be reduced through the use of appropriate pollution control equipment and/or pollution prevention practices (e.g. use of low emitting fuels) on all point sources, including the control equipment described in this document. As a result, "BACT" limits for $PM_{2.5}$ will not be included in the Project air emission permit, but installation and proper operation of suitable control equipment will be a permit requirement both to address specific concerns with fine particulate emissions from crushing operations and to ensure that Project emissions remain below the major source level. Key assumptions related to emissions and other modeling input parameters for $PM_{2.5}$ modeling conducted for the Supplemental Draft Environmental Impact Statement (SDEIS) would also be expected to lead to permit conditions.

In the time since the February 2009 emission control technology review was submitted, PolyMet has proposed several refinements to the proposed project. These changes include the use of cartridge filters for some emission units and the recycling of building air to reduce energy consumption and to reduce $NO_x$ emissions from the space heaters used for building heating. The Project as currently

proposed is described in NorthMet EIS Draft Alternative Summary Revised March 4, 2011 and NorthMet Project Description Version 2 submitted April 15, 2011. PolyMet discussed concerns over the venting of filtered air back into the buildings with the MPCA and on August 16, 2010, Ann Foss of the MPCA issued a memorandum (Attachment 2) which outlined an agreement between PolyMet and MPCA regarding emission controls for fine particulate matter when recycling building air.

## 1.2 Purpose of Addendum

As of July of 2008, $PM_{2.5}$ must be considered in PSD evaluations conducted in Minnesota and other states that implement federal PSD rules under delegation from EPA as required by a final rule promulgated by EPA on May 16, 2008. Therefore, the results of multiple evaluations of $PM_{2.5}$ control equipment are available to provide guidance in the selection of the appropriate pollution control equipment for Project Crushing Plant sources.

The evaluation of particulate controls for the Crushing Plant was originally reported in October of 2007 in *Emission Control Technology Review for NorthMet Project Processing Plant* and amended in February of 2009. The MPCA has requested an update to the emission control technology review to provide information for the SDEIS to account for any advances in $PM_{2.5}$ control technology that have occurred since implementation of $PM_{2.5}$ as a PSD pollutant and to ensure that the particulate emission control equipment selection for the Project is consistent with projects currently going through PSD review in Minnesota. The revised Addendum 01 includes information to address PolyMet's decision to use cartridge filter type dust collectors on some emission sources and to recycle filtered air streams back into buildings to reduce both $NO_x$ emissions and energy consumption from building heating systems. The recycling of exhaust air will be accomplished in a manner consistent with Attachment 2.

This addendum includes an update to the description of pollution control technology and an update to the EPA RACT/BACT/LAER Clearinghouse (RBLC) database search for comparable $PM_{2.5}$ emission control evaluations (Attachment 1) to include any $PM_{2.5}$ determinations that have been conducted since the *Emission Control Technology Review for NorthMet Project Processing Plant* report and addendum 01 were completed.

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

# 2.0 Update to Emission Control Technologies

Section 4 of the October, 2007 *Emission Control Technology Review for NorthMet Project Processing Plant* report includes a description of potentially applicable pollution control technology for particulate matter. Section 4.3 discusses fabric filters also known as baghouses or cartridge filters. In this addendum, the term "fabric filter" is used a generic term to indicate filter bags or cartridge filters. Some additional types of filter media for filter bags and cartridges have been identified since the original report was written. The following section provides an update to the discussion of fabric filters from the October 2007 version of the emission control technology review report, and updates in the February, 2009 Addendum 01 to reflect the use of cartridge filters in addition to baghouses for control of $PM_{2.5}$ emissions.

## 2.1 Fabric Filter

A fabric filter (baghouse or cartridge filter) consists of a number of individual filters (filter bags or cartridges) placed in parallel inside of an enclosure. Particulate matter is collected on the surface of the bags or cartridges as the gas stream passes through them. The dust cake which forms on the filter media from the collected particulate can contribute significantly to increasing the collection efficiency.

Two major baghouse types are the reverse-air fabric filter and the pulse-jet fabric filter. In a reverse-air fabric filter, the flue gas flows upward through the insides of vertical bags which open downward. The particulate matter thus collects on the insides of the bags, and the gas flow keeps the bags inflated. To clean the bags, a compartment of the fabric filter is taken off-line, and the gas flow in this compartment is reversed. This causes the bags to collapse, and collected dust to fall from the bags into hoppers. (Shaking, or another method, is sometimes employed to dislodge the dust from the bags.) The cleaning cycle in a reverse-air fabric filter typically lasts about three minutes per compartment. Because reverse-air cleaning is gentle, reverse-air fabric filters typically require a low air-to-cloth ratio of 2:1.

In a pulse-jet fabric filter, dirty air flows from the outside of the bags inward, and the bags are mounted on cages to keep them from collapsing. Dust that collects on the outsides of the bags is removed by a reverse pulse of high-pressure air. This cleaning does not require isolation of the bags from the flue gas flow, and thus may be done on-line.

Cartridge filter systems are a type of fabric filter often used as an alternative to traditional baghouse collectors. However, the size of cartridges is limited, so a cartridge filter cannot be used in

applications where large volumes of air must be treated. This occurs when the size of the fabric filter system requires on-site fabrication (e.g. a coal fired electric power plant). A cartridge filter works in the same way as a baghouse; that is, a fabric filter media is used to collect particulate matter. The cartridge filter media is designed to be porous enough to allow air to flow through the fabric, and with pore sizes small enough for effective particulate removal. The filter media used in cartridge filter is either pleated paper or pleated polymer sheets. The filter media is pleated to increase surface area, allowing a smaller collector size. The pleats also give the cartridges structural integrity; this eliminates the need for the metal cages used with filter bags. Similar to baghouse filter bags, cartridge filter media may be coated with either a fluoropolymer membrane or a micro fiber web coating for enhanced particulate removal. The ends of the pleated filter media are capped with plastic housings which hold the filter media in place, seal the ends of the filter and provide an opening for the filtered air to exit the cartridge. An automobile engine air filter is an example of how a cylindrical cartridge filter is constructed. Cartridge filter systems typically use a pulse-jet cleaning system, the same system sometimes used in baghouses as described above.

A wide variety of fabric filter materials exist. Standard filter bags are typically made from polyester, polypropylene, or fiberglass. Standard cartridge filters are constructed of paper (cellulose) or polymer films such as PPS (polyphenylene sulfide). Specialty bags and cartridges potentially provide additional emissions control and can withstand unique operating conditions such as high temperature or acidity. Some types of bags and/or cartridge filter designs potentially provide enhanced $PM_{2.5}$ control. Baghouse enhancements include utilization of intrinsically coated (IC) fabric bags, membrane bags, electrostatic fabric filter baghouse technology (ES-FFB) and micro denier fabrics/web coatings. Filter bags may be constructed of micro denier fabric or coated with membranes or web coatings for enhanced fine particulate removal Cartridge filters may be coated with membranes or web coatings for enhanced fine particulate removal. These are described below.

- **Intrinsically Coated Bags:** As the name indicates, IC bags use fabric made of coated fibers. The coating is typically Teflon® or a similar fluoropolymer material. Besides improving bag durability, the coating reduces the pore size between fibers which improves particulate removal efficiency, especially for smaller particles.

- **Membrane Bags:** Membrane bags or cartridges have a fluoropolymer or similar coating applied to the surface of the fabric or cartridge rather than to the individual fibers. Membrane bags contain smaller pore sizes than IC bags and, consequently, provide theoretically higher control efficiency for very small particles. The coating may also inhibit filter cake formation. This latter effect generally results in an overall reduction in pressure

drop and increase in bag life relative to standard bag materials. Reduced filter cake accumulation can also reduce the control effectiveness of other systems, such as alkali injection flue gas desulfurization (FGD), that rely on the filter cake for increased reagent-gas contact.

Figures 1 and 2 below are electron microscope photographs showing a membrane coated fabric and a close up of the membrane coating itself. Pore sizes in the membrane are generally two microns or less in size. The photos are from the McIlvaine webinar presentation "Gore™ Filter Media for High Sulfur Coal Applications" on January 7, 2010.



**Figure 1 Electron Microscope Photograph of a Membrane Coating on Fabric Substrate**

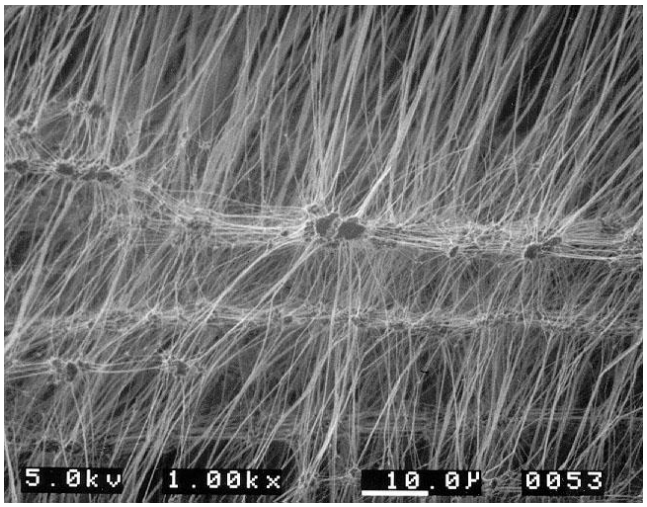



**Figure 2 Electron Microscope Photograph of a Membrane Coating**

- **Electrostatic Fabric Filters:** Electrostatic fabric filter baghouse (ES-FFB) technology has recently been developed through a partnership of the EPA and Southern Research Institute (SRI). The technology is solely licensed to General Electric Energy (GE) and is marketed as the Max-9™ ESFFB. It is fundamentally an electrostatic pulse-jet fabric filter hybrid. It

employs high voltage discharge electrodes to charge particles prior to deposition on the bag filters. Charging the particles theoretically causes them to agglomerate or flocculate, enhancing filtration efficiency of the fabric filter. GE reports their ESFFB technology is recommended for use in conjunction with a primary particulate control device; i.e., as a polishing control device for particulate matter.

- **Micro fibers and Web Coatings:** Micro fibers and web coatings provide a layer of small diameter fibers on the surface of the filter media which provides a filtering layer with small pore sizes similar to membrane coatings. In filter bag applications, micro denier fabrics may be used. Micro denier fabrics are typically felted fabric with two layers of fiber. Standard diameter fibers are used as the base material and micro fibers are added as an outer layer to the felt. The small diameter of the fibers allows the micro fibers to be packed more densely than standard fibers. This has the combined effect of reducing the filter pore size and increasing the surface area available for particle capture. Web coatings may be employed in filter bag and cartridge filter applications. In web coating applications, a micro fiber mat is applied to the surface of the bag fabric or cartridge filter. Figure 3 below is a photo of Donaldson's Ultra-Web® coating from their March 2011 Ultra-Web brochure. The Ultra-Web fibers are 0.2 to 0.3 microns in diameter.



**Figure 3 Electron Microscope Photo of a Web Coating**

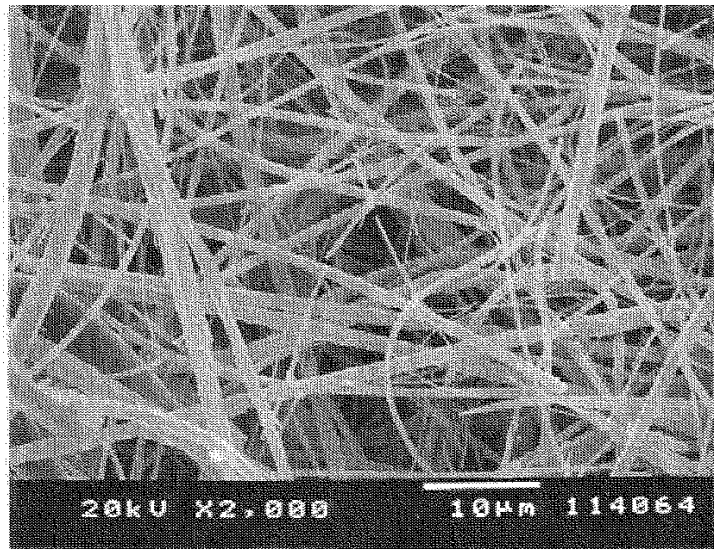



**Figure 4 Electron Microscope Photograph of a Micro Denier Fabric**

Figure 4 above is an electron microscope photograph of a micro denier fabric taken from the course notes from "Basic Solid/Liquid Separation and Basic Gas Filtration" presented by the American Filtration and Separation Society on October 15, 2007 in Ann Arbor, Michigan. As one can see from Figures 2, 3 and 4, membrane coatings, web coatings and micro denier fabrics are similar in nature. All three filter media contain fibers which are one micron or less in diameter and openings between fibers are generally 2.5 microns on less. These properties are effective at particulate removal because:

- The small pore openings trap most particles on the filtration surface. So, a filter cake is established quickly after each cleaning cycle. Once the filter cake is established, the filter cake becomes the primary filtering media.
- The small diameter fibers are highly effective at capturing residual submicron sized particles which were able to pass through the filter cake. Submicron particles are primarily capture by diffusion. The small diameter fibers are densely packed so distances particles travel by diffusion to capture sites on the fibers are short and the surface area for particle collection per ounce of fabric composed of micro fibers is much greater than fabrics composed of larger diameter fibers. These differences between small and large diameter fibers are clearly illustrated in Figures 1 and 3 where one can see the relative size of the micro fibers compared to the larger diameter fibers in the substrate.

One vendor of cartridge filter systems considered for recycling of treated air into buildings was Farr. Farr produces the "Gold Series for Mining" cartridge filters. Farr claims that their filters have produced $PM_{10}$ test results as low as 0.0005 gr/dscf. Their publications suggest that they would only

be willing to guarantee 5 mg/$m^3$, or 0.002 gr/dscf as evidenced by the statement "the Gold series meets the 5 mg/m3 or less emissions required to recirculate the air back into the work place…" in their product brochure. This emission rate is comparable to the performance of baghouses with conventional bags on ore processing sources as demonstrated through performance testing at existing facilities in Minnesota. Therefore cartridge filter systems can be considered to perform in a manner consistent with conventional filter bags.

There are several factors which have a stronger influence on emission control performance than the type of filter media. Examples are listed below.

- The air to cloth ratio dictates air velocity and capture efficiency through the baghouse.
- The number of cleaning cycles must be optimized for particulate capture because too frequent cleaning reduces the filter cake, and cleaning that is too infrequent can increase the pressure drop.
- Increasing the pressure drop across the baghouse increases the likelihood that the air flows through leaks in the baghouse.
- Routine maintenance also plays an important role in identifying leaks, including routine dye checks.

Based on the above information, PolyMet did not do separate analyses for the different types of filter media available.

The main operating limitation of a fabric filter is that its operating temperature is limited by the bag material. Most commonly used filter bag materials are limited to 250ºF – 300º F. Lower temperatures can be accommodated at ambient moisture levels (i.e. processes where appreciable quantities of water are not added to the exhaust gas). Fabric filters do not operate well when there is a significant amount of liquid phase water in the stream being treated. The moisture causes the particulates to form a very thick, wet and heavy cake that plugs the bags and cannot be removed. The plugging significantly reduces or blocks the airflow increasing the pressure drop across the bags or completing making the unit inoperable. High moisture levels can also weaken some bag materials (e.g. polyester) due to hydrolysis, resulting in reduced bag life. Some materials like glass fiber or Nomex may be operated at 500ºF and 400ºF, respectively, but are more expensive.

Fabric filter control efficiency under normal loading conditions typically is in the 98% - 99%+ range. Reduced efficiencies will occur when the inlet particle concentration is low. Fabric filter controls do

not significantly affect the temperature of the stream being treated, so condensable particulate matter control is limited to condensable particulates present in a filterable form in the fabric filter when it is being treated. Another disadvantage of fabric filters is high energy use. High efficiency filter media in fabric filters require higher pressure drops than Electro Static Precipitators (ESPs) to achieve the same low outlet particulate concentrations. On high flow volume sources, the increase in pressure drop for a fabric filter vs. ESP can result in significant increases in electrical energy use. Outlet particle concentrations typically are in the 0.005 gr/dscf range. In some cases lower concentrations can be achieved, but the outlet concentrations will depend on the size range and nature of the particles being filtered, and the type of filter media which can be used in that application. Therefore, fabric filters are most effective controlling sources with filterable particulates and less effective controlling hot exhaust streams with condensable particulates.

Particulate capture methods include impaction, interception and diffusion. Impaction and interception are effective particulate removal methods for particles of 1 micron and larger. Fabric filters, ESPs and wet scrubbers are all very effective at removing particles larger than one micron.

Fabric filters are the most effective means of controlling directly emitted filterable $PM_{2.5}$ because filters are best at controlling small particles. The primary mechanism for particles one micron and smaller is diffusion. Fabric filter media is effective at removing submicron particles because the short distances between fibers minimizes the distance small particles have to travel to reach a capture site on the filter media as shown in Figures 2 through 4. Submicron particle travel distances to capture sites are larger in ESP's and wet scrubbers than in fabric filters; therefore, they are not as effective as filtration in capturing sub-micron particles.

# 3.0 Control Equipment Evaluation for Ore Crushing

The following provides an updated evaluation of particulate control equipment for ore crushing and handling sources as originally presented in Section 5.1 and 5.6 of the *Emission Control Technology Review for NorthMet Project Processing Plant* dated October, 2007. This update incorporated additional entries in the EPA RBLC database.

## 3.1 Updated Overview of Ore Crushing

Liberation of metallic minerals by crushing and grinding is the first step in processing of the crude ore. Crude ore is delivered to the plant by rail car. Rail cars are tipped to unload the ore into the coarse ore crusher. Coarse ore crushing consists of two stages of gyratory crushing (primary and secondary crushing). After coarse ore crushing, the ore is transported into the coarse ore storage bins via pan feeders and conveyors. The two stages of fine ore crushing (tertiary and quaternary) are fed by vibratory feeders from the crude ore bins. Ore is screened after the first fine crushing stage allowing ore that is small enough to bypass the second stage. Ore from the fine ore crushers is fed to the fine ore storage bins via conveyors. Fine ore is transported from the fine ore bins to milling via vibratory feeders and conveyors. The final ore size reduction step is accomplished by wet milling. Wet milling occurs in rod mills followed by ball mills. The milled ore is conveyed to ore concentration in an ore/water slurry.

Sources of particulate matter, $PM_{10}$ and $PM_{2.5}$ in the crushing section of the plant include crushers, screens, vibratory and pan feeders, and material drops. All crushing and screening equipment and conveyor transfer points will be enclosed and ventilated to dust control equipment. Fine particulates collected by dust control equipment will be recovered to the process by adding to the ball mills. No solid waste stream is generated. No particulates are emitted from wet milling as the addition of water to the ore prevents dust formation.

The emissions of potential concern from the crushing operations are in the fine particulate $PM_{2.5}$, fraction. The chosen control technology is the most effective for both coarse particulate matter ($PM_{10}$) and for fine particulates ($PM_{2.5}$). In fact the performance differential between fabric filters and other emission control technologies is more pronounced for finer filterable particulate sizes and particulate emissions from the ore crushing sources are expected to be essentially 100% filterable (i.e. no condensable particulate emissions).

The RBLC currently (as of February 17, 2012) has 163 listed $PM_{2.5}$ emission limits. However, many of the sources identified with $PM_{2.5}$ limits were not similar to crushing operations at PolyMet.

Therefore, the RBLC $PM_{2.5}$ listings were filtered to identify only solids material handling and processing types of sources, and dissimilar sources such as heaters, boilers, combustion turbines, emergency generators and chemical plants were filtered out in a Microsoft Excel spreadsheet. The filtered list of RBLC $PM_{2.5}$ limits is show in Attachment 1, Table 1. All particulate limits (PM, $PM_{10}$, $PM_{2.5}$ and TSP) are listed in Table 1. Rows with $PM_{2.5}$ limits are highlighted. A green highlight indicates total $PM_{2.5}$ limit and a blue highlight indicates a filterable $PM_{2.5}$ limit (no condensable $PM_{2.5}$). Attachment 1 Tables 2A and 2B list the unfiltered RBLC findings. Table 2A includes current listings dated from June 2004 through December 2011, and Table 2B covers the period from June 2000 up to June 2004.

In the filtered data set, there were 14 facilities identified. Those facilities included 16 material handling and processing sources with $PM_{2.5}$ emission limits on a gr/dscf basis. These emission limits ranged from 0.001 gr/dscf to 0.0085 gr/dscf. The lowest limit, 0.001 gr/dscf, was for a lime storage silo. This source also had a total particulate limit (PM) of 0.005 gr/dscf, which is higher than the expected PM emission rate from PolyMet crushing sources. Therefore, the lime silo source is not representative of the crushing sources at PolyMet. The next lowest limit, 0.0022 gr/dscf, was a LAER/BACT determination for material handling and processing sources at the New Steel International, Inc facility in Ohio. Because this facility includes metallic mineral processing equipment, many of these sources will be similar in nature to the crushing sources at PolyMet. The determinations for 15 of the 16 sources identified in the RBLC search include add-on pollution control equipment. All but one of the specified controls are baghouses. The exception was a source controlled by a mechanical separator, and it is not likely that this emission unit was a source of fine particulate emissions. Therefore, it can be concluded that the majority determinations for $PM_{2.5}$ at solids material handling and processing sources in the RBLC database to date that are comparable to the Project ore crushing operations have specified fabric filters as the best available control.

There have been two recent permitting actions for taconite ore processing facilities in Minnesota. United Taconite was issued permit 13700113-005 for modifications to its facility in August, 2010. No BACT determinations were made for the United Taconite project. United States Steel has received approval from the Minnesota Pollution Control Agency Citizens Board to expand its facility in Keewatin, Minnesota. The permit includes BACT limits of 0.0020 gr/dscf for particulate control from taconite ore crushing and handling equipped with fabric filter controls. The project is still under federal review, and the permit has not been finalized to date.

LAER determinations are control equipment evaluations performed for pollutants for which the project location does not meet the ambient air quality standards (e.g. non-attainment areas). The

primary difference between BACT and LAER determinations is that in a LAER analysis, pollution control technologies are not excluded based on cost as they can be in a BACT analysis. As a result, a performance specification resulting from a LAER determination is expected to be at least as stringent as that which would result from a BACT determination conducted under the same circumstances.

## 3.2 Updated Selection of Emission Control Technology

PolyMet has agreed to install emission controls on ore crushing operations which are consistent with the best controls currently used in the metallic ore processing industries. This will ensure that emissions of fine particulate matter from ore crushing sources are controlled by state of the art emission controls consistent with recent BACT determinations in similar industries.

For the ore crushers and associated material handling sources, PolyMet proposes fabric filter (baghouse or cartridge filter) controls with a design specification of 0.0025 gr/dscf as measured by EPA Method 5. Fabric filters are the best choice for this application because the exhaust from the crushing operations will be at essentially ambient temperature and moisture, so there is no need to cool the gas stream to remove condensable particulate matter and problems due to the formation of a wet particulate cake are not expected to occur.

Per Attachment 2, PolyMet has agreed to use cartridge filters followed by High Efficiency Particulate Air (HEPA) filters for controlling fine particulate matter when recycling controlled emissions exhaust streams back into buildings. HEPA filters are used when exhaust air from the fabric filter is routed back into the building to provide an added level of assurance that worker exposure to inhalable dust is minimized. In this case the benefit of reduced heating fuel demand offsets the additional cost and energy usage. The according to manufacturer's data combination efficiency of cartridge and HEPA filters for fine particulate matter is 99.97%[1]. A copy of the August 16, 2010 MPCA memorandum is included as Attachment 2 to this report. Attached to this memorandum is a list of sources for which PolyMet proposed to use cartridge filters and cartridge filter/HEPA filter controls for fine particulate matter.

[1] The 99.97% control efficiency the manufacturer lists for its HEPAfilter is based on a specific test* procedure for measuring HEPA filter performance. The HEPA filter is tested using a thermally generated oil based aerosol with a particle size of 0.3 microns. Inlet aerosol concentration for the test must be 0.15 to 0.18 gr/dscf (80 to 100 mg/l). In comparison, ore crushing dust in the cartridge filter exhaust will be vs. 0.0025 gr/dscf or less.

*Institute of Environmental Science and Technology (IEST) Recommended Practice IEST-RP-CC01 (Type A, C or D)

When baghouse/cartridge filter exhaust is vented to the atmosphere, residual dust in the filter exhaust mixes with the ambient air and disperses. Therefore, inhalable dust concentrations at the facility boundary are significantly reduced. Air quality modeling studies previously completed and soon to be updated for the SDEIS have shown that $PM_{2.5}$ emissions from the facility will meet ambient air quality standards. Therefore, the use of HEPA filters would provide little if any benefits for reducing exposure to fine particulates outside the facility boundary, while increasing cost and energy usage.

Different emission rates for $PM_{10}$ and $PM_{2.5}$ are not expected because the controlled $PM_{2.5}$ emission rate will be nearly equal to the $PM_{10}$ emission rate. RBLC determinations for similar operations have $PM_{10}$ limits with the same numeric value at the $PM_{2.5}$ limits. As shown in electron microscope photographs of various filter media in Section 2 of this report, most of the openings in the fabric filter media are less than 1 micron in size. As a result, these filter media have a high collection efficiency for $PM_{2.5}$ sized particles, and the small pore size makes it nearly impossible for $PM_{10}$ particles to pass through the filter. As a result particles in the controlled exhaust stream will be primarily $PM_{2.5}$ sized particles, and the concentration of particles will be low (< 0.0025 gr/dscf). Best practices for operation and maintenance of the baghouses and cartridge filters will be followed to ensure continued performance consistent with the manufacturer's performance guarantees. It is anticipated that the air emission permit for the Project will require the preparation and adoption of an operation and maintenance plan for all control equipment at the facility. This plan can be used as a means of ensuring that the control equipment in the Ore Crushing Operations will be properly operated and maintained. The operation and maintenance plan will include best practices for fabric filter operation and maintenance such as:

1. Continuously monitor fabric filter operations using equipment differential pressure indicator. Operate the fabric filter equipment within the appropriate pressure drop range as demonstrated by performance testing.

2. Automate filter cleaning cycles based on pressure drop (rather than using an automatic time activated regardless of pressure drop) to maximize the dust removal capacity of the filter cake, and to minimize dust migration through the filters during filter cleaning.

3. Take corrective action as specified in the fabric filter operation and maintenance plan when potential leaks are indicated by the differential pressure and/or indications of visible emissions.

4. Inspect the fabric filter and filter elements for wear per manufacturer's recommendations and operating experience per procedures identified in the operation and maintenance plan.

5. Replace all filters on a schedule consistent with the normal life of the filter media, and as needed when leaks are detected. Install replacement filters which meet or exceed the performance criteria specified by the manufacturer.

6. Thoroughly inspect the fabric filters to ensure that no significant leaks are present after major maintenance events and as specified in the operation and maintenance plan.

7. Maintain fabric filter system monitoring equipment in a manner consistent with quality assurance standards as specified in the operation and maintenance plan. Operation and maintenance plan ranges will be based on the manufacturers recommendations.

Fabric filters have the highest level of particulate control in this application. The performance specifications for the proposed particulate control equipment is consistent with recent BACT and LAER $PM_{2.5}$ limit determinations for comparable sources as can be seen in Attachment 1. This table is a listing of all $PM_{2.5}$ determinations that could be located in the RBLC database. Determinations for other particulate matter pollutants (e.g. $PM_{10}$, total PM) are also included where they were done in conjunction with a $PM_{2.5}$ determination. There is only limited data available, but the proposed performance specification is similar to LAER determinations for ore processing and handling at a steel plant.

A detailed analysis of recent PM and $PM_{10}$ determinations was conducted as part of the original *Emission Control Technology Review for NorthMet Project Processing Plant* report. The June 10, 2011 review of RBLC data for this addendum included all $PM_{2.5}$ determinations since January 1, 2000, and the RBLC search output included $PM_{10}$, PM and TSP limits as well as $PM_{2.5}$ limits. Given the inclusive nature of the June 10, 2011 analysis, including the results of the October of 2007 analysis is not warranted.

To verify equipment performance and to establish operating parameters, PolyMet expects that the Project air emissions permit will require the testing of ore crushing sources for PM/$PM_{10}$/$PM_{2.5}$ using EPA Methods 5 and 202, as applicable, using three (3) one-hour test runs. Additional testing for particulate sizing may be conducted if needed for modeling demonstrations (e.g. EPA Method 201A for $PM_{10}$). During the performance test, the facility will measure emission control equipment process parameters. PolyMet expects that operating parameter limits for the crushing plant emission control equipment will be set using the data collected during the performance test so that control equipment performance can be verified on an ongoing basis. In cases where there are multiple emission units of a processing equipment type (e.g. pan feeders), PolyMet expects to test one stack/vent associated with each equipment type which is representative of that equipment. The facility will demonstrate

ongoing compliance based on the 24 hour average(s) of the process parameters established during the performance test.

Because particulate controls can be commissioned prior to start up and turned off after process equipment is shut down, no special limits are needed for startup or shutdown.

A 7% opacity limit is recommended for visible emissions from ore crushing equipment at which particulate emissions are vented through a stack or similar opening (i.e. the average opacity of material handling equipment cannot exceed 7% for more the one 6-minute period during an hour). A 7% opacity limit is consistent with the requirements of NSPS Subpart LL which applies to similar equipment at metallic mineral processing plants. PolyMet proposes an automated control equipment performance monitoring system to alert plant operations and management of off-spec operation of emission control equipment. This will enable corrective action as soon as it is practicable to do so per the applicable operation and maintenance plan for the affected control device. Because of the control equipment monitoring system, PolyMet expects that visible emissions from stacks at ore crushing equipment will not be monitored.

# Attachments

# Attachment 1

## Results of RBLC Search for $PM_{2.5}$ Determinations

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 1**
**RBLC Determinations with PM2.5, Updated February 17, 2012**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P10 - LIME SILO | 90.019 | Particulate Matter (PM) | B | PNEUMATIC CONVEYING, TOTAL ENCLOSURE AND BIN VENT FABRIC FILTER. | 0.13 | LB/H | | BACT-PSD | 0.005 | GR/DSCF | | 0 | | | 0.005 | | 0.005 |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P10 - LIME SILO | 90.019 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | PNEUMATIC CONVEYING, TOTAL ENCLOSURE, BIN VENT FABRIC FILTER | 0.026 | LB/H | | BACT-PSD | 0.001 | GR/ACF | | 0 | | | 0.001 | | 0.001 |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Ore Dryer (AB-202) | 62.999 | Particulate matter, total (TPM) | A | Replacing baghouses with a reverse jet wet scrubber | 0.011 | GR/DSCF | 3-HR AVG | BACT-PSD | 2 | LB/H | 3-HR AVG | 0.011 | GR/DSCF | 3-HR AVG | 0.011 | | 0.011 |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Ore Dryer (AB-202) | 62.999 | Particulate matter, total < 10 µ (TPM10) | A | replacing baghouses with reverse jet wet scrubber | 0.011 | GR/DSCF | 3-HR AVG | BACT-PSD | 2 | LB/H | 3-HR AVG | 0.011 | GR/DSCF | 3-HR AVG | 0.011 | | 0.011 |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | No. 7 Pigment Grinding Feed Bin (AK-107) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Baghouse | 0.005 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.005 | GR/DSCF | 3-H AVG | 0.005 | | 0.005 |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Ore Dryer (AB-202) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | A | replacing baghouses with reverse jet wet scrubber | 0.0085 | GR/DSCF | 3-HR AVG | BACT-PSD | 1.55 | LB/H | 3-HR AVG | 0.0085 | GR/DSCF | 3-HR AVG | 0.0085 | | 0.0085 |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | No. 7 Pigment Grinding Feed Bin (AK-107) | 62.999 | Particulate matter, total (TPM) | A | Baghouse | 0.01 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.01 | GR/DSCF | 3-H AVG | 0.01 | | 0.01 |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | No. 7 Pigment Grinding Feed Bin (AK-107) | 62.999 | Particulate matter, total < 10 µ (TPM10) | A | Baghouse | 0.01 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.01 | GR/DSCF | 3-H AVG | 0.01 | | 0.01 |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Scrap steel storage piles | 81.29 | Particulate matter, fugitive | P | Minimize drop height | 0.43 | T/YR | PER ROLLING 12 MONTHS FOR PM | BACT-PSD | 0.22 | T/YR | PER ROLLING 12 MONTHS FOR PM 10 | 0 | | | NA | | NA |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Material Storage Silos Equipment (MSS Group) | 99.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | Bin Vent Filter, good operating practices, and water sprays. | 0.005 | GR/DSCM | 3 H AV / CONDITION 2.15 | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Material Storage Silos Equipment (MSS Group) | 99.19 | Particulate matter, filterable < 10 µ (FPM10) | B | Bin Vent Filter, good operating practices, and water sprays. | 0.005 | GR/DSCM | 3 H AV / CONDITION 2.15 | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| OH-0335 | AK STEEL CORPORATION | OH | P0105639 | 6/22/2010 | Coke Converyor to Railcar Loadout | 81.39 | Particulate matter, total (TPM) | P | Total enclosure and wet material | 1.86 | LB/H | | BACT-PSD | 1.14 | T/YR | PER ROLLING 12 MONTHS | 0 | | | NA | | NA |
| OH-0335 | AK STEEL CORPORATION | OH | P0105639 | 6/22/2010 | Coke Converyor to Railcar Loadout | 81.39 | Particulate matter, total < 10 µ (TPM10) | P | Total enclosure and wet material | 0.88 | LB/H | | BACT-PSD | 0.54 | T/YR | PER ROLLING 12-MO. | 0 | | | NA | | NA |
| OH-0335 | AK STEEL CORPORATION | OH | P0105639 | 6/22/2010 | Coke Converyor to Railcar Loadout | 81.39 | Particulate matter, total < 2.5 µ (TPM2.5) | P | Total enclosure and wet material | 0.28 | LB/H | | LAER | 0.17 | T/YR | PER ROLLING 12 MO. | 0 | | | | NA | NA |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 1**
**RBLC Determinations with PM2.5, Updated February 17, 2012**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | ASH HANDLING | 99.12 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTER | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | COAL CRUSHING AND SILO STORAGE | 90.011 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTER | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | LIME SILO STORAGES | 90.019 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTERS | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | LIMESTONE UNLOADING | 99.19 | Particulate matter, fugitive | A | WET SUPPRESSION OR DUST SUPPRESSANT | 0 | | | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | ASH HANDLING | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | FABRIC FILTER | 0.005 | G/DSCF | 24 BLOCK | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | LIMESTONE STORAGE SILOS | 90.019 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTER | 0.005 | GR/DSCF | 24 HR | BACT-PSD | 0.51 | LB/H (EACH) | 24 HR | 0 | | | 0.005 | | 0.005 |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SLAB GRINDERS (S-218 AND S-219) | 99.012 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 FROM EACH SLAB GRINDER SHALL BE CONTROLLED AT ALL TIMES DURING OPERATION BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.0% | 0.0044 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.0044 | | 0.0044 |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | REVERSING ROUGHING MILL (S-204) | 81.39 | Particulate Matter (PM) | A | EMISSIONS OF PM SHALL BE CONTROLLED BY A WET ESP WITH A MINIMUM CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | REVERSING ROUGHING MILL (S-204) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 SHALL BE CONTROLLED BY A WET ESP WITH A MINIMUM CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SLAB GRINDERS (S-218 AND S-219) | 99.012 | Particulate Matter (PM) | A | EMISSIONS OF PM FROM EACH SLAB GRINDER SHALL BE CONTROLLED AT ALL TIMES DURING OPERATION BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.0% | 0.0044 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.0044 | | 0.0044 |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SLAB GRINDERS (S-218 AND S-219) | 99.012 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 FROM EACH SLAB GRINDER SHALL BE CONTROLLED AT ALL TIMES DURING OPERATION BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.0% | 0.0044 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.0044 | | 0.0044 |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ABRASIVE SAW (S-221) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 FROM THE ABRASIVE SAW SHALL BE CONTROLLED BY A ROTOCLONE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99%. | 0.16 | LB/H | | BACT-PSD | 0.7 | T/YR | | 0 | | | NA | | NA |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ABRASIVE SAW (S-221) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 FROM THE ABRASIVE SAW SHALL BE CONTROLLED BY A ROTOCLONE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99%. | 0.16 | LB/H | | BACT-PSD | 0.7 | T/YR | | 0 | | | NA | | NA |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ABRASIVE SAW (S-221) | 81.39 | Particulate Matter (PM) | A | EMISSIONS OF PM FROM THE ABRASIVE SAW SHALL BE CONTROLLED BY A ROTOCLONE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99%. | 0.16 | LB/H | | BACT-PSD | 0.7 | T/YR | | 0 | | | NA | | NA |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 1**
**RBLC Determinations with PM2.5, Updated February 17, 2012**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | REVERSING ROUGHING MILL (S-204) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 SHALL BE CONTROLLED BY A WET ESP WITH A MINIMUM CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke crushing and sceening | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | Baghouse | 3.43 | LB/H | | LAER | 15.55 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | 0.008 | GR/DSCF | | | 0.008 | 0.008 |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coal handling, processing, and transfer | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | Enclosure and wet suppression | 4.6 | LB/H | SUMMATION OF ALL COAL HANDLING PROCESSES | LAER | 0.52 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | | | NA | NA |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke and breeze handling and processing | 81.19 | Particulate matter, filterable (FPM) | P | Partially enclosed bunker and coke transfer points; breeze silo | 18.6 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | BACT-PSD | 0.0008 | LB/T | EMISSION FACTOR FROM AP-42 SECTION13.2.4 | 0 | | | NA | | NA |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke and breeze handling and processing | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | Partially enclosed bunker and coke transfer points; breeze silo | 16.71 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | BACT-PSD | 0 | | | 0.0008 | LB/T | EMISSION FACTOR FROM AP-42 SECTION13.2.4 | NA | | NA |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke crushing and sceening | 81.19 | Particulate matter, filterable (FPM) | A | Baghouse | 3.43 | LB/H | BAGHOUSE STACK | BACT-PSD | 18.6 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | 0.008 | GR/DSCF | | 0.008 | | 0.008 |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke crushing and sceening | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | A | Baghouse | 3.43 | LB/H | FROM BAGHOUSE STACK | BACT-PSD | 16.71 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | 0.008 | GR/DSCF | | 0.008 | | 0.008 |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke and breeze handling and processing | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | Partially enclosed bunker and coke transfer points; breeze silo | 15.55 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | LAER | 0.0008 | LB/T | EMISSION FACTOR FROM AP-42 SECTION13.2.4 | 0.0008 | LB/T | | | NA | NA |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coal handling, processing, and transfer | 81.19 | Particulate matter, filterable (FPM) | P | Enclosure and wet suppression | 4.6 | LB/H | SUMMATION OF ALL COAL HANDLING PROCESSES | BACT-PSD | 3.47 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | | NA | | NA |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coal handling, processing, and transfer | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | Enclosure and wet suppression | 4.6 | LB/H | SUMMATION OF ALL COAL HANDLING PROCESSES | BACT-PSD | 1.67 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | | NA | | NA |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | ATS PLANT | 50.006 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | PROPER EQUIPMENT DESIGN AND OPERATION, GOOD COMBUSTION PRACTICES, AND BURNING OF GASEOUS FUELS | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | ATS PLANT | 50.006 | Particulate matter, filterable < 10 µ (FPM10) | P | PROPER EQUIPMENT DESIGN AND OPERATION, GOOD COMBUSTION PRACTICES, AND BURNING OF GASEOUS FUELS | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONTINUOUS CASTERS AND SLAG POT DUMPING (2) | 81.23 | Particulate Matter (PM) | A | BAGHOUSE | 1.4 | LB/H | | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | 0.0022 | | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | SCRAP, COAL, IRON ORE BARGE UNLOADING | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | USE OF ENCLOSURES, MINIMIZING DROP HEIGHT, AND VENTING TRANSFER POINTS TO A BAGHOUSE | 0.93 | LB/H | | LAER | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | FOR BAGHOUSE | | 0.0022 | 0.0022 |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 1**
**RBLC Determinations with PM2.5, Updated February 17, 2012**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL AND IRON ORE UNLOADING & CONVEYING TO STORAGE (3) | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | USE OF ENCLOSURES AND A BAGHOUSE | 0.93 | LB/H | FOR EACH OF 3 SOURCES | LAER | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0.0022 | GR/DSCF | FOR BAGHOUSE | | 0.0022 | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | SCRAP, COAL, IRON ORE BARGE UNLOADING | 99.12 | Particulate matter, total (TPM) | B | USE OF ENCLOSURES, MINIMIZING DROP HEIGHT, AND VENTING TRANSFER POINTS TO A BAGHOUSE | 0.93 | LB/H | | BACT-PSD | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | FOR BAGHOUSE | 0.0022 | | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | SCRAP, COAL, IRON ORE BARGE UNLOADING | 99.12 | Particulate matter, fugitive | N | | 6.15 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | BACT-PSD | 2.84 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | | NA | | NA |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL AND IRON ORE UNLOADING & CONVEYING TO STORAGE (3) | 99.12 | Particulate Matter (PM) | B | USE OF ENCLOSURES AND A BAGHOUSE | 0.93 | LB/H | FOR EACH OF 3 SOURCES | BACT-PSD | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | 0.0022 | GR/DSCF | FOR BAGHOUSE | 0.0022 | | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL AND IRON ORE UNLOADING & CONVEYING TO STORAGE (3) | 99.12 | Particulate matter, fugitive | N | | 2.4 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | BACT-PSD | 0.99 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | | NA | | NA |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ALLOY, FLUX, CARBON, LIMESTONE, COKE HANDLING (2) | 99.12 | Particulate matter, fugitive | N | | 5.79 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | BACT-PSD | 2.1 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | | NA | | NA |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ALLOY, FLUX, CARBON, LIMESTONE, COKE HANDLING (2) | 99.12 | Particulate Matter (PM) | B | USE OF ENCLOSURES AND A BAGHOUSE | 1.4 | LB/H | FROM BAGHOUSE STACKS | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | 0.0022 | GR/DSCF | FOR BAGHOUSE | 0.0022 | | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | IRON ORE GRINDING (6) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE W/ 2 CYCLONES | 1.04 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | LAER | 4.56 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | | 0.0022 | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONTINUOUS CASTERS AND SLAG POT DUMPING (2) | 81.23 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 1.4 | LB/H | | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | | 0.0022 | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ALLOY, FLUX, CARBON, LIMESTONE, COKE HANDLING (2) | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | USE OF ENCLOSURES AND A BAGHOUSE | 1.4 | LB/H | FROM BAGHOUSE STACKS | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0.0022 | GR/DSCF | FROM BAGHOUSE | | 0.0022 | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL GRINDING (6) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | | 0.0022 | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONVEYORS, HOPPERS, SCREENS TO ROTARY HEARTH FURNACE | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH BAGHOUSE | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | | 0.0022 | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL GRINDING (6) | 81.29 | Particulate matter, fugitive | N | | 0.47 | T/YR | FOR PM AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 0.18 | T/YR | FOR PM10 AS A ROLLING 12-MONTH SUMMATION | 0 | | | NA | | NA |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL GRINDING (6) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | 0.0022 | | 0.0022 |

**PolyMet Mining, Inc.**
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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | IRON ORE GRINDING (6) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE W/ 2 CYCLONES | 1.04 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | BACT-PSD | 4.56 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | 0.0022 | | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | IRON ORE GRINDING (6) | 81.29 | Particulate matter, fugitive | N | | 1.03 | T/YR | FOR PM AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 0.4 | T/YR | FOR PM10 AS A ROLLING 12-MONTH SUMMATION | 0 | | | NA | | NA |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONVEYORS, HOPPERS, SCREENS TO ROTARY HEARTH FURNACE | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH BAGHOUSE | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | | 0.0022 | | 0.0022 |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONVEYORS, HOPPERS, SCREENS TO ROTARY HEARTH FURNACE | 81.29 | Particulate matter, fugitive | N | | 5.19 | T/YR | FOR PM AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 1.88 | T/YR | FOR PM10 AS A ROLLING 12-MONTH SUMMATION | 0 | | | NA | | NA |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | OTHER COAL/COKE HANDLING OPERATIONS | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | WHEN HANDLING A ''WET'' MATERIAL: MAINTAIN ADEQUATE MOISTURE CONTENT; COLLECT SPILLED MATERIAL. WHEN HANDLING A ''DRY'' MATERIAL: | 0 | | SEE NOTE | LAER | 0 | | | 0 | | | | NA | NA |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | ENCLOSURE AND BAGHOUSE | 0.005 | GR/DSCF | | LAER | 0 | | | 0 | | | | 0.005 | 0.005 |
| IL-0110 | GRANITE CITY WORKS | IL | 6070088 | 3/13/2008 | COKE CONVEYOR SYSTEM | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | ENCLOSURES FOR CONVEYORS; FABRIC FILTERS FOR DAY BINS, WATER SPRAYING | 0.005 | GR/DSCF | | LAER | 0 | | | 0 | | | | 0.005 | 0.005 |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, total < 2.5 µ (TPM2.5) | A | ENCLOSURE AND BAGHOUSE | 0.008 | GR/DSCF | | LAER | 0 | | | 0 | | | | 0.008 | 0.008 |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | OTHER COAL/COKE HANDLING OPERATIONS | 81.19 | Particulate matter, filterable (FPM) | P | WHEN HANDLING A ''WET'' MATERIAL: MAINTAIN ADEQUATE MOISTURE CONTENT; COLLECT SPILLED MATERIAL. WHEN HANDLING A ''DRY'' MATERIAL: | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | OTHER COAL/COKE HANDLING OPERATIONS | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | WHEN HANDLING A ''WET'' MATERIAL: MAINTAIN ADEQUATE MOISTURE CONTENT; COLLECT SPILLED MATERIAL. WHEN HANDLING A ''DRY'' MATERIAL: | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | | NA | | NA |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, filterable (FPM) | A | ENCLOSURE AND BAGHOUSE | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | A | ENCLOSURE AND BAGHOUSE | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, total (TPM) | A | ENCLOSURE AND BAGHOUSE | 0.008 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.008 | | 0.008 |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, total < 10 µ (TPM10) | A | ENCLOSE AND BAGHOUSE | 0.008 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.008 | | 0.008 |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IL-0110 | GRANITE CITY WORKS | IL | 6070088 | 3/13/2008 | COKE CONVEYOR SYSTEM | 81.19 | Particulate matter, filterable (FPM) | B | ENCLOSURES FOR CONVEYORS; FABRIC FILTERS FOR DAY BINS, WATER SPRAYING | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| IL-0110 | GRANITE CITY WORKS | IL | 6070088 | 3/13/2008 | COKE CONVEYOR SYSTEM | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | B | ENCLOSURES FOR CONVEYORS; FABRIC FILTERS FOR DAY BINS, WATER SPRAYING | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | | 0.005 | | 0.005 |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | SCRAP SHREDDER BAGHOUSE | 81.38 | Particulate Matter (PM) | N | | 9.7 | LB/H | | BACT-PSD | 42.49 | T/YR | | 0 | | | NA | | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (4) PELLET LINE LOT BLENDER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.03 | LB/H | EACH | Other Case-by-Case | 0.06 | T/YR | EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) POWDER MASTERBATCH WEIGHT BIN VENT FILTER | 63.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | NONE INDICATED | 0.03 | LB/H | EACH | Other Case-by-Case | 0.01 | T/YR | LESS THAN, EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) PELLET REFEED BIN VENT | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.03 | LB/H | EACH | Other Case-by-Case | 0.01 | T/YR | LESS THAN, EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (4) CARLOT SILO BLENDERS | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.27 | LB/H | EACH | Other Case-by-Case | 0.47 | T/YR | EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | BAGGING BIN VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.27 | LB/H | | Other Case-by-Case | 0.47 | T/YR | | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | ADDITIVE FEED HOPPER VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.01 | LB/H | | Other Case-by-Case | 0.01 | T/YR | | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) POWDER MASTERBATCH WEIGHT BIN VENT FILTER | 63.999 | Particulate Matter (PM) | A | FILTER | 0.16 | LB/H | EACH | Other Case-by-Case | 0.03 | T/YR | EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) POWDER MASTERBATCH WEIGHT BIN VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.03 | LB/H | EACH | Other Case-by-Case | 0.01 | T/YR | LESS THAN, EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) INLINE BLENDER VENT FILTER | 63.999 | Particulate Matter (PM) | A | FILTER | 0.02 | LB/H | EACH | Other Case-by-Case | 0.08 | T/YR | EACH | | | | | NA | NA |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) INLINE BLENDER VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.02 | LB/H | EACH | Other Case-by-Case | 0.07 | T/YR | EACH | | | | | NA | NA |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | SLAG PROCESSING | 81.39 | Particulate Matter (PM) | P | WATER APPLICATION TO CONTROL FUGITIVE EMISSIONS. | 5.7 | LB/H | | BACT-PSD | 8.3 | T/YR | | | | NOT AVAILABLE | NA | | NA |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 1**
**RBLC Determinations with PM2.5, Updated February 17, 2012**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | SLAG PROCESSING | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | WATER APPLICATION TO CONTROL FUGITIVE EMISSIONS. | 2.9 | LB/H | | BACT-PSD | 4.1 | T/YR | | | | NOT AVAILABLE | NA | | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FEED HOPPER, FCC-3A | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.04 | LB/H | | Other Case-by-Case | 0.18 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FLASH DRYER, FCC-8 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 1 | LB/H | | Other Case-by-Case | 4.4 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FINAL PRODUCT, FCC-9A | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.58 | LB/H | | Other Case-by-Case | 2.55 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FLASH DRYER, FCC-10 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 1 | LB/H | | Other Case-by-Case | 4.4 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | KAOLIN DOSING BAG HOPPER, FCC-19 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.29 | LB/H | | Other Case-by-Case | 1.26 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FINAL PRODUCT CALCINER, FCC-74 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.26 | LB/H | | Other Case-by-Case | 1.14 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | MAIN BAG FILTER | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | THE BAG FILTER IS A PM CONTROL | 1.2 | LB/H | | Other Case-by-Case | 5.3 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | (2) CRUDE PRODUCT | 62.02 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAG FILTER | 0.07 | LB/H | EACH | Other Case-by-Case | 0.28 | T/YR | EACH | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | (2) CRUDE PRODUCT | 62.02 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.07 | LB/H | EACH | Other Case-by-Case | 0.28 | T/YR | EACH | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | (2) PRODUCT AIR SLIDE, FCC-61&62 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.09 | LB/H | EACH | Other Case-by-Case | 0.38 | T/YR | EACH | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BLENDING SILO | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FITLER | 0.24 | LB/H | | Other Case-by-Case | 1.07 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BULK LOADOUT, FCC-65 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.24 | LB/H | | Other Case-by-Case | 1.07 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | PORTABLE BAG FILTER, FCC-66 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.09 | LB/H | | Other Case-by-Case | 0.19 | T/YR | | | | | | NA | NA |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 1**
**RBLC Determinations with PM2.5, Updated February 17, 2012**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time | BACT gr/dscf | Non-BACT Lb/MMBtu | gr/dscf STD Emission Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | C ALUMINA SILO, FCC-20 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.29 | LB/H | | Other Case-by-Case | 0.91 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | SPRAY DRYER, FCC-21 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 8.59 | LB/H | | Other Case-by-Case | 37.41 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | SEPARATOR FINES, FCC-23 | 62.999 | Particulate Matter (PM) | A | BAG FILTER | 0.48 | LB/H | | Other Case-by-Case | 2.09 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | KAOLIN UNLOADING, FCC-40 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.15 | LB/H | | Other Case-by-Case | 0.32 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | KAOLIN SILO, FCC-68 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.26 | LB/H | | Other Case-by-Case | 0.58 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | C ALUMINA DOSING, FCC-69 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.24 | LB/H | | Other Case-by-Case | 0.55 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BOC SILO, FCC-70 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.19 | LB/H | | Other Case-by-Case | 0.41 | T/YR | | | | | | NA | NA |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BOC DOSING, FCC-71 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.21 | LB/H | | Other Case-by-Case | 0.44 | T/YR | | | | | | NA | NA |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *LA-0258 | CALCASIEU PLANT | LA | PSD-LA-746 | 12/21/2011 | TURBINE EXHAUST STACK NO. 1 & NO. 2 | 15.11 | Particulate matter, total < 2.5 µ (TPM2.5) | P | USE OF PIPELINE NATURAL GAS | 17 | LB/HR | HOURLY MAXIMUM | BACT-PSD | 17 | LB/HR | HOURLY MAXIMUM / STARTUP & SHUTDOWN ONLY | 0 | | |
| *LA-0258 | CALCASIEU PLANT | LA | PSD-LA-746 | 12/21/2011 | TURBINE EXHAUST STACK NO. 1 & NO. 2 | 15.11 | Particulate matter, total < 10 µ (TPM10) | P | USE OF PIPELINE NATURAL GAS | 17 | LB/HR | HOURLY MAXIMUM | BACT-PSD | 17 | LB/HR | HOURLY MAXIMUM / STARTUP & SHUTDOWN ONLY | 0 | | |
| *LA-0256 | COGENERATION PLANT | LA | PSD-LA-754 | 12/6/2011 | COGENERATION TRAINS 1-3 (1-10, 2-10, 3-10) | 15.21 | Particulate matter, total < 10 µ (TPM10) | P | USE OF NATURAL GAS AS FUEL AND GOOD COMBUSTION PRACTICES | 3.72 | LB/HR | HOURLY MAXIMUM | BACT-PSD | 0 | | | 0 | | |
| *LA-0256 | COGENERATION PLANT | LA | PSD-LA-754 | 12/6/2011 | EMERGENCY GENERATOR | 17.13 | Particulate matter, total < 2.5 µ (TPM2.5) | P | USE OF NATURAL GAS AS FUEL AND GOOD COMBUSTION PRACTICES | 0.01 | LB/HR | HOURLY MAXIMUM | BACT-PSD | 0 | | | 0 | | |
| *LA-0256 | COGENERATION PLANT | LA | PSD-LA-754 | 12/6/2011 | EMERGENCY GENERATOR | 17.13 | Particulate matter, total < 10 µ (TPM10) | P | USE OF NATURAL GAS AS FUEL AND GOOD COMBUSTION PRACTICES | 0.01 | LB/HR | HOURLY MAXIMUM | BACT-PSD | 0 | | | 0 | | |
| *LA-0256 | COGENERATION PLANT | LA | PSD-LA-754 | 12/6/2011 | COGENERATION TRAINS 1-3 (1-10, 2-10, 3-10) | 15.21 | Particulate matter, total < 2.5 µ (TPM2.5) | P | USE OF NATURAL GAS AS FUEL AND GOOD COMBUSTION PRACTICES | 3.72 | LB/HR | HOURLY MAXIMUM | BACT-PSD | 0 | | | 0 | | |
| *FL-0329 | SHELL OFFSHORE INC. | FL | OCS-EPA-R4006 | 11/28/2011 | Source-Wide Limits | 11.22 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 9.9 | TPY | 12-MONTH ROLLING | | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Main Propulsion Engines | 17.11 | Particulate matter, filterable (FPM) | P | Use of good combustion practices based on the current manufacturer's specifications for these engines, and additional enhanced work practice standards including an engine | 0.43 | G/KW-HR | 24-HOUR ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Main Propulsion Engines | 17.11 | Particulate matter, total < 10 µ (TPM10) | P | Use of good combustion practices based on the current manufacturer's specifications for these engines, and additional enhanced work practice standards including an engine | 0.24 | G/KW-HR | 24-HOUR ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Boiler | 13.22 | Particulate matter, total < 2.5 µ (TPM2.5) | N | Use of good combustion and maintenance practices, based on the current manufacturer's specifications for this boiler. | 0.01 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Crane Engines (units 1 and 2) | 17.11 | Particulate matter, total (TPM) | P | Use of certified EPA Tier 1 engines and good combustion practices based on the current manufacturer's specifications for this engine. | 0.6 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Crane Engines (units 3 and 4) | 17.11 | Particulate matter, total (TPM) | N | Use of good combustion practices, based on the current manufacturer's specifications for this engine | 1.3 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Emergency Engine | 17.11 | Particulate matter, total (TPM) | N | Use of good combustion practices, based on the current manufacturer's specifications for this engine | 0.03 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Emergency Fire Pump Engine | 17.11 | Particulate matter, total (TPM) | N | Use of good combustion practices, based on the current manufacturer's specifications for this engine | 0.002 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Boiler | 13.22 | Particulate matter, total (TPM) | N | Use of good combustion and maintenance practices, based on the current manufacturer's specifications for this boiler. | 0.05 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Boiler | 13.22 | Particulate matter, total < 10 µ (TPM10) | N | Use of good combustion and maintenance practices, based on the current manufacturer's specifications for this boiler. | 0.02 | TONS PER YEAR | 12-MONTH ROLLING | BACT-PSD | 0 | | | 0 | | |
| *FL-0328 | ENI - HOLY CROSS DRILLING PROJECT | FL | OCS-EPA-R4007 | 10/27/2011 | Main Propulsion Engines | 17.11 | Particulate matter, total < 2.5 µ (TPM2.5) | P | Use of good combustion practices based on the current manufacturer's specifications for these engines, and additional enhanced work practice standards including an engine | 0.24 | G/KW-HR | 24-HOUR ROLLING | BACT-PSD | 0 | | | 0 | | |
| *PA-0275 | CRAWFORD RENEWABLE ENERGY LLC/GREENWOOD TWP | PA | 20-305A | 10/24/2011 | Circulating Fluidized Bed Boilers (2) | 11.9 | Particulate matter, total < 2.5 µ (TPM2.5) | N | Baghouse | 0.01 | LB/MMBTU | 8760 | BACT-PSD | 10.5 | LB/HR | 8760 | 45.99 | TPY | 8760 |
| *PA-0275 | CRAWFORD RENEWABLE ENERGY LLC/GREENWOOD TWP | PA | 20-305A | 10/24/2011 | Circulating Fluidized Bed Boilers (2) | 11.9 | Particulate matter, filterable < 10 µ (FPM10) | A | Baghouse | 0.02 | LB/MMBTU | 8760 | BACT-PSD | 21 | LB/HR | 8760 | 91.98 | TPY | 8760 |
| *PA-0275 | CRAWFORD RENEWABLE ENERGY LLC/GREENWOOD TWP | PA | 20-305A | 10/24/2011 | Material Handling, Plant Roadways, and Cooling Tower | 99.19 | Particulate matter, filterable < 10 µ (FPM10) | B | | 7.29 | TPY | 8760 | BACT-PSD | 0 | | | 0 | | |
| *PA-0275 | CRAWFORD RENEWABLE ENERGY LLC/GREENWOOD TWP | PA | 20-305A | 10/24/2011 | Fire Water Pump | 17.2 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.08 | LB/HR | | BACT-PSD | 0.0008 | TPY | | 0 | | |
| TX-0600 | THOMAS C. FERGUSON POWER PLANT | TX | PSDTX1244 | 9/1/2011 | Natural gas-fired turbines | 15.21 | Particulate matter, total < 2.5 µ (TPM2.5) | P | pipeline quality natural gas | 33.43 | LB/H | 1-H | BACT-PSD | 0 | | | 0 | | |
| FL-0326 | MEDLEY LANDFILL | FL | 0250615-012-AC (PSD-FL-414) | 8/25/2011 | Landfill Gas-to-Energy | 17.14 | Particulate matter, total < 2.5 µ (TPM2.5) | P | Pretreatment of landfill gas and good combustion practices | 10 | % OPACITY | | BACT-PSD | 0 | SEE NOTES | | 0 | | |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | UNIT 6 COOLING TOWER | 99.009 | Particulate matter, total < 2.5 µ (TPM2.5) | P | HIGH EFFICIENCY MIST ELIMINATOR | 0.0005 | PERCENT DRIFT | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.0005 | PERCENT DRIFT | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | COMBINED CYCLE TURBINE GENERATORS (UNITS 6A & 6B) | 15.21 | Particulate matter, total < 10 µ (TPM10) | P | WHILE FIRING NATURAL GAS: USE OF PIPELINE QUALITY NATURAL GAS AND GOOD COMBUSTION PRACTICES WHILE FIRING FUEL OIL: USE OF ULTRA LOW SULFUR FUEL OIL AND | 26.23 | LB/H | HOURLY AVERAGE W/O DUCT BURNER | BACT-PSD | 33.16 | LB/H | HOURLY AVERAGE W/ DUCT BURNER | 0 | | |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | AUXILIARY BOILER (AUX-1) | 11.31 | Particulate matter, total < 10 µ (TPM10) | P | USE OF PIPELINE QUALITY NATURAL GAS AND GOOD COMBUSTION PRACTICES | 7.6 | LB/MMSCF | ANNUAL AVERAGE | BACT-PSD | 0 | | | 7.6 | LB/MMSCF | ANNUAL AVERAGE |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | CHILLER COOLING TOWER (CHILL CT) | 99.009 | Particulate matter, total < 2.5 µ (TPM2.5) | P | HIGH EFFICIENCY MIST ELIMINATOR | 0.001 | PERCENT DRIFT | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.001 | PERCENT DRIFT | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | CHILLER COOLING TOWER (CHILL CT) | 99.009 | Particulate matter, total < 10 µ (TPM10) | P | HIGH EFFICIENCY MIST ELIMINATOR | 0.001 | PERCENT DRIFT | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.001 | PERCENT DRIFT | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | EMERGENCY DIESEL GENERATOR | 17.11 | Particulate matter, total < 2.5 µ (TPM2.5) | P | ULTRA LOW SULFUR DIESEL AND GOOD COMBUSTION PRACTICES | 0.15 | G/HP-H | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.15 | G/HP-H | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | UNIT 6 COOLING TOWER | 99.009 | Particulate matter, total < 10 µ (TPM10) | P | HIGH EFFICIENCY MIST ELIMINATOR | 0.0005 | PERCENT DRIFT | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.0005 | PERCENT DRIFT | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | EMERGENCY FIRE PUMP | 17.21 | Particulate matter, total < 2.5 µ (TPM2.5) | P | ULTRA LOW SULFUR DIESEL AND GOOD COMBUSTION PRACTICES | 0.15 | G/HP-H | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.15 | G/HP-H | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | AUXILIARY BOILER (AUX-1) | 11.31 | Particulate matter, total < 2.5 µ (TPM2.5) | P | USE OF PIPELINE QUALITY NATURAL GAS AND GOOD COMBUSTION PRACTICES | 7.6 | LB/MMSCF | ANNUAL AVERAGE | BACT-PSD | 0 | | | 7.6 | LB/MMSCF | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | EMERGENCY DIESEL GENERATOR | 17.11 | Particulate matter, total < 10 µ (TPM10) | P | ULTRA LOW SULFUR DIESEL AND GOOD COMBUSTION PRACTICES | 0.15 | G/HP-H | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.15 | G/HP-H | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | EMERGENCY FIRE PUMP | 17.21 | Particulate matter, total < 10 µ (TPM10) | P | ULTRA LOW SULFUR DIESEL AND GOOD COMBUSTION PRACTICES | 0.15 | G/HP-H | ANNUAL AVERAGE | BACT-PSD | 0 | | | 0.15 | G/HP-H | ANNUAL AVERAGE |
| LA-0254 | NINEMILE POINT ELECTRIC GENERATING PLANT | LA | PSD-LA-752 | 8/16/2011 | COMBINED CYCLE TURBINE GENERATORS (UNITS 6A & 6B) | 15.21 | Particulate matter, total < 2.5 µ (TPM2.5) | P | WHILE FIRING NATURAL GAS: USE OF PIPELINE QUALITY NATURAL GAS AND GOOD COMBUSTION PRACTICES WHILE FIRING FUEL OIL: USE OF ULTRA LOW SULFUR FUEL OIL AND GOOD COMBUSTION PRACTICES | 26.23 | LB/H | HOURLY AVERAGE W/O DUCT BURNER | BACT-PSD | 33.16 | LB/H | HOURLY AVERAGE W/ DUCT BURNER | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P10 - LIME SILO | 90.019 | Particulate Matter (PM) | B | PNEUMATIC CONVEYING, TOTAL ENCLOSURE AND BIN VENT FABRIC FILTER. | 0.13 | LB/H | | BACT-PSD | 0.005 | GR/DSCF | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P30 - DIRECT CONTACT SCRUBBER WITH COOLING TOWER | 62.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | HIGH EFFICIENCY DRIFT ELIMINATOR (W/ ADDITIONAL LAYER) | 0.0005 | % CIRCULATION DRIFT | | BACT-PSD | 0.027 | LB/H | (BASED ON 42% PM2.5) | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P21, P22, P23 - CARBONATORS | 62.999 | Particulate Matter (PM) | A | CHEVRON TYPE DEMISTERS (2 PASS OR MORE) | 0.4 | LB/H | PER CARBONATOR (3 HR. AVG.) | BACT-PSD | 0.09 | GR/DSCF | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P30 - DIRECT CONTACT SCRUBBER WITH COOLING TOWER | 62.999 | Particulate Matter (PM) | B | HIGH EFFICIENCY MIST / DRIFT ELIMINATOR (WITH ADDITIONAL LAYER), LIMITS ON % SOLIDS | 0.0005 | % CIRCULATION DRIFT | | BACT-PSD | 0.064 | LB/H | | 0 | | |

**PolyMet Mining, Inc.**
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**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P40, P50 - COOLING TOWERS | 62.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | HIGH EFFICIENCY MIST / DRIFT ELIMINATOR (W/ ADDITONAL LAYER) | 0.0005 | % CIRCULATION DRIFT | | BACT-PSD | 0 | | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P40, P50 - COOLING TOWERS | 62.999 | Particulate Matter (PM) | B | HIGH EFFICIENCY MIST / DRIFT ELIMINATORS (W/ ADDITIONAL LAYER) | 0.0005 | % CIRCULATION DRIFT | | BACT-PSD | 0 | | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P60 - COOLING TOWER | 62.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | HIGH EFFICIENCY MIST / DRIFT ELIMINATORS (W/ ADDITIONAL LAYER); DISSOLVED SOLIDS LIMIT | 0.0005 | % CIRCULATION DRIFT | | BACT-PSD | 0 | | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P60 - COOLING TOWER | 62.999 | Particulate Matter (PM) | B | HIGH EFFICIENCY MIST / DRIFT ELIMINATORS (W/ ADDITIONAL LAYER); DISSOLVED SOLIDS LIMIT | 0.0005 | % CIRCULATION DRIFT | | BACT-PSD | 0 | | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | P10 - LIME SILO | 90.019 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | PNEUMATIC CONVEYING, TOTAL ENCLOSURE, BIN VENT FABRIC FILTER | 0.026 | LB/H | | BACT-PSD | 0.001 | GR/ACF | | 0 | | |
| WI-0252 | SPECIALTY MINERALS INC. - SUPERIOR | WI | 09-DCF-251 | 7/22/2011 | F01 - FUGITIVE DUST EMISSIONS | 99.1 | Particulate Matter (PM) | P | PAVING ROADWAYS AND PARKING, MAINTENANCE OF PAVED AREAS AND TOTAL ENCLOSURES FOR RAW MATERIAL TRANSFERS. | 0 | | | BACT-PSD | 0 | | | 0 | | |
| AK-0072 | DUTCH HARBOR POWER PLANT | AK | AQ0215CPT03 | 7/14/2011 | EU 15 Caterpillar C-280-16 | 17.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | Positive Crankcase Ventilation Installed as part of the design | 0.5 | G/KW-H | INSTANTANEOUS | BACT-PSD | 0 | | | 0 | | |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Ore Dryer (AB-202) | 62.999 | Particulate matter, total (TPM) | A | Replacing baghouses with a reverse jet wet scrubber | 0.011 | GR/DSCF | 3-HR AVG | BACT-PSD | 2 | LB/H | 3-HR AVG | 0.011 | GR/DSCF | 3-HR AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Ore Dryer (AB-202) | 62.999 | Particulate matter, total < 10 µ (TPM10) | A | replacing baghouses with reverse jet wet scrubber | 0.011 | GR/DSCF | 3-HR AVG | BACT-PSD | 2 | LB/H | 3-HR AVG | 0.011 | GR/DSCF | 3-HR AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 1 Oxygen Preheater (AH-102) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | N | BACT is good combustion. | 0.0025 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.0025 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 1 HCl Recovery Process (AC-101) | 62.999 | Particulate matter, total (TPM) | A | 4-stage scrubbing, thermal oxidizer, dual reverse-jet scrubbers, cyclonic gas-liquid separator | 6.17 | LB/H | 3-H AVG | BACT-PSD | 0 | | | 6.17 | LB/H | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 1 HCl Recovery Process (AC-101) | 62.999 | Particulate matter, total < 10 µ (TPM10) | A | 4-stage scrubbing, thermal oxidizer, dual reverse-jet scrubbers, cyclonic gas-liquid separator | 6.17 | LB/H | 3-H AVG | BACT-PSD | 0 | | | 6.17 | LB/H | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Oxygen Preheater (AH-202) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | N | BACT is good combustion. | 0.0025 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.0025 | GR/DSCF | 3-H AVG |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 HCl Recovery Process (AC-201) | 62.999 | Particulate matter, total (TPM) | P | 4-stage scrubbing, thermal oxidizer, dual reverse-jet scrubbers, cyclonic gas-liquid separator | 6.17 | LB/HR | 3-HR AVG | BACT-PSD | 0 | | | 6.17 | LB/HR | 3-HR AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 HCl Recovery Process (AC-201) | 62.999 | Particulate matter, total < 10 µ (TPM10) | A | 4-stage scrubbing, thermal oxidizer, dual reverse-jet scrubbers, cyclonic gas-liquid separator | 6.17 | LB/HR | 3-HR AVG | BACT-PSD | 0 | | | 6.17 | LB/HR | 3-HR AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | No. 7 Pigment Grinding Feed Bin (AK-107) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Baghouse | 0.005 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.005 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 1 Oxygen Preheater (AH-102) | 62.999 | Particulate matter, total (TPM) | N | BACT is good combustion. | 0.0026 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.0026 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 1 Oxygen Preheater (AH-102) | 62.999 | Particulate matter, total < 10 µ (TPM10) | N | BACT is good combustion. | 0.0026 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.0026 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Ore Dryer (AB-202) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | A | replacing baghouses with reverse jet wet scrubber | 0.0085 | GR/DSCF | 3-HR AVG | BACT-PSD | 1.55 | LB/H | 3-HR AVG | 0.0085 | GR/DSCF | 3-HR AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Oxygen Preheater (AH-202) | 62.999 | Particulate matter, total (TPM) | N | BACT is good combustion | 0.0026 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.0026 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 Oxygen Preheater (AH-202) | 62.999 | Particulate matter, total < 10 µ (TPM10) | N | BACT is good combustion. | 0.0026 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.0026 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 1 HCl Recovery Process (AC-101) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | A | 4-stage scrubbing, thermal oxidizer, dual reverse-jet scrubbers, cyclonic gas-liquid separator | 5 | LB/H | 3-H AVG | BACT-PSD | 0 | | | 5 | LB/H | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | No. 7 Pigment Grinding Feed Bin (AK-107) | 62.999 | Particulate matter, total (TPM) | A | Baghouse | 0.01 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.01 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | No. 7 Pigment Grinding Feed Bin (AK-107) | 62.999 | Particulate matter, total < 10 µ (TPM10) | A | Baghouse | 0.01 | GR/DSCF | 3-H AVG | BACT-PSD | 0 | | | 0.01 | GR/DSCF | 3-H AVG |
| MS-0091 | DUPONT DELISLE FACILITY | MS | 1020-00115 | 3/21/2011 | Line 2 HCl Recovery Process (AC-201) | 62.999 | Particulate matter, total < 2.5 µ (TPM2.5) | A | 4-stage scrubbing, thermal oxidizer, dual reverse-jet scrubbers, cyclonic gas-liquid separator | 5 | LB/HR | 3-HR AVG | BACT-PSD | 0 | | | 5 | LB/HR | 3-HR AVG |
| OH-0342 | FAIRCREST STEEL | OH | P0104388 | 12/29/2010 | Electric Arc Furnace | 81.21 | Particulate matter, total < 10 µ (TPM10) | A | Roof canopy hood fume collecion system with Direct Evacuation Control to baghouse | 0.0017 | GR/DSCF | | OTHER CASE-BY-CASE | 49.4 | T/YR | AS AROLLING 12 MONTH SUMMATION | 0 | | |

**PolyMet Mining, Inc.**
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**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0342 | FAIRCREST STEEL | OH | P0104388 | 12/29/2010 | Electric Arc Furnace | 81.21 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Roof canopy hood fume collecion system with Direct Evacuation Control to baghouse | 0.0009 | GR/DSCF | | OTHER CASE-BY-CASE | 0 | | | 0 | | |
| TX-0587 | SWEENY REFINERY | TX | 5920A AND PSDTX103M4 | 12/29/2010 | Fluid Catalytic Cracking Unit (FCCU) | 50.003 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Regenerator cyclones and Electrostatic Precipitator | 1.334 | LB/TON OF COKE BURN | | BACT-PSD | 385.38 | T/YR | | 0 | | |
| TX-0593 | TEXAS CLEAN ENERGY PROJECT | TX | PSDTX1218 | 12/28/2010 | Integrated Gasification Combined Cycle | 11.11 | Particulate matter, total (TPM) | P | gasification of coal and syngas clean-up before combustion in turbine and duct burners; burning low ash fuels (including natural gas) | 0.009 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| TX-0593 | TEXAS CLEAN ENERGY PROJECT | TX | PSDTX1218 | 12/28/2010 | Integrated Gasification Combined Cycle | 11.11 | Particulate matter, total < 10 µ (TPM10) | P | gasificaiton of coal and syngas clean-up before combustion in turbine and duct burners; burning low ash fuels (natural gas) | 0.009 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| TX-0593 | TEXAS CLEAN ENERGY PROJECT | TX | PSDTX1218 | 12/28/2010 | Integrated Gasification Combined Cycle | 11.11 | Particulate matter, total < 2.5 µ (TPM2.5) | P | gasification of coal and syngas clean-up before combustion in turbine and duct burners; burning low ash fuels (natural gas) | 0.009 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | EAR, Continuous casting, and 6 pre-heaters | 81.21 | Particulate matter, total < 2.5 µ (TPM2.5) | B | Building enclosure equipped with a canopy hood/baghouse system capable of achiieving 100% capture of meltshop emissions. | 0.0049 | GR/DSCF | | BACT-PSD | 108.96 | T/YR | PER ROLLING 12 MO. FROM MELT SHOP | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Reheat furnace for steel billet | 81.23 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 0.0075 | LB/MMBTU | PER MMBTU HEAT INPUT; AP-42 | BACT-PSD | 6.04 | T/YR | PER ROLLING 12 MONTHS | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Melt Shop Spray Contact Cooling Tower | 81.29 | Particulate matter, total (TPM) | N | | 0.22 | LB/H | | BACT-PSD | 0.96 | T/YR | PER ROLLING 12 MONTHS | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Melt Shop Spray Contact Cooling Tower | 81.29 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 0.04 | LB/H | | BACT-PSD | 0.15 | T/YR | PER ROLLING 12 MONTHS | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Rolling Mill Contact Cooling Tower | 81.29 | Particulate matter, total (TPM) | N | | 0.46 | LB/H | | BACT-PSD | 2.01 | T/YR | PER ROLLING 12 MONTHS | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Scrap steel storage piles | 81.29 | Particulate matter, fugitive | P | Minimize drop height | 0.43 | T/YR | PER ROLLING 12 MONTHS FOR PM | BACT-PSD | 0.22 | T/YR | PER ROLLING 12 MONTHS FOR PM 10 | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Roadways | 99.15 | Particulate matter, fugitive | P | Best available control measures to include watering, resurfacing, chemical stabilization, and/or speed reduction at sufficient frequency to ensure compliance. | 30.64 | T/YR | PER ROLLING 12 MONTHS FOR | BACT-PSD | 5.93 | T/YR | PER ROLLING 12 MONTHS FOR FUGITIVE PM 10 | 0 | | |
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | EAR, Continuous casting, and 6 pre-heaters | 81.21 | Particulate matter, total < 10 µ (TPM10) | B | Building enclosure equipped with a canopy hood/baghouse system capable of achiieving 100% capture of meltshop emissions. | 0.0052 | GR/DSCF | | BACT-PSD | 115.63 | T/YR | PER ROLLING 12-MO. FROM MELT SHOP | 0 | | |

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**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0341 | NUCOR STEEL MARION, INC. | OH | P0105283 | 12/23/2010 | Rolling Mill Contact Cooling Tower | 81.29 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 0.07 | LB/H | | BACT-PSD | 0.32 | T/YR | PER ROLLING 12 MONTHS | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Boiler, Biomass Wood | 11.12 | Particulate matter, filterable < 10 µ (FPM10) | A | Fabric filter baghouse and dust sorbent injection system. | 0.01 | LB/MMBTU | (FILTERABLE) 30 H AV / CONDITION 2.10 | BACT-PSD | 0.018 | LB/MMBTU | (TOTAL) 3 H AV / CONDITION 2.11 | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Biomass Fuel Preparation & Hamdling (BFPH Group) | 99.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | Fabric filter baghouse, enclosure, and water spray. | 0.005 | GR/DSCM | 3 H AV / CONDITION 2.14 | BACT-PSD | 0 | | | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Biomass Fuel Preparation & Hamdling (BFPH Group) | 99.19 | Particulate matter, filterable < 10 µ (FPM10) | B | Fabric filter baghouse, enclosure, and water spray. | 0.005 | GR/DSCM | 3 H AV / CONDITION 2.14 | BACT-PSD | 0 | | | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Material Storage Silos Equipment (MSS Group) | 99.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | Bin Vent Filter, good operating practices, and water sprays. | 0.005 | GR/DSCM | 3 H AV / CONDITION 2.15 | BACT-PSD | 0 | | | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Material Storage Silos Equipment (MSS Group) | 99.19 | Particulate matter, filterable < 10 µ (FPM10) | B | Bin Vent Filter, good operating practices, and water sprays. | 0.005 | GR/DSCM | 3 H AV / CONDITION 2.15 | BACT-PSD | 0 | | | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Boiler, Biomass Wood | 11.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | Fabric filter baghouse and dust sorbent injection system. | 0.018 | LB/MMBTU | (TOTAL) 3 H AV/ CONDITION 2.11 | BACT-PSD | 0 | | | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Cooling Tower | 99.009 | Particulate matter, filterable (FPM) | A | Drift Eliminators | 0.0005 | % EFFECTIVENESS | CONDITION 2.17 | BACT-PSD | 0 | | | 0 | | |
| GA-0141 | WARREN COUNTY BIOMASS ENERGY FACILITY | GA | 4911-301-0016-P-01-0 | 12/17/2010 | Firewater Pump, 2 | 17.22 | Particulate matter, total (TPM) | P | Compliance with 40 CFR 60, Subpart IIII. | 0 | | SEE NOTES | BACT-PSD | 0 | | | 0 | | |
| OH-0343 | SMART PAPERS-HAMILTON MILL | OH | P0106289 | 11/1/2010 | Spreader Stoker Boiler | 12.12 | Particulate matter, total < 10 µ (TPM10) | A | Baghouse | 0.104 | LB/MMBTU | PER MMBTU OF HEAT INPUT | OTHER CASE-BY-CASE | 113.9 | T/YR | | 0 | | |
| OH-0343 | SMART PAPERS-HAMILTON MILL | OH | P0106289 | 11/1/2010 | Pulverized Dry-Bottom Boiler | 11.19 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Baghouse | 0.024 | GR/DSCF | | OTHER CASE-BY-CASE | 0 | | | 0 | | |
| OH-0343 | SMART PAPERS-HAMILTON MILL | OH | P0106289 | 11/1/2010 | Spreader Stoker Boiler | 12.12 | Particulate matter, total (TPM) | A | Baghouse | 0.116 | LB/MMBTU | PER MMBTU OF ACTUAL HEAT INPUT | OTHER CASE-BY-CASE | 126.5 | T/YR | | 0 | | |
| OH-0343 | SMART PAPERS-HAMILTON MILL | OH | P0106289 | 11/1/2010 | Pulverized Dry-Bottom Boiler | 11.19 | Particulate matter, total < 10 µ (TPM10) | A | Baghouse | 0.042 | GR/DSCF | | OTHER CASE-BY-CASE | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
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**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0343 | SMART PAPERS-HAMILTON MILL | OH | P0106289 | 11/1/2010 | Pulverized Dry-Bottom Boiler | 11.19 | Particulate matter, total (TPM) | A | Baghouse | 0.116 | LB/MMBTU | PER MMBTU OF ACTUAL HEAT INPUT | OTHER CASE-BY-CASE | 0 | | | 0 | | |
| OH-0343 | SMART PAPERS-HAMILTON MILL | OH | P0106289 | 11/1/2010 | Spreader Stoker Boiler | 12.12 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Baghouse | 0.03 | GR/DSCF | | OTHER CASE-BY-CASE | 77.2 | T/YR | | 0 | | |
| NJ-0076 | PSEG FOSSIL LLC KEARNY GENERATING STATION | NJ | 12200-BOP100002 | 10/27/2010 | SIMPLE CYCLE TURBINE | 15.11 | Particulate matter, total < 10 µ (TPM10) | P | Good combustion practice, Use of Clean Burning Fuel: Natural gas | 6 | LB/H | AVERAGE OF THREE TESTS | BACT-PSD | 0 | | | 0 | | |
| NJ-0076 | PSEG FOSSIL LLC KEARNY GENERATING STATION | NJ | 12200-BOP100002 | 10/27/2010 | SIMPLE CYCLE TURBINE | 15.11 | Particulate matter, total < 2.5 µ (TPM2.5) | P | Good combustion practice, Use of Clean Burning Fuel: Natural gas | 6 | LB/H | AVERGE OF THREE TESTS | BACT-PSD | 0 | | | 0 | | |
| NJ-0076 | PSEG FOSSIL LLC KEARNY GENERATING STATION | NJ | 12200-BOP100002 | 10/27/2010 | SIMPLE CYCLE TURBINE | 15.11 | Particulate matter, filterable (FPM) | P | Good combustion practice, Use of Clean Burning Fuel: Natural gas | 6 | LB/H | AVERAGE OF THREE TESTS | BACT-PSD | 0 | | | 0 | | |
| NJ-0077 | HOWARD DOWN STATION | NJ | 75507-BOP090003 | 9/16/2010 | SIMPLE CYCLE (NO WASTE HEAT RECOVERY)(>25 MW) | 15.11 | Particulate matter, filterable < 10 µ (FPM10) | N | USE OF CLEAN BURNING FUELS; NATURAL GAS AS PRIMARY FUEL AND ULTRA LOW SULFUR DISTILLATE OIL WITH 15 PPMSULFUR BY WEIGHT AS BACKUP FUEL | 5 | LB/H | AVERAGE OF THREE TESTS | BACT-PSD | 0 | | | 0 | | |
| NJ-0077 | HOWARD DOWN STATION | NJ | 75507-BOP090003 | 9/16/2010 | SIMPLE CYCLE (NO WASTE HEAT RECOVERY)(>25 MW) | 15.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | USE OF CLEAN BURNING FUELS; NATURAL GAS AS PRIMARY FUEL AND ULTRA LOW SULFUR DISTILLATE OIL WITH 15 PPMSULFUR BY WEIGHT AS BACKUP FUEL | 5 | LB/H | AVERAGE OF THREE TESTS | BACT-PSD | 0 | | | 0 | | |
| TX-0596 | MARSHALL PLANT | TX | PSDTX1183 | 8/20/2010 | Carbon Production | 69.015 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | fabric filter | 0.01 | GR/DSCF | | BACT-PSD | 15.84 | LB/H | 1-H | 0 | | |
| TX-0596 | MARSHALL PLANT | TX | PSDTX1183 | 8/20/2010 | Carbon Production | 69.015 | Particulate matter, filterable < 10 µ (FPM10) | A | fabric filter | 0.01 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| TX-0596 | MARSHALL PLANT | TX | PSDTX1183 | 8/20/2010 | Carbon Production | 69.015 | Particulate matter, filterable (FPM) | A | fabric filter | 0.01 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| TX-0590 | KING POWER STATION | TX | PSDTX1125 | 8/5/2010 | Turbine | 15.21 | Particulate matter, total (TPM) | P | use low ash fuel (natural gas or low sulfur diesel as a backup) and good combustion practices | 11.1 | LB/H | | BACT-PSD | 19.8 | LB/H | | 0 | | |
| TX-0590 | KING POWER STATION | TX | PSDTX1125 | 8/5/2010 | Turbine | 15.21 | Particulate matter, total < 10 µ (TPM10) | P | use of low ash fuel (natural gas or low sulfur diesel as a backup) | 11.1 | LB/H | | BACT-PSD | 19.8 | LB/H | | 0 | | |
| TX-0590 | KING POWER STATION | TX | PSDTX1125 | 8/5/2010 | Turbine | 15.21 | Particulate matter, total < 2.5 µ (TPM2.5) | P | use of low ash fuel (natural gas or low sulfur diesel as a backup) | 11.1 | LB/H | | BACT-PSD | 19.8 | LB/H | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NH-0018 | BERLIN BIOPOWER | NH | TP-0054 | 7/26/2010 | EU01 BOILER #1 | 11.12 | Particulate matter, filterable (FPM) | A | BAGHOUSE | 0.01 | LB/MMBTU | STACK TEST | BACT-PSD | 0 | | | 0 | | |
| NH-0018 | BERLIN BIOPOWER | NH | TP-0054 | 7/26/2010 | EU01 BOILER #1 | 11.12 | Particulate matter, filterable < 10 µ (FPM10) | A | BAGHOUSE | 0.01 | LB/MMBTU | STACK TEST | BACT-PSD | 0 | | | 0 | | |
| NH-0018 | BERLIN BIOPOWER | NH | TP-0054 | 7/26/2010 | EU01 BOILER #1 | 11.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 0.01 | LB/MMBTU | STACK TEST | BACT-PSD | 0 | | | 0 | | |
| NH-0018 | BERLIN BIOPOWER | NH | TP-0054 | 7/26/2010 | EU02 4-CELL WET COOLING TOWER | 12.29 | Particulate matter, fugitive | A | DRIFT ELIMINATORS | 0.0005 | % BY WGT OF FLOW | STACK TEST | BACT-PSD | 0 | | | 0 | | |
| NH-0018 | BERLIN BIOPOWER | NH | TP-0054 | 7/26/2010 | EU03 FIRE PUMP ENGINE | 17.21 | Particulate matter, filterable (FPM) | N | | 0.3 | E-5 LB/MMBTU | STACK TESTING | MACT | 0 | | | 0 | | |
| OH-0335 | AK STEEL CORPORATION | OH | P0105639 | 6/22/2010 | Coke Converyor to Railcar Loadout | 81.39 | Particulate matter, total (TPM) | P | Total enclosure and wet material | 1.86 | LB/H | | BACT-PSD | 1.14 | T/YR | PER ROLLING 12 MONTHS | 0 | | |
| OH-0335 | AK STEEL CORPORATION | OH | P0105639 | 6/22/2010 | Coke Converyor to Railcar Loadout | 81.39 | Particulate matter, total < 10 µ (TPM10) | P | Total enclosure and wet material | 0.88 | LB/H | | BACT-PSD | 0.54 | T/YR | PER ROLLING 12-MO. | 0 | | |
| OH-0335 | AK STEEL CORPORATION | OH | P0105639 | 6/22/2010 | Coke Converyor to Railcar Loadout | 81.39 | Particulate matter, total < 2.5 µ (TPM2.5) | P | Total enclosure and wet material | 0.28 | LB/H | | LAER | 0.17 | T/YR | PER ROLLING 12 MO. | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | CIRCULATING FLUIDIZED BED BOILER CFB1 AND CFB2 | 11.11 | Particulate matter, filterable (FPM) | A | BAGHOUSE | 0.09 | LB/MMBTU | 30 DAY AVERAGE | BACT-PSD | 210 | LB/H | 24 HOUR BLOCK | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | CIRCULATING FLUIDIZED BED BOILER CFB1 AND CFB2 | 11.11 | Particulate matter, filterable < 10 µ (FPM10) | A | BAGHOUSE | 0.09 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | COALING TOWERS | 99.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | BACT FOR PM/PM10/PM2.5 IS 0.0005% DRIFT ELIMINATORS | 0 | | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | ASH HANDLING | 99.12 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTER | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | COAL CRUSHING AND SILO STORAGE | 90.011 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTER | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |

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**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | COAL STOCKPILE | 90.011 | Particulate Matter (PM) | P | WET SUPPRESSION, DUST SUPPRESSENT LOWERING WELL AND COMPACTION. | 10 | OPACITY | 3 MINUTE | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | LIME SILO STORAGES | 90.019 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTERS | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | LIMESTONE UNLOADING | 99.19 | Particulate matter, fugitive | A | WET SUPPRESSION OR DUST SUPPRESSANT | 0 | | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | COALING TOWERS | 99.999 | Particulate matter, filterable < 10 µ (FPM10) | P | 0.0005% DRIFT ELIMINATORS | 0 | | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | ASH HANDLING | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | FABRIC FILTER | 0.005 | G/DSCF | 24 BLOCK | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | HAUL ROADS | 99.14 | Particulate matter, fugitive | A | PAVED ROADWAYS, CLEANING OR PROMPT REMOVAL OF MATERIAL, AND THE APPLICATION OF WET SUPPRESSION, AS APPLICABLE. | 0 | | | BACT-PSD | 0 | | | 0 | | |
| KY-0100 | J.K. SMITH GENERATING STATION | KY | V-05-070 R3 | 4/9/2010 | LIMESTONE STORAGE SILOS | 90.019 | Particulate matter, filterable < 10 µ (FPM10) | A | FABRIC FILTER | 0.005 | GR/DSCF | 24 HR | BACT-PSD | 0.51 | LB/H (EACH) | 24 HR | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | THREE (3) WALKING BEAM REHEAT FURNACES (S-201, S-202, AND S-203) | 81.39 | Particulate Matter (PM) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM. | 0.0075 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | THREE (3) WALKING BEAM REHEAT FURNACES (S-201, S-202, AND S-203) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM10. | 0.0075 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SLAB GRINDERS (S-218 AND S-219) | 99.012 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 FROM EACH SLAB GRINDER SHALL BE CONTROLLED AT ALL TIMES DURING OPERATION BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.9% | 0.0044 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | REVERSING ROUGHING MILL (S-204) | 81.39 | Particulate Matter (PM) | A | EMISSIONS OF PM SHALL BE CONTROLLED BY A WET ESP WITH A MINIMUM CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | REVERSING ROUGHING MILL (S-204) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 SHALL BE CONTROLLED BY A WET ESP WITH A MINIMUM CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ACTIVE HEAT PANEL (S-205) | 19.6 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM2.5. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ACTIVE HEAT PANEL (S-205) | 19.6 | Particulate Matter (PM) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ACTIVE HEAT PANEL (S-205) | 19.6 | Particulate matter, filterable < 10 µ (FPM10) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM10. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ACTIVE HOT BOX (S-207) | 19.6 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM2.5. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | 7-STAND HOT FINISHING MILL (S-206) | 81.39 | Particulate Matter (PM) | A | EMISSIONS OF PM SHALL BE CONTROLLED BY TWO (2) WET ESPS EACH WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | 7-STAND HOT FINISHING MILL (S-206) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 SHALL BE CONTROLLED BY TWO (2) WET ESPS EACH WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | FOUR (4) ANNEALING FURNACES (S-208, S-209, S-210, AND S-211) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM2.5. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ACTIVE HOT BOX (S-207) | 19.6 | Particulate matter, filterable < 10 µ (FPM10) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM10. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | FOUR (4) CAR BOTTOM FURNACES (S-212, S-213, S-214, S-215) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM2.5. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ACTIVE HOT BOX (S-207) | 19.6 | Particulate Matter (PM) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | FOUR (4) ANNEALING FURNACES (S-208, S-209, S-210, AND S-211) | 81.39 | Particulate Matter (PM) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | FOUR (4) ANNEALING FURNACES (S-208, S-209, S-210, AND S-211) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM10. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TORCH CUTTING OPERATION (S-220) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | EMISSIONS OF PM2.5 SHALL BE CONTROLLED BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.9%. THE PERMITTEE SHALL ALSO EMPLOY | 0.0074 | LB/MMBTU | | BACT-PSD | 0.067 | LB/TON METAL | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | THREE (3) WALKING BEAM REHEAT FURNACES (S-201, S-202, AND S-203) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM2.5. | 0.0075 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | FOUR (4) CAR BOTTOM FURNACES (S-212, S-213, S-214, S-215) | 81.39 | Particulate Matter (PM) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | FOUR (4) CAR BOTTOM FURNACES (S-212, S-213, S-214, S-215) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM10. | 0.0074 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SOAKING PITS (S-216 AND S-217) | 81.39 | Particulate Matter (PM) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM. | 0.0076 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SOAKING PITS (S-216 AND S-217) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM10. | 0.0076 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SOAKING PITS (S-216 AND S-217) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | THE PERMITTEE SHALL EMPLOY EFFECTIVE COMBUSTION AND OPERATIONAL CONTROL PRACTICES TO MINIMIZE EMISSIONS OF PM2.5. | 0.0076 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SLAB GRINDERS (S-218 AND S-219) | 99.012 | Particulate Matter (PM) | A | EMISSIONS OF PM FROM EACH SLAB GRINDER SHALL BE CONTROLLED AT ALL TIMES DURING OPERATION BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF | 0.0044 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TWO (2) SLAB GRINDERS (S-218 AND S-219) | 99.012 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 FROM EACH SLAB GRINDER SHALL BE CONTROLLED AT ALL TIMES DURING OPERATION BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL | 0.0044 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | PLASMA TORCH CUTTING OPERATION (S-222) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 FROM THE PLASMA TORCH CUTTING OPERATION SHALL BE CONTROLLED BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF | 0.01 | LB/H | | BACT-PSD | 0.04 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ABRASIVE SAW (S-221) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 FROM THE ABRASIVE SAW SHALL BE CONTROLLED BY A ROTOCLONE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99%. | 0.16 | LB/H | | BACT-PSD | 0.7 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TORCH CUTTING OPERATION (S-220) | 81.39 | Particulate Matter (PM) | B | EMISSIONS OF PM SHALL BE CONTROLLED BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.9%. THE PERMITTEE SHALL ALSO EMPLOY | 0.0074 | LB/MMBTU | | BACT-PSD | 0.067 | LB/TON METAL | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | TORCH CUTTING OPERATION (S-220) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | B | EMISSIONS OF PM10 SHALL BE CONTROLLED BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.9%. THE PERMITTEE SHALL ALSO EMPLOY | 0.0074 | LB/MMBTU | | BACT-PSD | 0.067 | LB/TON METAL | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ABRASIVE SAW (S-221) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 FROM THE ABRASIVE SAW SHALL BE CONTROLLED BY A ROTOCLONE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99%. | 0.16 | LB/H | | BACT-PSD | 0.7 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | ABRASIVE SAW (S-221) | 81.39 | Particulate Matter (PM) | A | EMISSIONS OF PM FROM THE ABRASIVE SAW SHALL BE CONTROLLED BY A ROTOCLONE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99%. | 0.16 | LB/H | | BACT-PSD | 0.7 | T/YR | | 0 | | |

**PolyMet Mining, Inc.**
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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | EMERGENCY GENERATOR #1 (EG-01) | 17.1 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 2.66 | LB/H | | BACT-PSD | 0.27 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | PLASMA TORCH CUTTING OPERATION (S-222) | 81.39 | Particulate Matter (PM) | A | EMISSIONS OF PM FROM THE PLASMA TORCH CUTTING OPERATION SHALL BE CONTROLLED BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF | 0.01 | LB/H | | BACT-PSD | 0.04 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | PLASMA TORCH CUTTING OPERATION (S-222) | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | A | EMISSIONS OF PM10 FROM THE PLASMA TORCH CUTTING OPERATION SHALL BE CONTROLLED BY A BAGHOUSE WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF | 0.01 | LB/H | | BACT-PSD | 0.04 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | REVERSING ROUGHING MILL (S-204) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 SHALL BE CONTROLLED BY A WET ESP WITH A MINIMUM CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | EMERGENCY GENERATOR #1 (EG-01) | 17.1 | Particulate Matter (PM) | N | | 0.54 | G/KW-H | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | EMERGENCY GENERATOR #1 (EG-01) | 17.1 | Particulate matter, filterable < 10 µ (FPM10) | N | | 2.66 | LB/H | | BACT-PSD | 0.27 | T/YR | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | 7-STAND HOT FINISHING MILL (S-206) | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | EMISSIONS OF PM2.5 SHALL BE CONTROLLED BY TWO (2) WET ESPS EACH WITH A MINIMUM OVERALL CONTROL EFFICIENCY OF 99.5%. | 13 | MG/CUBIC METER | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | EMERGENCY GENERATOR #2 (EG-02) | 17.1 | Particulate Matter (PM) | N | | 0.2 | G/KW-H | | BACT-PSD | 0 | | | 0 | | |
| PA-0274 | ALLEGHENY LUDLUM CORPORATION - BRACKENRIDGE FACILITY | PA | 0059-I008 | 2/16/2010 | EMERGENCY GENERATOR #2 (EG-02) | 17.1 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.44 | LB/H | | BACT-PSD | 0.04 | T/YR | | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Charging, Coke Oven Batteries (3) with heat recovery | 81.115 | Particulate matter, fugitive | A | traveling hood | 1.35 | LB/H | | LAER | 1.23 | T/YR | PER A ROLLING 12 MONTH SUMMATION | 0.027 | LB/T | PER TON OF COAL CHARGED (AP-42 FACTOR) |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Charging, Coke Oven Batteries (3) with heat recovery | 81.115 | Particulate matter, filterable (FPM) | A | Baghouse with traveling hood | 3.7 | LB/H | | BACT-PSD | 3.4 | T/YR | PER A ROLLING 12 MONTH SUMMATION | 0.0081 | LB/T | PER TON OF DRY COAL CHARGED |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Charging, Coke Oven Batteries (3) with heat recovery | 81.115 | Particulate matter, filterable < 10 µ (FPM10) | A | Baghouse with traveling hood | 3.7 | LB/H | | BACT-PSD | 3.4 | T/YR | PER A ROLLING 12 MONTH SUMMATION | 0.0081 | LB/T | PER TON OF DRY COAL CHARGED |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Storage Piles, coal and coke | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 1.29 | T/YR | FROM WIND EROSION AND LOAD-IN/OUT | LAER | 0 | | | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3) without heat recovery | 81.112 | Particulate matter, filterable (FPM) | N | Bypass one HRSG at a time, one stack | 21 | LB/H | | BACT-PSD | 10.1 | T/YR | PER ROLLING 12-MONTHS FOR HRSG BYPASS | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3) without heat recovery | 81.112 | Particulate matter, filterable < 10 µ (FPM10) | N | Bypass one HRSG at a time, one stack | 21 | LB/H | | BACT-PSD | 10 | T/YR | PER ROLLING 12-MONTHS FOR HRSG BYPASS | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke crushing and sceening | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | Baghouse | 3.43 | LB/H | | LAER | 15.55 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | 0.008 | GR/DSCF | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3), bypass lime spray dryer/baghouse for maintenance | 81.19 | Particulate matter, filterable (FPM) | N | Bypass of control | 105 | LB/H | FROM BYPASS TO SPRAY DRYER/BAGHOUSE | BACT-PSD | 6.3 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.049 | GR/DSCF | FROM BYPASS TO SPRAY DRYER/BAGHOUSE |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3), bypass lime spray dryer/baghouse for maintenance | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | N | Bypass control | 105 | LB/H | FROM BYPASS TO SPRAY DRYER/BAGHOUSE | BACT-PSD | 6.3 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.049 | GR/DSCF | FROM BYPASS TO SPRAY DRYER/BAGHOUSE |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Charging, Coke Oven Batteries (3) with heat recovery | 81.115 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | Baghouse with traveling hood | 3.7 | LB/H | | LAER | 3.4 | T/YR | PER A ROLLING 12 MONTH SUMMATION | 0.0081 | LB/T | PER TON OF DRY COAL CHARGED |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3) with heat recovery | 81.112 | Particulate matter, filterable (FPM) | A | Spray dryer/baghouse system | 10.7 | LB/H | | BACT-PSD | 46.9 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.005 | GR/DSCF | EMISSION FACTOR FROM STACK TEST* |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3) with heat recovery | 81.112 | Particulate matter, filterable < 10 µ (FPM10) | A | Spray dryer/baghouse system | 10.7 | LB/H | | BACT-PSD | 46.9 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.005 | GR/DSCF | EMISSION FACTOR FROM STACK TEST* |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coal handling, processing, and transfer | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | Enclosure and wet suppression | 4.6 | LB/H | SUMMATION OF ALL COAL HANDLING PROCESSE | LAER | 0.52 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Pushing, Coke Battery with heat recovery-3 | 81.111 | Particulate matter, filterable (FPM) | A | Multiclone dust collector | 14.3 | LB/H | | BACT-PSD | 13.09 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.04 | LB/T | PER TON OF COKE PUSHED |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Pushing, Coke Battery with heat recovery-3 | 81.111 | Particulate matter, filterable < 10 µ (FPM10) | A | Multiclone dust collector | 14.3 | LB/H | | BACT-PSD | 13.09 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.04 | LB/T | PER TON OF COKE PUSHED |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3) with heat recovery | 81.112 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | Spray dryer/baghouse system | 10.7 | LB/H | | LAER | 46.9 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.005 | GR/DSCF | EMISSION FACTOR FROM STACK TEST* |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Quench Tower | 81.19 | Particulate matter, filterable (FPM) | P | Interior baffle system with baffle plates which allow no more than 5% of the cross sectional area of the tower to be uncovered or open to the sky. | 60 | LB/H | | BACT-PSD | 54.75 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 1100 | MG/L | PER LITER OF WATER* |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Quench Tower | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | Interior baffle system with baffle plates which allow no more than 5% of the cross sectional area of the tower to be uncovered or open to the sky. | 22 | LB/H | | BACT-PSD | 20.08 | T/YR | PER A ROLLING 12-MONTH SUMMATION | 1100 | MG/L | PER LITER OF WATER* |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Quench Tower | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | Interior baffle system with baffle plates which allow no more than 5% of the cross sectional area of the tower to be uncovered or open to the sky. | 13.5 | LB/H | | LAER | 12.32 | T/YR | PER A ROLLING 12-MONTH SUMMATION | 1100 | MG/L | PER LITER OF WATER* |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke and breeze handling and processing | 81.19 | Particulate matter, filterable (FPM) | P | Partially enclosed bunker and coke transfer points; breeze silo | 18.6 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | BACT-PSD | 0.0008 | LB/T | EMISSION FACTOR FROM AP-42 SECTION13.2.4 | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke and breeze handling and processing | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | Partially enclosed bunker and coke transfer points; breeze silo | 16.71 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | BACT-PSD | 0 | | | 0.0008 | LB/T | EMISSION FACTOR FROM AP-42 SECTION13.2.4 |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Pushing, Coke Battery with heat recovery-3 | 81.111 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | Multiclone dust collector | 14.3 | LB/H | | LAER | 13.09 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.04 | LB/T | PER TON OF COKE PUSHED |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke crushing and sceening | 81.19 | Particulate matter, filterable (FPM) | A | Baghouse | 3.43 | LB/H | BAGHOUSE STACK | BACT-PSD | 18.6 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | 0.008 | GR/DSCF | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke crushing and sceening | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | A | Baghouse | 3.43 | LB/H | FROM BAGHOUSE STACK | BACT-PSD | 16.71 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | 0.008 | GR/DSCF | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke and breeze handling and processing | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | Partially enclosed bunker and coke transfer points; breeze silo | 15.55 | T/YR | PER A ROLLING 12 MO. FUGITIVE + STACK | LAER | 0.0008 | LB/T | EMISSION FACTOR FROM AP-42 SECTION13.2.4 | 0.0008 | LB/T | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coal handling, processing, and transfer | 81.19 | Particulate matter, filterable (FPM) | P | Enclosure and wet suppression | 4.6 | LB/H | SUMMATION OF ALL COAL HANDLING PROCESSE | BACT-PSD | 3.47 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coal handling, processing, and transfer | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | Enclosure and wet suppression | 4.6 | LB/H | SUMMATION OF ALL COAL HANDLING PROCESSE | BACT-PSD | 1.67 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3) without heat recovery | 81.112 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | Bypass one HRSG at a time, one stack | 21 | LB/H | FOR BYPASS | LAER | 10.1 | T/YR | PER ROLLING 12 MONTHS FOR HRSG BYPASS | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Storage Piles, coal and coke | 81.19 | Particulate matter, filterable (FPM) | N | | 7.51 | T/YR | FROM WIND EROSION AND LOAD-IN/OUT | BACT-PSD | 0 | | | 0 | | |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Storage Piles, coal and coke | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | N | | 3.64 | T/YR | FROM WIND EROSION AND LOAD-IN/OUT | BACT-PSD | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Coke Oven Batteries (3), bypass lime spray dryer/baghouse for maintenance | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | Bypass control | 105 | LB/H | FROM BYPASS TO SPRAY DRYER/BAGHOUSE | LAER | 6.3 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.049 | GR/DSCF | FROM BYPASS TO SPRAY DRYER/BAGHOUSE |
| OH-0332 | MIDDLETOWN COKE COMPANY | OH | P0104768 | 2/9/2010 | Roadways and Parking areas | 99.14 | Particulate matter, fugitive | P | Control measures (watering etc.) when necessary | 1.08 | T/YR | PM, AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 0.21 | T/YR | PM10, AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - THERMAL OXIDIZER | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 1.49 | LB/H | | BACT-PSD | 0.026 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT TANK FARM FLARE - A5 | 19.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 0.016 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - THERMAL OXIDIZER | 64.999 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 1.49 | LB/H | | BACT-PSD | 0.026 | G/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER A | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT FLARE A1 | 19.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 0.07 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER A | 64.999 | Particulate Matter (PM) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER B | 64.999 | Particulate Matter (PM) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER B | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT FLARE A2 | 19.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 0.07 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER C | 64.999 | Particulate Matter (PM) | A | PACKED BED SCRUBBER | 0.55 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER C | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | PACKED BED SCRUBBER | 0.55 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW HCN PRODUCTION UNIT - FLARE HCNA - 2 | 19.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 0.11 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER D | 64.999 | Particulate Matter (PM) | A | PACKED BED SCRUBBER | 0.55 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER D | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | PACKED BED SCRUBBER | 0.55 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | AMSUL PRODUCTION UNIT - DUST SCRUBBER A10 | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | WET SCRUBBER | 0.24 | LB/H | | BACT-PSD | 0.0145 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER E | 64.999 | Particulate Matter (PM) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER E | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW HCN PRODUCTION UNIT - THERMAL OXIDIZER / WASTE HEAT BOILER | 12.3 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 0.36 | LB/H | | BACT-PSD | 0.0544 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | EXISTING HCN PRODUCTION UNIT - WASTE HEAT BOILER | 12.3 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 1.58 | LB/H | | BACT-PSD | 0.005 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | EXISTING HCN PRODUCTION UNIT - WASTE HEAT BOILER | 12.3 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 1.58 | LB/H | | BACT-PSD | 0.005 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW AMSUL PRODUCTION UNIT DUST SCRUBBER | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | WET SCRUBBER | 0.36 | LB/H | | BACT-PSD | 0.0544 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT FLARE A1 | 19.31 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 0.07 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER A | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT FLARE A1 | 19.31 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 0.07 | LB/H | | BACT-PSD | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT FLARE A2 | 19.31 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 0.07 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT FLARE A2 | 19.31 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 0.07 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER B | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT TANK FARM FLARE - A5 | 19.31 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 0.016 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | HCN PRODUCTION UNIT TANK FARM FLARE - A5 | 19.31 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 0.016 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER E | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | PACKED BED SCRUBBER | 0.37 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | AMSUL PRODUCTION UNIT - DUST SCRUBBER A10 | 64.999 | Particulate Matter (PM) | A | WET SCRUBBER | 0.24 | LB/H | | BACT-PSD | 0.0145 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | AMSUL PRODUCTION UNIT - DUST SCRUBBER A10 | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | WET SCRUBBER | 0.24 | LB/H | | BACT-PSD | 0.0145 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER C | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | PACKED BED SCRUBBER | 0.55 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ACROLEIN PRODUCTION UNIT - THERMAL OXIDIZER | 64.999 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 0.833 | LB/H | | BACT-PSD | 0.003 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ACROLEIN PRODUCTION UNIT - THERMAL OXIDIZER | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 0.833 | LB/H | | BACT-PSD | 0.003 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - CEILCOTE SCRUBBER D | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | PACKED BED SCRUBBER | 0.55 | LB/H | | BACT-PSD | 0.0023 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW HCN PRODUCTION UNIT - THERMAL OXIDIZER / WASTE HEAT BOILER | 12.3 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 0.36 | LB/H | | BACT-PSD | 0.0544 | GR/DSCF | | 0 | | |

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| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ACROLEIN PRODUCTION UNIT - THERMAL OXIDIZER | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 0.833 | LB/H | | BACT-PSD | 0.003 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW HCN PRODUCTION UNIT - THERMAL OXIDIZER / WASTE HEAT BOILER | 12.3 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 0.36 | LB/H | | BACT-PSD | 0.0544 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW HCN PRODUCTION UNIT - FLARE HCNA - 2 | 19.31 | Particulate Matter (PM) | N | GOOD COMBUSTION PRACTICES | 0.11 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW HCN PRODUCTION UNIT - FLARE HCNA - 2 | 19.31 | Particulate matter, filterable < 10 µ (FPM10) | N | GOOD COMBUSTION PRACTICES | 0.11 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | METHIONINE PRODUCTION UNIT - THERMAL OXIDIZER | 64.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 1.49 | LB/H | | BACT-PSD | 0.026 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW AMSUL PRODUCTION UNIT DUST SCRUBBER | 64.999 | Particulate Matter (PM) | A | WET SCRUBBER | 0.36 | LB/H | | BACT-PSD | 0.0544 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | ANDRUSSOW AMSUL PRODUCTION UNIT DUST SCRUBBER | 64.999 | Particulate matter, filterable < 10 µ (FPM10) | A | WET SCRUBBER | 0.36 | LB/H | | BACT-PSD | 0.0544 | GR/DSCF | | 0 | | |
| AL-0249 | EVONIK DEGUSSA CORPORATION | AL | X001, X008, X043, X125 | 1/7/2010 | EXISTING HCN PRODUCTION UNIT - WASTE HEAT BOILER | 12.3 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | GOOD COMBUSTION PRACTICES | 1.58 | LB/H | | BACT-PSD | 0.005 | GR/DSCF | | 0 | | |
| MN-0078 | SAPPI CLOQUET LLC | MN | 01700002-011 | 10/28/2009 | COOLING TOWER | 99.009 | Particulate matter, total < 2.5 µ (TPM2.5) | A | DRIFT ELIMINATORS | 0.01 | LB/H | | BACT-PSD | 0.02 | PERCENT | DRIFT RATE (MAXIMUM) | 0 | | |
| MN-0078 | SAPPI CLOQUET LLC | MN | 01700002-011 | 10/28/2009 | PAPER MACHINE | 30.241 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 1.82 | LB/H | 3 HR AVERAGE, FOR PAPER PRODUCTI | BACT-PSD | 0.96 | LB/H | 3 HR AVERAGE, FOR FUEL COMBUSTION | 0 | | |
| MN-0078 | SAPPI CLOQUET LLC | MN | 01700002-011 | 10/28/2009 | BOILER | 11.31 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 2.5 | LB/H | 3 HOUR AVERAGE | BACT-PSD | 0 | | | 0 | | |
| MN-0078 | SAPPI CLOQUET LLC | MN | 01700002-011 | 10/28/2009 | BOILER | 11.12 | Particulate matter, total < 2.5 µ (TPM2.5) | A | EXISTING MULTICLONE/ESP COMBINATION | 13.5 | LB/H | 3 HOUR AVERAGE | BACT-PSD | 0 | | | 0 | | |
| MN-0078 | SAPPI CLOQUET LLC | MN | 01700002-011 | 10/28/2009 | BOILER | 11.12 | Particulate matter, total < 2.5 µ (TPM2.5) | A | EXISTING MULTICLONE/ESP COMBINATION | 13.5 | LB/H | 3 HOUR AVERAGE | BACT-PSD | 0 | | | 0 | | |

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| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NJ-0075 | BAYONNE ENERGY CENTER | NJ | 12863- BOP080001 | 9/24/2009 | COMBUSTION TURBINES, SIMPLE CYCLE , ROLLS ROYCE, 8 | 15.11 | Particulate matter, filterable < 10 µ (FPM10) | P | BURNING CLEAN FUELS, NATURAL GAS AND ULTRA LOW SULFUR DISTILLATE OIL WITH SULFUR CONTENT OF 15 PPM. | 5 | LB/H | | OTHER CASE-BY-CASE | 0 | | | 0 | | |
| NJ-0075 | BAYONNE ENERGY CENTER | NJ | 12863- BOP080001 | 9/24/2009 | COMBUSTION TURBINES, SIMPLE CYCLE , ROLLS ROYCE, 8 | 15.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | BURNING CLEAN FUELS, NATURAL GAS AND ULTRA LOW SULFUR DISTILLATE OIL WITH SULFUR CONTENT OF 15 PPM. | 5 | LB/H | | OTHER CASE-BY-CASE | 0 | | | 0 | | |
| NJ-0074 | WEST DEPTFORD ENERGY | NJ | 56078-BOP080001 | 5/6/2009 | TURBINE, COMBINED CYCLE | 15.2 | Particulate matter, filterable < 10 µ (FPM10) | N | CLEAN FUELS - NATURAL GAS AND ULTRA LOW SULFUR (15PPM SULFUR) DISTILLATE OIL | 18.66 | LB/H | | Other Case-by-Case | 0 | | | 0 | | |
| NJ-0074 | WEST DEPTFORD ENERGY | NJ | 56078-BOP080001 | 5/6/2009 | TURBINE, COMBINED CYCLE | 15.2 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | USE OF CLEAN FUELS, NATURAL GAS AND ULTRA LOW SULFUR DISTILLATE OIL | 18.66 | LB/H | | Other Case-by-Case | 0 | | | 0 | | |
| MA-0036 | BRAYTON POINT STATION | MA | 052-120-MA14 | 4/12/2009 | NATURAL DRAFT COOLING TOWERS (2) | 11.11 | Particulate matter, filterable < 10 µ (FPM10) | A | DRIFT ELIMINATORS | 1066 | LB/H | 24 HOURS | BACT-PSD | 0 | | | 0 | | |
| MA-0036 | BRAYTON POINT STATION | MA | 052-120-MA14 | 4/12/2009 | NATURAL DRAFT COOLING TOWERS (2) | 11.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | DRIFT ELIMINATORS | 1066 | LB/H | 24 HOURS | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | CRUDE HEATER | 12.3 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMBUSTION PRACITICES, USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | CLAUS SRU TGTU | 50.006 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | PROPER EQUIPMENT DESIGN AND OPERATION, GOOD COMBUSTION PRACTICES, AND BURNING OF GASEOUS FUELS | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | VACUUM HEATER | 13.3 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMBUSTION PRACTICES/USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | ATS PLANT | 50.006 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | PROPER EQUIPMENT DESIGN AND OPERATION, GOOD COMBUSTION PRACTICES, AND BURNING OF GASEOUS FUELS | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | COOLING WATER TOWER | 99.009 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | HIGH EFFICIENCY DRIFT ELIMINATOR | 0.0005 | % | TOTAL LIQUID DRIFT | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | NO. 1 H2 HEATER | 11.3 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMBUSTION PRACTICES/USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | NO. 2 H2 HEATER | 12.3 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMBUSTION PRACTICES/USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | CRUDE HEATER | 12.3 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | GOOD COMBUSTION PRACTICES, USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | CLAUS SRU TGTU | 50.006 | Particulate matter, filterable < 10 µ (FPM10) | P | PROPER EQUIPMENT DESIGN AND OPERATION, GOOD COMBUSTION PRACTICES, AND BURNING OF GASEOUS FUELS | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | VACUUM HEATER | 13.3 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | GOOD COMBUSTION PRACTICES/USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | ATS PLANT | 50.006 | Particulate matter, filterable < 10 µ (FPM10) | P | PROPER EQUIPMENT DESIGN AND OPERATION, GOOD COMBUSTION PRACTICES, AND BURNING OF GASEOUS FUELS | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | NO. 1 H2 HEATER | 11.3 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | GOOD COMBUSTION PRACTICES/USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | COOLING WATER TOWER | 99.009 | Particulate matter, filterable < 10 µ (FPM10) | A | HIGH EFFICIENCY DRIFT ELIMINATOR | 0.0005 | % | TOTAL LIQUID DRIFT | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | NO. 2 H2 HEATER | 12.3 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | GOOD COMBUSTION PRACTICES/USE OF CLEAN BURNING FUELS | 0.0075 | LB/MMBTU | PER ROLLING 12-MONTH TIME PERIOD | BACT-PSD | 0 | | | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | WWTF THERMAL OXIDIZER | 19.2 | Particulate matter, filterable < 10 µ (FPM10) | P | PROPER EQUIPMENT DESIGN, GOOD COMBUSTION PRACTICES, OPTIMIZED FUEL-TO-AIR RATIO | 0.011 | LB/H | | BACT-PSD | 10 | % | OPACITY | 0 | | |
| MT-0030 | BILLINGS REFINERY | MT | 2619-24 | 11/19/2008 | WWTF THERMAL OXIDIZER | 19.2 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | PROPER EQUIPMENT DESIGN, GOOD COMBUSTION PRACTICES, OPTIMIZED FUEL-TO-AIR RATIO | 0.011 | LB/H | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | COMBUSTION TURBINES (2) | 15.11 | Particulate Matter (PM) | N | | 0.012 | LB/MMBTU @ 15% O2 | 3-HR AVERAGE | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | COMBUSTION TURBINES (2) | 15.11 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.012 | LB/MMBTU @ 15% O2 | 3-HR AVERAGE | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | COOLING TOWER | 99.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0 | | SEE NOTE | LAER | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | BOILER | 13.31 | Particulate Matter (PM) | N | | 0.005 | LB/MMBTU | 3-HR AVERAGE | BACT-PSD | 0 | | | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | BOILER | 13.31 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.005 | LB/MMBTU | 3-HR AVERAGE | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | BOILER | 13.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.005 | LB/MMBTU | 3-HR AVERAGE | LAER | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | INTERNAL COMBUSTION ENGINE - EMERGENCY FIRE WATER PUMP | 17.21 | Particulate Matter (PM) | N | | 0.15 | G/HP-H | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | INTERNAL COMBUSTION ENGINE - EMERGENCY FIRE WATER PUMP | 17.21 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.15 | GR-HP-H | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | HEATER | 13.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.007 | LB/MMBTU | | LAER | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | INTERNAL COMBUSTION ENGINE - EMERGENCY GENERATOR | 17.21 | Particulate Matter (PM) | N | | 0.15 | G/HP-H | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | INTERNAL COMBUSTION ENGINE - EMERGENCY GENERATOR | 17.21 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.15 | G/HP-H | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | COMBUSTION TURBINES (2) | 15.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.012 | LB/MMBTU @ 15% O2 | 3-HR AVERAGE | LAER | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | HEATER | 13.31 | Particulate Matter (PM) | N | | 0.007 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | HEATER | 13.31 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.007 | LB/MMBTU | | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | INTERNAL COMBUSTION ENGINE - EMERGENCY FIRE WATER PUMP | 17.21 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.15 | G/HP-H | | LAER | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | COOLING TOWER | 99.999 | Particulate Matter (PM) | N | | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | COOLING TOWER | 99.999 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MD-0040 | CPV ST CHARLES | MD | CPCN CASE NO. 9129 | 11/12/2008 | INTERNAL COMBUSTION ENGINE - EMERGENCY GENERATOR | 17.21 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.15 | G/HP-H | | LAER | 0 | | | 0 | | |
| VA-0311 | VIRGINIA CITY HYBRID ENERGY CENTER | VA | 11526 | 6/30/2008 | 2 CIRCULATING FLUIDIZED BED BOILERS | 11.11 | Particulate matter, filterable (FPM) | P | GOOD COMBUSTIONS PRACTICES AND BAGHOUSE | 0.01 | LB/MMBTU | 3 HOURS | BACT-PSD | 0.009 | LB/MMBTU | 30 DAY ROLLING AVERAGE | 0.009 | LB/MMBTU | 30 DAY ROLLING AVERAGE |
| VA-0311 | VIRGINIA CITY HYBRID ENERGY CENTER | VA | 11526 | 6/30/2008 | 2 CIRCULATING FLUIDIZED BED BOILERS | 11.11 | Particulate matter, total < 10 µ (TPM10) | P | GOOD COMBUSTION PRACTICES AND BAGHOUSE | 0.012 | LB/MMBTU | 3 HOURS | BACT-PSD | 0.012 | LB/MMBTU | 3 HOURS | 0 | | |
| VA-0311 | VIRGINIA CITY HYBRID ENERGY CENTER | VA | 11526 | 6/30/2008 | 2 CIRCULATING FLUIDIZED BED BOILERS | 11.11 | Particulate matter, total < 2.5 µ (TPM2.5) | P | GOOD COMBUSTION PRACTICES AND BAGHOUSE | 0.012 | LB/MMBTU | 3 HOURS | BACT-PSD | 0.012 | LB/MMBTU | 3 HOURS | 0 | | |
| VA-0311 | VIRGINIA CITY HYBRID ENERGY CENTER | VA | 11526 | 6/30/2008 | AUXILIARY BOILER | 12.9 | Particulate matter, total < 10 µ (TPM10) | N | | 0.024 | LB/MMBTU | | BACT-PSD | 0.024 | LB/MMBTU | | 0 | | |
| VA-0311 | VIRGINIA CITY HYBRID ENERGY CENTER | VA | 11526 | 6/30/2008 | AUXILIARY BOILER | 12.9 | Particulate matter, total < 2.5 µ (TPM2.5) | N | | 0.024 | LB/MMBTU | | BACT-PSD | 0.024 | LB/MMBTU | | 0 | | |
| MI-0386 | RIPLEY HEATING PLANT | MI | 60-07 | 5/12/2008 | CFB BOILER | 12.19 | Particulate matter, filterable (FPM) | A | FABRIC FILTER | 0.025 | LB/MMBTU | STACK TEST/COMS | Other Case-by-Case | 0.1 | LB/MMBTU | | 0 | | |
| MI-0386 | RIPLEY HEATING PLANT | MI | 60-07 | 5/12/2008 | CFB BOILER | 12.19 | Particulate matter, filterable < 10 µ (FPM10) | A | CYCLONE PLUS FABRIC FILTER | 0.03 | LB/MMBTU | STACK TEST/COMS | BACT-PSD | 26.9 | T/YR | 12-MONTH ROLLING TIME PERIOD | 0 | | |
| MI-0386 | RIPLEY HEATING PLANT | MI | 60-07 | 5/12/2008 | CFB BOILER | 12.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | CYCLONE PLUS FABRIC FILTER | 0.03 | LB/MMBTU | STACK TEST/COMS | BACT-PSD | 26.9 | T/YR | 12-MONTH ROLLING TIME PERIOD | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | PICKLE GALVANIZING LINE (2) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 0.99 | LB/H | FROM SHARED STACK | BACT-PSD | 4.34 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | TUNDISH PREHEATER (8) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 0.0017 | LB/H | | LAER | 0.007 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | VACUUM OXYGENT DEGASSER (4) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | USE OF NATURAL GAS | 0.12 | LB/H | FROM FLARE CONTROL 4 VOD | LAER | 0.53 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | PUSH-PULL CONTINUOUS PICKLE LINE (1) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 0.99 | LB/H | | BACT-PSD | 4.34 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |

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| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | VACUUM DEGAS BOILERS (2) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | USE OF NATURAL GAS | 0.39 | LB/H | | LAER | 1.71 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | DIRECT REDUCED IRON MATERIAL HANDLING | 99.12 | Particulate Matter (PM) | B | BUILDING ENCLOSURE, ENCLOSURES, BAGHOUSE | 0.47 | LB/H | | BACT-PSD | 2.06 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ANNEALING FURNACE TO PICKLE GALVANIZING LINE (2) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | USE OF NATURAL GAS | 0.45 | LB/H | FOR EACH ANNEALING FURNACE | LAER | 1.97 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | DIRECT REDUCED IRON MATERIAL HANDLING | 99.12 | Particulate matter, fugitive | N | | 1.43 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | LAER | 0.56 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONTINUOUS CASTERS AND SLAG POT DUMPING (2) | 81.23 | Particulate Matter (PM) | A | BAGHOUSE | 1.4 | LB/H | | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | DIRECT REDUCED IRON MATERIAL HANDLING | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | BUILDING ENCLOSURE, ENCLOSURES, BAGHOUSE | 0.47 | LB/H | | LAER | 2.05 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | VACUUM OXYGENT DEGASSER (4) | 81.29 | Particulate Matter (PM) | P | USE OF NATURAL GAS | 0.12 | LB/H | FROM FLARE CONTROL 4 VOD | BACT-PSD | 0.53 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | SCRAP, COAL, IRON ORE BARGE UNLOADING | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | USE OF ENCLOSURES, MINIMIZING DROP HEIGHT, AND VENTING TRANSFER POINTS TO A BAGHOUSE | 0.93 | LB/H | | LAER | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | FOR BAGHOUSE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL AND IRON ORE UNLOADING & CONVEYING TO STORAGE (3) | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | USE OF ENCLOSURES AND A BAGHOUSE | 0.93 | LB/H | FOR EACH OF 3 SOURCES | LAER | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0.0022 | GR/DSCF | FOR BAGHOUSE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | PAVED ROADWAYS AND PARKING AREAS | 99.14 | Particulate Matter (PM) | P | CONTROL MEASURES INCLUDE APPLICATION OF WET SUPPRESSANTS, WATERING, SPEED REDUCTION, AND VACUUMING OR SWEEPING. | 153.4 | T/YR | FUGITIVE DUST | BACT-PSD | 0 | | | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | SCRAP, COAL, IRON ORE BARGE UNLOADING | 99.12 | Particulate matter, total (TPM) | B | USE OF ENCLOSURES, MINIMIZING DROP HEIGHT, AND VENTING TRANSFER POINTS TO A BAGHOUSE | 0.93 | LB/H | | BACT-PSD | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | FOR BAGHOUSE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | PICKLE GALVANIZING LINE (2) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 0.99 | LB/H | FROM SHARED STACK | LAER | 4.34 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | SCRAP, COAL, IRON ORE BARGE UNLOADING | 99.12 | Particulate matter, fugitive | N | | 6.15 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | BACT-PSD | 2.84 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | |

**PolyMet Mining, Inc.**
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Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | PUSH-PULL CONTINUOUS PICKLE LINE (1) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 0.99 | LB/H | | LAER | 4.34 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL AND IRON ORE UNLOADING & CONVEYING TO STORAGE (3) | 99.12 | Particulate Matter (PM) | B | USE OF ENCLOSURES AND A BAGHOUSE | 0.93 | LB/H | FOR EACH OF 3 SOURCES | BACT-PSD | 4.07 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | 0.0022 | GR/DSCF | FOR BAGHOUSE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL AND IRON ORE UNLOADING & CONVEYING TO STORAGE (3) | 99.12 | Particulate matter, fugitive | N | | 2.4 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | BACT-PSD | 0.99 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ALLOY, FLUX, CARBON, LIMESTONE, COKE HANDLING (2) | 99.12 | Particulate matter, fugitive | N | | 5.79 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | BACT-PSD | 2.1 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ALLOY, FLUX, CARBON, LIMESTONE, COKE HANDLING (2) | 99.12 | Particulate Matter (PM) | B | USE OF ENCLOSURES AND A BAGHOUSE | 1.4 | LB/H | FROM BAGHOUSE STACKS | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM | 0.0022 | GR/DSCF | FOR BAGHOUSE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | IRON ORE GRINDING (6) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE W/ 2 CYCLONES | 1.04 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | LAER | 4.56 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | TUNDISH PREHEATER (8) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 0.0017 | LB/H | | BACT-PSD | 0.007 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONTINUOUS CASTERS AND SLAG POT DUMPING (2) | 81.23 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 1.4 | LB/H | | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ALLOY, FLUX, CARBON, LIMESTONE, COKE HANDLING (2) | 99.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | USE OF ENCLOSURES AND A BAGHOUSE | 1.4 | LB/H | FROM BAGHOUSE STACKS | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION FOR PM10 | 0.0022 | GR/DSCF | FROM BAGHOUSE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ELECTRIC ARC FURNACE (2) | 81.21 | Particulate Matter (PM) | A | BAGHOUSE AND DIRECT EVACUATION CONTROL W/ 100% CAPTURE EFFICIENCY | 0.0014 | GR/DSCF | EACH BAGHOUSE (2) TO EAF AND LMF | BACT-PSD | 0 | | | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL GRINDING (6) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ACID REGENERATION PLANT (2) | 81.29 | Particulate Matter (PM) | P | USE OF NATURAL GAS | 2.62 | LB/H | FOR EACH OF 2 ACID REGENERATION PLANTS | BACT-PSD | 11.48 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | TUNNEL FURNACE (2) | 81.29 | Particulate Matter (PM) | P | USE OF NATURAL GAS | 1.43 | LB/H | FOR EACH OF 2 TUNNEL FURNACES | BACT-PSD | 6.26 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONVEYORS, HOPPERS, SCREENS TO ROTARY HEARTH FURNACE | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH BAGHOUSE | LAER | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | WASTE HEAT BOILERS (6) | 13.11 | Particulate Matter (PM) | A | LIME SPRAY DRYER AND BAGHOUSE | 0.0024 | GR/DSCF | FILTERABLE PM | BACT-PSD | 0.025 | LB/MMBTU | OR CHOICE OF TSM LIMIT BELOW | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | TUNNEL FURNACE (2) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | USE OF NATURAL GAS | 1.43 | LB/H | FOR EACH OF 2 TUNNEL FURNACES | LAER | 6.26 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | VACUUM DEGAS BOILERS (2) | 81.29 | Particulate Matter (PM) | P | USE OF NATURAL GAS | 0.39 | LB/H | | BACT-PSD | 1.71 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ACID REGENERATION PLANT (2) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | USE OF NATURAL GAS | 2.62 | LB/H | FOR EACH OF 2 ACID REGENERATION PLANTS | LAER | 11.48 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ROTARY HEARTH FURNACE (6) | 81.29 | Particulate Matter (PM) | A | LIME SPRAY DRYER AND BAGHOUSE | 0.0024 | GR/DSCF | FILTERABLE PM | BACT-PSD | 0.025 | LB/MMBTU | OR CHOICE OF TSM LIMIT BELOW | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COOLING TOWERS (12) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | DRIFT ELIMINATORS | 3.42 | LB/H | FOR ALL 12 COOLING TOWERS TOGETHER | LAER | 14.99 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COOLING TOWERS (12) | 81.29 | Particulate Matter (PM) | P | DRIFT ELIMINATORS | 3.42 | LB/H | FOR ALL 12 COOLING TOWERS TOGETHER | BACT-PSD | 14.99 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | WASTE HEAT BOILERS (6) | 13.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | LIME SPRAY DRYER AND BAGHOUSE | 21.48 | LB/H | | LAER | 0.0127 | GR/DSCF | | 0.036 | LB/MMBTU | AS A 3-HOUR AVERAGE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL GRINDING (6) | 81.29 | Particulate matter, fugitive | N | | 0.47 | T/YR | FOR PM AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 0.18 | T/YR | FOR PM10 AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | COAL GRINDING (6) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ROTARY HEARTH FURNACE (6) | 81.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | LIME SPRAY DRYER AND BAGHOUSE | 21.48 | LB/H | | LAER | 0.0127 | GR/DSCF | | 0.036 | LB/MMBTU | AS A 3-HOUR AVERAGE |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | IRON ORE GRINDING (6) | 81.29 | Particulate Matter (PM) | A | BAGHOUSE W/ 2 CYCLONES | 1.04 | LB/H | FROM EACH INDIVIDUAL BAGHOUSE | BACT-PSD | 4.56 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | PAVED ROADWAYS AND PARKING AREAS | 99.14 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | CONTROL MEASURES INCLUDE APPLICATION OF WET SUPPRESSANTS, WATERING, SPEED REDUCTION, AND VACUUMING OR SWEEPING. | 29.9 | T/YR | FUGITIVE DUST | LAER | 0 | | | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | IRON ORE GRINDING (6) | 81.29 | Particulate matter, fugitive | N | | 1.03 | T/YR | FOR PM AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 0.4 | T/YR | FOR PM10 AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONVEYORS, HOPPERS, SCREENS TO ROTARY HEARTH FURNACE | 81.29 | Particulate Matter (PM) | A | BAGHOUSE | 1.4 | LB/H | FROM EACH BAGHOUSE | BACT-PSD | 6.13 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0022 | GR/DSCF | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | ELECTRIC ARC FURNACE (2) | 81.21 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE AND DIRECT EVACUATION CONTROL W/ 100% CAPTURE EFFICIENCY | 36.05 | LB/H | 1 EAF W/ 2 LMF | LAER | 136.63 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0032 | GR/DSCF | EACH BAGHOUSE (2) TO EAF AND LMF |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | CONVEYORS, HOPPERS, SCREENS TO ROTARY HEARTH FURNACE | 81.29 | Particulate matter, fugitive | N | | 5.19 | T/YR | FOR PM AS A ROLLING 12-MONTH SUMMATION | BACT-PSD | 1.88 | T/YR | FOR PM10 AS A ROLLING 12-MONTH SUMMATION | 0 | | |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | LADLE METALLURGY FURNACE (4) | 81.22 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE AND DIRECT EVACUATION CONTROL W/ 100% CAPTURE EFFICIENCY | 36.05 | LB/H | 1 EAF W/ 2 LMF | LAER | 136.63 | T/YR | AS A ROLLING 12-MONTH SUMMATION | 0.0032 | GR/DSCF | EACH BAGHOUSE (2) TO EAF AND LMF |
| OH-0315 | NEW STEEL INTERNATIONAL, INC., HAVERHILL | OH | 07-00587 | 5/6/2008 | LADLE METALLURGY FURNACE (4) | 81.22 | Particulate Matter (PM) | A | BAGHOUSE AND DIRECT EVACUATION CONTROL W/ 100% CAPTURE EFFICIENCY | 0.0014 | GR/DSCF | EACH BAGHOUSE (2) TO EAF AND LMF | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | ROADS, PARKING AREAS, OTHER OPEN AREAS | 81.19 | Particulate matter, filterable (FPM) | P | WORK PRACTICES: PAVING, FLUSHING, DUST SUPPRESSANT, SWEEPING/VACUUM | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | ROADS, PARKING AREAS, OTHER OPEN AREAS | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | WORK PRACTICES: PAVING, FLUSHING, DUST SUPPRESSANT, SWEEPING/VACUUM | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | ROADS, PARKING AREAS, OTHER OPEN AREAS | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | WORK PRACTICES: PAVING, FLUSHING, DUST SUPPRESSANT, SWEEPING/VACUUM | 0 | | SEE NOTE | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Charging | 81.115 | Particulate matter, total (TPM) | A | Baghouse with traveling hood. | 0.016 | LB/T | COAL | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Charging | 81.115 | Particulate matter, total < 10 µ (TPM10) | A | Baghouse with traveling hood. | 0.016 | LB/T | COAL | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Doors | 81.113 | Particulate matter, total < 2.5 µ (TPM2.5) | P | Pressure in each oven or in a common battery tunnel shall be maintained at a negative pressure consistent with the NESHAP. | 0 | | SEE NOTE | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Doors | 81.113 | Particulate matter, total < 10 µ (TPM10) | P | Pressure in each oven or in a common battery tunnel shall be maintained at a negative pressure consistent with the NESHAP. | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | OTHER COAL/COKE HANDLING OPERATIONS | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | WHEN HANDLING A ‘‘WET‘‘ MATERIAL: MAINTAIN ADEQUATE MOISTURE CONTENT; COLLECT SPILLED MATERIAL. WHEN HANDLING A ‘‘DRY‘‘ MATERIAL: APPLICATION OF WATER OR DUST SUPPRESSANT. | 0 | | SEE NOTE | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Doors | 81.113 | Particulate matter, total (TPM) | P | Pressure in each oven or in a common battery tunnel shall be maintained at a negative pressure consistent with the NESHAP. | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Pushing | 81.111 | Particulate matter, total (TPM) | A | Mobile hood with multiclone. | 0.08 | LB/T | COKE PUSHED | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Pushing | 81.111 | Particulate matter, total < 10 µ (TPM10) | A | Mobile hood with multiclone. | 0.08 | LB/T | COKE PUSHED | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Main Stack | 81.112 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | HRSG, spray dryer/fabric filter system. | 0.005 | GR/DSCF | | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Main Stack | 81.112 | Particulate matter, total < 10 µ (TPM10) | A | HRSG, spray dryer/fabric filter system. | 0.011 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Main Stack | 81.112 | Particulate matter, total (TPM) | A | HRSG, spray dryer/fabric filter system. | 0.011 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Main Stack | 81.112 | Particulate matter, filterable (FPM) | A | HRSG, spray dryer/fabric filter system. | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Main Stack | 81.112 | Particulate matter, filterable < 10 µ (FPM10) | A | HRSG, spray dryer/fabric filter system. | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | ENCLOSURE AND BAGHOUSE | 0.005 | GR/DSCF | | LAER | 0 | | | 0 | | |
| IL-0110 | GRANITE CITY WORKS | IL | 6070088 | 3/13/2008 | COKE CONVEYOR SYSTEM | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | ENCLOSURES FOR CONVEYORS; FABRIC FILTERS FOR DAY BINS, WATER SPRAYING | 0.005 | GR/DSCF | | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | INDIVIDUAL WASTE HEAT STACKS, SIX | 81.19 | Particulate matter, total (TPM) | P | WORK PRACTICES | 0.08 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | INDIVIDUAL WASTE HEAT STACKS, SIX | 81.19 | Particulate matter, total < 10 µ (TPM10) | P | WORK PRACTICES | 0.08 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, total < 2.5 µ (TPM2.5) | A | ENCLOSURE AND BAGHOUSE | 0.008 | GR/DSCF | | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | QUENCHING | 81.19 | Particulate matter, filterable (FPM) | B | WATER QUALITY AND TOWER WITH BAFFLES | 0.044 | LB/T | COAL CHARGED | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | QUENCHING | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | B | WATER QUALITY AND TOWER WITH BAFFLES. | 0.044 | LB/T | COAL CHARGED | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Main Stack | 81.112 | Particulate matter, total < 2.5 µ (TPM2.5) | A | HRSG, spray dryer/fabric filter system. | 0.011 | GR/DSCF | | RACT | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | OTHER COAL/COKE HANDLING OPERATIONS | 81.19 | Particulate matter, filterable (FPM) | P | WHEN HANDLING A ‘‘WET‘‘ MATERIAL: MAINTAIN ADEQUATE MOISTURE CONTENT; COLLECT SPILLED MATERIAL. WHEN HANDLING A ‘‘DRY‘‘ MATERIAL: APPLICATION OF WATER OR DUST SUPPRESSANT. | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | OTHER COAL/COKE HANDLING OPERATIONS | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | P | WHEN HANDLING A ‘‘WET‘‘ MATERIAL: MAINTAIN ADEQUATE MOISTURE CONTENT; COLLECT SPILLED MATERIAL. WHEN HANDLING A ‘‘DRY‘‘ MATERIAL: APPLICATION OF WATER OR DUST SUPPRESSANT. | 0 | | SEE NOTE | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Charging | 81.115 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Baghouse with traveling hood. | 0.016 | LB/T | COAL | LAER | 0 | | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2A**
**RBLC Determinations with PM2.5, Updated Feb 17, 2011 - All Current Data**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, filterable (FPM) | A | ENCLOSURE AND BAGHOUSE | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | A | ENCLOSURE AND BAGHOUSE | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | QUENCHING | 81.19 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | WATER QUALITY AND TOWER WITH BAFFLES. | 0.044 | LB/T | COAL CHARGED | LAER | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, total (TPM) | A | ENCLOSURE AND BAGHOUSE | 0.008 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | COKE CRUSHING AND SCREENING | 81.19 | Particulate matter, total < 10 µ (TPM10) | A | ENCLOSE AND BAGHOUSE | 0.008 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | Pushing | 81.111 | Particulate matter, total < 2.5 µ (TPM2.5) | A | Mobile hood with multiclone. | 0.08 | LB/T | COKE PUSHED | LAER | 0 | | | 0 | | |
| IL-0110 | GRANITE CITY WORKS | IL | 6070088 | 3/13/2008 | COKE CONVEYOR SYSTEM | 81.19 | Particulate matter, filterable (FPM) | B | ENCLOSURES FOR CONVEYORS; FABRIC FILTERS FOR DAY BINS, WATER SPRAYING | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0110 | GRANITE CITY WORKS | IL | 6070088 | 3/13/2008 | COKE CONVEYOR SYSTEM | 81.19 | Particulate matter, filterable < 10 µ (FPM10) | B | ENCLOSURES FOR CONVEYORS; FABRIC FILTERS FOR DAY BINS, WATER SPRAYING | 0.005 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| IL-0109 | GATEWAY ENERGY & COKE COMPANY | IL | 6070020 | 3/13/2008 | INDIVIDUAL WASTE HEAT STACKS, SIX | 81.19 | Particulate matter, total < 2.5 µ (TPM2.5) | P | WORK PRACTICES | 0.08 | GR/DSCF | | BACT-PSD | 0 | | | 0 | | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 2 | 16.21 | Particulate Matter (PM) | P | SULFUR IN GAS ASSUMED MAX. 1.2 GR/100 SCF; WORK PRACTICE TO MINIMIZE NH3 SLIP. | 3.9 | LB/H | ABOVE/BELOW 0F, 1 HOUR AVG | BACT-PSD | 0.023 | LB/MMBTU | WITH DUCT FIRING, 1 HOUR AVG | 10 | % OPACITY | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 2 | 16.21 | Particulate matter, filterable < 10 µ (FPM10) | P | SULFUR IN GAS ASSUMED MAX 1.2 GR/100 SCF;WORK PRACTICE TO MINIMIZE NH3 SLIP. | 4.1 | LB/H | BELOW 0F, 1 HOUR AVG | BACT-PSD | 0.023 | LB/MMBTU | NO DUCT FIRING, 1 HOUR AVG | 10 | % OPACITY | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | EMERGENCY DIESEL GENERATORS (2) | 17.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM S | 0.19 | LB/H | 1 HOUR AVG | BACT-PSD | 20 | % OPACITY | | 0 | | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 3 | 16.21 | Particulate matter, filterable < 10 µ (FPM10) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM; WORK PRACTICE TO MINIMIZE NH3 SLIP. | 6.3 | LB/H | ABOVE 0'F, 1 HOUR AVG | BACT-PSD | 6.5 | LB/H | BELOW 0'F, 1 HOUR AVG | 0.04 | LB/MMBTU | NO DUCT FIRING, 1 HOUR AVG |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 2 | 16.21 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | SULFUR IN GAS ASSUMED MAX 1.2 GR/100 SCF; WORK PRACTICE TO MINIMIZE NH3 SLIP. | 3.9 | LB/H | ABOVE O'F, 1 HOUR AVG | BACT-PSD | 0.023 | LB/MMBTU | NO DUCT FIRING, 1 HOUR AVG | 10 | % OPACITY | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 3 | 16.21 | Particulate Matter (PM) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM; WORK PRACTICE TO MINIMIZE NH3 SLIP. | 6.3 | LB/H | ABOVE 0'F, 1 HOUR AVG | BACT-PSD | 6.5 | LB/MMBTU | NO DUCT FIRING, 1 HOUR AVG | 20 | % OPACITY | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 4 | 16.29 | Particulate Matter (PM) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM, WORK PRACTICE TO MINIMIZE NH3 SLIP. | 8.3 | LB/H | ABOVE 0'F, 1 HOUR AVG | BACT-PSD | 8.6 | LB/H | BELOW 0'F, 1 HOUR AVG | 0.031 | LB/MMBTU | ABOVE 0'F, 1 HOUR AVG |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 4 | 16.29 | Particulate matter, filterable < 10 µ (FPM10) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM, WORK PRACTICE TO MINIMIZE NH3 SLIP. | 8.3 | LB/H | ABOVE 0'F, 1 HOUR AVG | BACT-PSD | 8.6 | LB/H | BELOW 0'F, 1 HOUR AVG | 0.031 | LB/MMBTU | ABOVE 0'F, 1 HOUR AVG |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 3 | 16.21 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM, WORK PRACTICE TO MINIMIZE NH3 SLIP. | 6.3 | LB/H | AVOVE 0'F, 1 HOUR AVG | BACT-PSD | 6.5 | LB/H | BELWO 0'F, 1 HOUR AVG | 0.04 | LB/MMBTU | NO DUCT FIRING, 1 HOUR AVG |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 1 | 16.21 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | SULFUR IN GAS ASSIGNED MAX 1.2 GR/100 SCF; WORK PRACTICE TO MINIMIZE NHZ SLIP | 6.7 | LB/H | ABOVE/BELOW 1 HOUR AVG | BACT-PSD | 0.023 | LB/MMBTU | ABOV/BELOW 1 HOUR AVG W/DUCT FIRING | 0 | | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | EMERGENCY DIESEL GENERATORS (2) | 17.11 | Particulate Matter (PM) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM S. | 0.19 | LB/H | 1 HOUR AVG | BACT-PSD | 20 | % OPACITY | | 0 | | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | EMERGENCY DIESEL GENERATORS (2) | 17.11 | Particulate matter, filterable < 10 µ (FPM10) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM S | 0.19 | LB/H | 1 HOUR AVG | BACT-PSD | 20 | % OPACITY | | 0 | | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 1 | 16.21 | Particulate Matter (PM) | P | SULFUR IN GAS ASSIGNED MAX 1.2 GR/100 SCF; WORK PRACTICE TO MINIMIZE NHZ SLIP. | 6.5 | LB/H | ABOV 1 HOUR AVG | BACT-PSD | 0.022 | LB/MMBTU | ABOVE 1 HOUR AVG W/DUCT FIRING | 0 | | |
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 4 | 16.29 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | ULTRA LOW SULFUR DIESEL AT 15 PPM, WORK PRACTICE TO MINIMIZE NH3 SLIP. | 8.3 | LB/H | ABOVE 0'F, 1 HOUR AVG | BACT-PSD | 8.6 | LB/H | BELOW 0'F, 1 HOUR AVG | 0.031 | LB/MMBTU | ABOVE 0'F, 1 HOUR AVG |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NY-0101 | CORNELL COMBINED HEAT & POWER PROJECT | NY | NY-0001 | 3/12/2008 | COMBUSTION TURBINES 1 | 16.21 | Particulate matter, filterable < 10 µ (FPM10) | P | SULFUR IN GAS ASSIGNED MAX 1.2 GR/100 SCF; WORK PRACTICE TO MINIMIZE NHZ SLIP | 6.7 | LB/H | ABOVE/BELOW 1 HOUR AVG | BACT-PSD | 0.023 | LB/MMBTU | ABOVE/BELOW 1 HOUR AVG W/DUCT FIRING | 0 | | |
| VA-0305 | INGENCO K&O FACILITY | VA | 52148 | 9/26/2007 | ELECTRIC GENERATION | 17.11 | Particulate matter, filterable < 10 µ (FPM10) | B | GOOD COMBUSTIONS PRACTICES AND CONTINUOUS MONITORING DEVICES | 115.9 | T/YR | | N/A | 115.9 | T/YR | | 0 | | |
| VA-0305 | INGENCO K&O FACILITY | VA | 52148 | 9/26/2007 | ELECTRIC GENERATION | 17.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | B | GOOD COMBUSTIONS PRACTICES AND CONTINUOUS MONITORING DEVICES | 115.9 | T/YR | | N/A | 115.9 | T/YR | | 0 | | |
| VA-0310 | WASTE MANAGEMENT MIDPENN | VA | 40920 | 5/29/2007 | 8 CATERPILLAR ENGINE/GENERATORS | 16.12 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMUBSTION PRACTICES | 16.8 | T/YR | | BACT-PSD | 16.8 | T/YR | | 0 | | |
| VA-0310 | WASTE MANAGEMENT MIDPENN | VA | 40920 | 5/29/2007 | 8 CATERPILLAR ENGINE/GENERATORS | 16.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | GOOD COMBUSTION PRACTICES | 16.8 | T/YR | | BACT-PSD | 16.8 | T/YR | | 0 | | |
| PA-0253 | CONOCOPHILLIPS TRAINER REFINERY | PA | 23-0003I | 2/6/2007 | BOILER 9 | 11.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | EMISSION LIMITS MANTIANED BY BURNING NATURAL GAS OR RFG | 3.13 | LB/H | | BACT-PSD | 13.7 | T/YR | 12 CONSECUTIVE MONTHS | 0 | | |
| PA-0253 | CONOCOPHILLIPS TRAINER REFINERY | PA | 23-0003I | 2/6/2007 | BOILER 9 | 11.31 | Particulate matter, filterable < 10 µ (FPM10) | P | EMISSIONS WILL BE CONTROLLED BY ONLY BURNING NATURAL GAS AND RFG | 3.13 | LB/H | | BACT-PSD | 13.7 | T/YR | 12 CONSECUTIVE MONTHS | 0 | | |
| PA-0253 | CONOCOPHILLIPS TRAINER REFINERY | PA | 23-0003I | 2/6/2007 | BOILER 10 | 11.31 | Particulate matter, filterable < 10 µ (FPM10) | P | CONTROL IS ONLY BURNING NG AND RFG IN THR BOILERS | 3.13 | LB/H | | BACT-PSD | 13.7 | T/YR | 12 CONSECUTIVE MONTHS | 0 | | |
| PA-0253 | CONOCOPHILLIPS TRAINER REFINERY | PA | 23-0003I | 2/6/2007 | BOILER 10 | 11.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 3.13 | LB/H | | BACT-PSD | 13.7 | T/YR | 12 CONSECUTIVE MONTHS | 0 | | |
| VA-0302 | INGENCO BRUNSWICK FACILITY | VA | 52154 | 10/19/2006 | DIESEL GENERATOR FOR ELECTRIC | 16.12 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 115.9 | T/YR | | N/A | 0 | | | 115.9 | T/YR | |
| VA-0302 | INGENCO BRUNSWICK FACILITY | VA | 52154 | 10/19/2006 | DIESEL GENERATOR FOR ELECTRIC | 16.12 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMBUSTION PRACTICES. | 115.9 | T/YR | | N/A | 0 | | | 115.9 | T/YR | |
| NJ-0068 | MANCHESTER RENEWABLE POWER CORPORATION | NJ | BOP 060001 | 10/6/2006 | LANDFILL GAS FUELED RECIPROCATING ENGINES(6) | 17.14 | Particulate matter, filterable < 10 µ (FPM10) | P | | 0.2 | G/B-HP-H | | BACT-PSD | 0.98 | LB/H | | 0 | | |
| NJ-0068 | MANCHESTER RENEWABLE POWER CORPORATION | NJ | BOP 060001 | 10/6/2006 | LANDFILL GAS FUELED RECIPROCATING ENGINES(6) | 17.14 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | | 0.98 | LB/H | | Other Case-by-Case | 0 | | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | PREHEAT FURNACE NO 2 | 81.38 | Particulate Matter (PM) | N | | 0.84 | LB/H | | BACT-PSD | 3.68 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | SCRAP SHREDDER BAGHOUSE | 81.38 | Particulate Matter (PM) | N | | 9.7 | LB/H | | BACT-PSD | 42.49 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | WELL FURNACE HOOD BAGHOUSE #1 | 81.38 | Particulate Matter (PM) | N | | 4.29 | LB/H | | BACT-PSD | 18.77 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | WELL FURNACE HOOD | 81.38 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 2.6 | LB/H | | BACT-PSD | 11.39 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | WELL FURNACE HOOD BAGHOUSE #2 | 81.38 | Particulate Matter (PM) | N | | 2.6 | LB/H | | BACT-PSD | 11.39 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | WELL FURNACES (4) | 81.31 | Particulate Matter (PM) | N | | 1.31 | LB/H | | BACT-PSD | 5.74 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | DOME FURNACE | 81.31 | Particulate Matter (PM) | N | | 9.11 | LB/H | | BACT-PSD | 39.9 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | HOLDING FURNACES (3) | 81.37 | Particulate Matter (PM) | N | | 0.44 | LB/H | | BACT-PSD | 1.93 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | PREHEAT FURNACE NO 1 | 81.37 | Particulate Matter (PM) | N | | 0.84 | LB/H | | BACT-PSD | 3.68 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | PREHEAT FURNACE NO 3 | 81.38 | Particulate Matter (PM) | N | | 0.88 | LB/H | | BACT-PSD | 3.85 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | ROLLING MILL (2) | 81.49 | Particulate Matter (PM) | N | | 3 | LB/H | | BACT-PSD | 13.14 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | ANNEALING FURNACES (8) | 81.39 | Particulate Matter (PM) | N | | 0.22 | LB/H | | BACT-PSD | 0.96 | T/YR | | 0 | | |
| TX-0503 | ALUMAX SECONDARY ALUMINUM SMELTER | TX | PSD-TX 886 AND 9476 | 5/15/2006 | THERMAL OXIDIZERS (2) | 81.49 | Particulate Matter (PM) | N | | 0.48 | LB/H | | BACT-PSD | 2.1 | T/YR | | 0 | | |

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Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | LADLE DRYERS/PREHEATERS (2) | 81.37 | Particulate matter, filterable < 10 µ (FPM10) | P | GOOD COMBUSTION PRACTICES WITH PROPER NATURAL GAS BURNER DESIGN; NO ADD-ON CONTROLS | 0.11 | LB/H | FOR EACH OF 2 PREHEATERS | LAER | 0.96 | T/YR | FROM BOTH PREHEATERS TOGETHER | 7.6 | LB/MMSCF | AP-42 EMISSION FACTOR FOR NG |
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | ELECTRIC ARC FURNACE | 81.31 | Particulate Matter (PM) | A | TOTAL BUILDING EVACUATION TO REVERSE AIR BAGHOUSE | 37.7 | LB/H | | BACT-PSD | 165.3 | T/YR | | 0.0018 | GR/DSCF | |
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | ELECTRIC ARC FURNACE | 81.31 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | TOTAL BUILDING EVACUATION TO REVERSE AIR BAGHOUSE | 100.6 | LB/H | | LAER | 440.8 | T/YR | | 0.0048 | GR/DSCF | |
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | ELECTRIC ARC FURNACE | 81.31 | Particulate matter, filterable < 10 µ (FPM10) | A | TOTAL BUILDING EVACUATION TO REVERSE AIR BAGHOUSE | 28.7 | LB/H | | LAER | 125.6 | T/YR | | 0.0014 | GR/DSCF | |
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | LADLE METALLURGY FURNACE | 81.34 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | TOTAL BUILDING EVACUATION TO REVERSE AIR BAGHOUSE | 100.6 | LB/H | | LAER | 440.8 | T/YR | | 0.0048 | GR/DSCF | |
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | LADLE METALLURGY FURNACE | 81.34 | Particulate matter, filterable < 10 µ (FPM10) | A | TOTAL BUILDING EVACUATION TO REVERSE AIR BAGHOUSE | 28.7 | LB/H | | LAER | 125.6 | T/YR | | 0.0014 | GR/DSCF | |
| OH-0302 | REPUBLIC ENGINEERED PRODUCTS, INC. | OH | 15-01591 | 8/30/2005 | LADLE METALLURGY FURNACE | 81.34 | Particulate Matter (PM) | A | TOTAL BUILDING EVACUATION TO REVERSE AIR BAGHOUSE | 37.7 | LB/H | | BACT-PSD | 165.3 | T/YR | | 0.0018 | GR/DSCF | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | L-AREA GAS TURBINE | 15.11 | Particulate matter, filterable < 10 µ (FPM10) | N | | 2.09 | LB/H | | RACT | 9.16 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N-3 BACKUP INSTRUMENT AIR COMPRESSOR | 19.9 | Particulate Matter (PM) | N | | 0.08 | LB/H | | BACT-PSD | 0.03 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N-5 COOLING TOWER NORTH | 50.006 | Particulate Matter (PM) | A | DRIFT ELIMINATORS | 2.04 | LB/H | | BACT-PSD | 8.92 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N-5 COOLING TOWER SOUTH | 50.006 | Particulate Matter (PM) | A | DRIFT ELIMINATORS | 2.84 | LB/H | | BACT-PSD | 12.44 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N-7 COOLING TOWER | 50.006 | Particulate Matter (PM) | A | DRIFT ELIMINATORS | 7.65 | LB/H | | BACT-PSD | 33.51 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N7/8 PREHEATER | 19.6 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.04 | LB/H | | BACT-PSD | 0.19 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N-3,4 PREHEATER | 19.6 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.02 | LB/H | | BACT-PSD | 0.09 | T/YR | | 0 | | |
| TX-0487 | ROHM AND HAAS CHEMICALS LLC LONE STAR PLANT | TX | PSD-TX-828M1 | 3/24/2005 | N-5/6 PREHEATER | 19.6 | Particulate matter, filterable < 10 µ (FPM10) | N | | 0.09 | LB/H | | BACT-PSD | 0.39 | T/YR | | 0 | | |
| NE-0021 | CASS COUNTY POWER PLANT | NE | 70919C01 | 6/22/2004 | 2-173 MW COMBUSTION TURBINES | 15.11 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | | 0.12 | LB/MMBTU | | Other Case-by-Case | 15.3 | LB/H | | 0 | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2B**
**RBLC Determinations with PM2.5, June 10, 2011 Search Data Older than February 2012 RBLC Search Date Range**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | PACKAGE BOILER | 19.6 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.84 | LB/H | | Other Case-by-Case | 3.7 | T/YR | | | | NOT AVAILABLE |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | STANDBY INCINERATOR | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 5.21 | LB/H | | Other Case-by-Case | 2.29 | T/YR | | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | WASTE HEAT BOILER | 19.6 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 5.24 | LB/H | | Other Case-by-Case | 22.95 | T/YR | | | | NOT AVAILABLE |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | REGENERATIVE GAS HEATER | 19.6 | Particulate Matter (PM) | N | NONE INDICATED | 0.03 | LB/H | | Other Case-by-Case | 0.01 | T/YR | LESS THAN | | | NOT AVAILABLE |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | PACKAGE BOILER BO-4 | 13.31 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.48 | LB/H | | N/A | 2.11 | T/YR | | 0.008 | LB/MMBTU | CALCULATED |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (4) PELLET LINE LOT BLENDER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.03 | LB/H | EACH | Other Case-by-Case | 0.06 | T/YR | EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | PELLET OFFSPEC BIN | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.03 | LB/H | | Other Case-by-Case | 0.01 | T/YR | | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) POWDER MASTERBATCH WEIGHT BIN VENT FILTER | 63.999 | Particulate matter, filterable < 2.5 µ (FPM2.5) | N | NONE INDICATED | 0.03 | LB/H | EACH | Other Case-by-Case | 0.01 | T/YR | LESS THAN, EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) PELLET REFEED BIN VENT | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.03 | LB/H | EACH | Other Case-by-Case | 0.01 | T/YR | LESS THAN, EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | VACUUM CLEANING SYSTEM | 63.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.16 | LB/H | | Other Case-by-Case | 0.07 | T/YR | | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | VACUUM CLEANING SYSTEM | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.08 | LB/H | | Other Case-by-Case | 0.03 | T/YR | | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (4) CARLOT SILO BLENDERS | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.27 | LB/H | EACH | Other Case-by-Case | 0.47 | T/YR | EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | BAGGING BIN VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.27 | LB/H | | Other Case-by-Case | 0.47 | T/YR | | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | ADDITIVE FEED HOPPER VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.01 | LB/H | | Other Case-by-Case | 0.01 | T/YR | | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) POWDER MASTERBATCH WEIGHT BIN VENT FILTER | 63.999 | Particulate Matter (PM) | A | FILTER | 0.16 | LB/H | EACH | Other Case-by-Case | 0.03 | T/YR | EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) POWDER MASTERBATCH WEIGHT BIN VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.03 | LB/H | EACH | Other Case-by-Case | 0.01 | T/YR | LESS THAN, EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) INLINE BLENDER VENT FILTER | 63.999 | Particulate Matter (PM) | A | FILTER | 0.02 | LB/H | EACH | Other Case-by-Case | 0.08 | T/YR | EACH | | | |
| TX-0378 | LA PORTE POLYPROPYLENE PLANT | TX | PSD-TX-989 | 11/5/2001 | (2) INLINE BLENDER VENT FILTER | 63.999 | Particulate matter, filterable < 10 µ (FPM10) | A | FILTER | 0.02 | LB/H | EACH | Other Case-by-Case | 0.07 | T/YR | EACH | | | |
| WA-0307 | PORTLAND CEMENT CLINKERING PLANT | WA | PSD-90-03 | 10/5/2001 | KILN EXHAUST STACK | 90.028 | Particulate Matter (PM) | A | BAGHOUSE | 10.6 | LB/H | | LAER | 46 | T/YR | | | | NOT AVAILABLE, SEE NOTES |
| WA-0307 | PORTLAND CEMENT CLINKERING PLANT | WA | PSD-90-03 | 10/5/2001 | KILN EXHAUST STACK | 90.028 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAGHOUSE STACK | 0.005 | GR/DSCF | 24 H PERIOD | LAER | | | | | | NOT AVAILABLE |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | FURNACE, REHEAT | 81.39 | Particulate matter, filterable < 10 µ (FPM10) | P | NATURAL GAS COMBUSTION/GOOD COMBUSTION PRACTICES. | 1 | LB/H | | BACT-PSD | 4.2 | T/YR | | | | NOT AVAILABLE |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | ROADS, PAVED & UNPAVED | 99.19 | Particulate matter, filterable < 10 µ (FPM10) | P | WATER APPLICATON TO CONTROL FUGITIVE EMISSIONS. | 6.9 | T/YR | | BACT-PSD | | | | | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2B**
**RBLC Determinations with PM2.5, June 10, 2011 Search Data Older than February 2012 RBLC Search Date Range**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | SLAG PROCESSING | 81.39 | Particulate Matter (PM) | P | WATER APPLICATION TO CONTROL FUGITIVE EMISSIONS. | 5.7 | LB/H | | BACT-PSD | 8.3 | T/YR | | | | NOT AVAILABLE |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | SLAG PROCESSING | 81.39 | Particulate matter, filterable < 2.5 µ (FPM2.5) | P | WATER APPLICATION TO CONTROL FUGITIVE EMISSIONS. | 2.9 | LB/H | | BACT-PSD | 4.1 | T/YR | | | | NOT AVAILABLE |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | PREHEATERS, LADLE, (3) | 13.31 | Particulate matter, filterable < 10 µ (FPM10) | P | NATURAL GAS COMBUSTION/GOOD COMBUSTION PRACTICES. | 0.2 | LB/H | combined | BACT-PSD | 0.7 | T/YR | combined | | | NOT AVAILABLE |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | FURNACE, ELECTIC ARC | 81.31 | Particulate Matter (PM) | A | BAGHOUSE. | 0.0052 | GR/DSCF | | BACT-PSD | | | | 0.0052 | GR/DSCF | |
| AR-0044 | ARKANSAS STEEL ASSOCIATES | AR | 35-AOP-R3 | 1/5/2001 | LADLE METALLURGY STATION | 81.34 | Particulate Matter (PM) | A | BAGHOUSE. | 0.0052 | GR/DSCF | | BACT-PSD | 1 | LB/H | | 0.0052 | GR/DSCF | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | DIESEL ENGINE, FCC-67 | 19.8 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.32 | LB/H | | Other Case-by-Case | 0.67 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FEED HOPPER, FCC-3A | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.04 | LB/H | | Other Case-by-Case | 0.18 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CALCINER, FCC-5A | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.08 | LB/H | | Other Case-by-Case | 0.34 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FLASH DRYER, FCC-8 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 1 | LB/H | | Other Case-by-Case | 4.4 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | MOLSIEVE CALCINER, FCC-9 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.02 | LB/H | | Other Case-by-Case | 0.11 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FINAL PRODUCT, FCC-9A | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.58 | LB/H | | Other Case-by-Case | 2.55 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FLASH DRYER, FCC-10 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 1 | LB/H | | Other Case-by-Case | 4.4 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | MOLSIEVE CALCINER, FCC-12 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.02 | LB/H | | Other Case-by-Case | 0.11 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | STRIKE TANKS VENT, FCC-18 | 62.02 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.84 | LB/H | | Other Case-by-Case | 2.95 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | KAOLIN DOSING BAG HOPPER, FCC-19 | 62.999 | Particulate Matter (PM) | N | NONE INDICATED | 0.29 | LB/H | | Other Case-by-Case | 1.26 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | STEAM BOILER, FCC-27 | 19.6 | Particulate Matter (PM) | N | NONE INDICATED | 0.3 | LB/H | | Other Case-by-Case | 1.3 | T/YR | | | | NOT AVAILABLE |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | SCR UNIT, FCC-75 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.01 | LB/H | | Other Case-by-Case | 0.05 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | FINAL PRODUCT CALCINER, FCC-74 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | N | NONE INDICATED | 0.26 | LB/H | | Other Case-by-Case | 1.14 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | MAIN BAG FILTER | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | THE BAG FILTER IS A PM CONTROL | 1.2 | LB/H | | Other Case-by-Case | 5.3 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CRUDE UNLOADING, FCC-50 | 62.02 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.01 | LB/H | LESS THAN | Other Case-by-Case | 0.01 | T/YR | LESS THAN | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | (2) CRUDE PRODUCT | 62.02 | Particulate matter, filterable < 2.5 µ (FPM2.5) | A | BAG FILTER | 0.07 | LB/H | EACH | Other Case-by-Case | 0.28 | T/YR | EACH | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | (2) CRUDE PRODUCT | 62.02 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.07 | LB/H | EACH | Other Case-by-Case | 0.28 | T/YR | EACH | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CRUDE PRODUCT, FCC-53 | 62.02 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.01 | LB/H | | Other Case-by-Case | 0.05 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CRUDE PRODUCT, FCC-54 | 62.02 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.03 | LB/H | | Other Case-by-Case | 0.09 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | VENTILATION AIR, FCC-55 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.01 | LB/H | | Other Case-by-Case | 0.04 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | PRODUCT TRANSPORT, FCC-57 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.04 | LB/H | | Other Case-by-Case | 0.15 | T/YR | | | | |

**PolyMet Mining, Inc.**
**Emission Control Technology Review Report Addendum 01 Revision 3, Attachment 1 Table 2B**
**RBLC Determinations with PM2.5, June 10, 2011 Search Data Older than February 2012 RBLC Search Date Range**

Compiled data set includes all particulate matter (e.g. PM, PM10, PM2.5) determinations that include PM2.5 as a Pollutant
Control Equipment Codes: P = Pollution prevention, A = Add-on controls, B = Both, N = No controls feasible

| RBLCID | FACILITY NAME | FACILITY STATE | PERMIT NUM | PERMIT DATE | PROCESS NAME | PROCESS TYPE | POLLUTANT | CONTROL CODE | CONTROL DESCRIPTION | Emission Limit 1 | Emission Limit 1 Units | Emission Limit 1 Avg Time | CASE-BY-CASE BASIS | Emission Limit 2 | Emission Limit 2 Units | Emission Limit 2 Avg Time | STD Emission Limit | STD Limit Unit | STD Limit Avg Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CRUDE & PRODUCT, FCC-58 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.42 | LB/H | | Other Case-by-Case | 1.82 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | (2) PRODUCT AIR SLIDE, FCC-61&62 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.09 | LB/H | EACH | Other Case-by-Case | 0.38 | T/YR | EACH | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | PRODUCT VACUUM, FCC-63 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.26 | LB/H | | Other Case-by-Case | 1.16 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BLENDING SILO | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FITLER | 0.24 | LB/H | | Other Case-by-Case | 1.07 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BULK LOADOUT, FCC-65 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.24 | LB/H | | Other Case-by-Case | 1.07 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | PORTABLE BAG FILTER, FCC-66 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.09 | LB/H | | Other Case-by-Case | 0.19 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | RESLURRY TANK, FCC-11 | 62.999 | Particulate Matter (PM) | A | BAG FILTER | 0.3 | LB/H | | Other Case-by-Case | 1.2 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CALCINER SCRUBBER | 62.999 | Particulate Matter (PM) | A | SCRUBBER | 0.1 | LB/H | LESS THAN | Other Case-by-Case | 0.1 | T/YR | LESS THAN | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | PORTACLAY/RESLURRY, FCC-16 | 62.999 | Particulate Matter (PM) | A | BAG FILTER | 0.05 | LB/H | | Other Case-by-Case | 0.24 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | C ALUMINA SILO, FCC-20 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.29 | LB/H | | Other Case-by-Case | 0.91 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | SPRAY DRYER, FCC-21 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 8.59 | LB/H | | Other Case-by-Case | 37.41 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | CRUDE PRODUCT, 21.1-21.3 | 62.999 | Particulate Matter (PM) | A | BAG FILTER | 0.1 | LB/H | | Other Case-by-Case | 0.6 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | SEPARATOR FINES, FCC 23 | 62.999 | Particulate Matter (PM) | A | BAG FILTER | 0.48 | LB/H | | Other Case-by-Case | 2.09 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | KAOLIN UNLOADING, FCC-40 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.15 | LB/H | | Other Case-by-Case | 0.32 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | KAOLIN SILO, FCC-68 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.26 | LB/H | | Other Case-by-Case | 0.58 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | C ALUMINA DOSING, FCC-69 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.24 | LB/H | | Other Case-by-Case | 0.55 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BOC SILO, FCC-70 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.19 | LB/H | | Other Case-by-Case | 0.41 | T/YR | | | | |
| TX-0334 | AKZO NOBEL POLYMER CHEMICALS TRIGONOX 201 | TX | N022 | 6/20/2000 | BOC DOSING, FCC-71 | 62.999 | Particulate matter, filterable < 10 µ (FPM10) | A | BAG FILTER | 0.21 | LB/H | | Other Case-by-Case | 0.44 | T/YR | | | | |

# Attachment 2

## MPCA August 16, 2010 Memorandum - PolyMet Mining Company Plant Site Refinement Proposal, Venting Emission Control Exhaust Air Indoors

SF-00006-05 (4/66)

DEPARTMENT: POLLUTION CONTROL AGENCY

STATE OF MINNESOTA

# Office Memorandum

DATE: August 16, 2010

TO: Stuart Arkley, Eco Services
Minnesota DNR

Al Trippel, DNR Contractor
ERM

FROM: Ann Foss, Director AMF
Strategic Projects Sector
Industrial Division

PHONE: 651-757-2366

SUBJECT: POLYMET MINING COMPANY PLANT SITE REFINEMENT PROPOSAL; VENTING EMISSIONS CONTROL EXHAUST AIR INDOORS

On May 27, 2010, PolyMet proposed several refinements to its project including changes to reduce its impact to visibility in nearby Class I areas. In the previously proposed project, natural gas combustion for space heating was a significant source of NOx emissions, which contributes to visibility impairment. In its May 27, 2010, project refinement, PolyMet proposed to reduce space heating needs by recycling emissions control exhaust air from some of its emissions points back into the buildings. Venting the exhaust air indoors would reduce the amount of ambient air drawn into the building and subsequently reduce space heating needs and visibility impacts. PolyMet has proposed that some emissions points would be vented indoors at all times and that some emissions points would be vented indoors only during the cold weather months. See the attached spreadsheet outlining the emissions points that PolyMet has proposed to vent inside. While the MPCA does not regulate indoor air quality, it wants to make certain that this proposal would not negatively affect indoor air quality for plant employees.

The ore body proposed to be mined by PolyMet contains mineral fibers that are released to the air, as a small fraction of its particulate matter emissions, when the ore is processed. The state of Minnesota defines fibers as chrysotile and amphibole mineral particles with 3-to-1 or greater aspect ratios. Fibers are chemically identical to asbestos, but are often physically shorter than asbestos. The state of Minnesota is currently developing a method to quantify the health risk of inhaling fibers. Because of the similarity to asbestos, the state regulates airborne fiber emissions to minimize ambient exposures.

PolyMet has proposed to control its indoor particulate emissions using cartridge filters followed by a HEPA filter. According to manufacturer's data, together the cartridge filter and HEPA filter will achieve 99.97% control efficiency for particles, including fibers, that are 0.3 microns and larger (the MDH analytical method using a transmission

electron microscope can detect fibers as small as 0.5 microns.) HEPA filters are required during asbestos abatement projects under the asbestos NESHAP to protect worker's health. As a result of the high efficiency of the proposed cartridge filters and HEPA filters for reducing fine particulate and fibers contained in the particulate emissions, exposure of the plant employees to fibers would be minimal.

MPCA gives conditional approval to PolyMet's proposal to vent its emissions control exhaust air from some of its emissions points back into the buildings pending installation of alarmed parametric monitors. In order to approve the proposal, the MPCA requires that PolyMet install differential pressure transmitters to continuously monitor the pressure drop across the filters equipped with audible alarms if the pressure drops are not within the required range. If the pressure drop for a piece of control equipment falls out of the required range, PolyMet is required to shutdown the associated emissions units or vent the emissions outside the building during the upset period.

**Emission Controls**
30-Jun-10

| System | Equipment served | Existing | Proposed | CAMS | Must Vent Inside | Could Vent Inside |
|---|---|---|---|---|---|---|
| **Coarse Crushers** | | | | | | |
| North rail dump | North 60" crusher | Baghouse for 60 crusher | Upgraded baghouse | broken bag detector | No | No |
| North crushing | North tin can and 36" crushers | Baghouse for 60 crusher | Cartridge | broken cartridge detector | No | No |
| South rail dump | South 60" crusher | Baghouse for 60 crusher | Upgraded baghouse | broken bag detector | No | No |
| South crushing | South tin can and 36" crushers | Baghouse for 60 crusher | Cartridge | broken cartridge detector | No | No |
| North pan feeders | North pan feeder aspiration | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| South pan feeders | South pan feeder aspiration | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North pan feeder discharge | North transfer to conv. 1A | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North pan feeder discharge | North transfer to conv. 1B | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| South pan feeder discharge | South transfer to conv. 1A | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| South pan feeder discharge | South transfer to conv. 1B | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| **Drive House** | | | | | | |
| Conveyor transfer point | Conveyor 1A&2A | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| Conveyor transfer point | Conveyor 1B&2B | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| **Fine Crushers** | | | | | | |
| 2A tripper car dust collection | 2A tripper car | none | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | Yes | Year-round |
| 2B tripper car dust collection | 2B tripper car | none | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | Yes | Year-round |
| West tripper car discharge bins | West coarse ore bins | Baghouse + wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| East tripper car discharge bins | East coarse ore bins | Baghouse + wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| West fine crushers 1 and conveyance | W1 crushing line | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| West fine crushers 2 and conveyance | W2 crushing line | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| East fine crushers 1 and conveyance | E1 crushing line | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| Conveyor 3A, 3B, & 4B transfer point | Conveyor 3A, 3B, to 4B | Wet scrubber | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Heating season only |
| **Concentrator** | | | | | | |
| Conveyor transfer point | Conveyor 4B and 5N | Wet scrubber | Cartridge | broken cartridge detector | No | No |
| 5N tripper car dust collection | 5N tripper car | none | Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | Yes | Year-round |
| Sample lab | Sample lab dust collection | Wet scrubber | Cartridge | broken cartridge detector | No | No |
| North bin ventilation #1 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #2 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #3 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #4 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #5 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #6 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #7 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| North bin ventilation #8 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | broken cartridge det. w/ pressure across HEPA | No | Year-round |
| Bin discharge conveyance section 1 | North concentrator lines 1-3 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | broken cartridge detector | No | No |
| Bin discharge conveyance section 2 | North concentrator lines 4-6 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | broken cartridge detector | No | No |
| Bin discharge conveyances section 3 | North concentrator lines 7-9 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | broken cartridge detector | No | No |
| Bin discharge conveyances section 4 | North concentrator lines 10-12 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | broken cartridge detector | No | No |

**Notes**

Cartridge filter as stated in vendor information is 99.99% efficient on particles sized 0.5 micron and larger.
HEPA filter as stated in vendor information is 99.97% efficient for particles sized 0.3 micron and larger.
Recommended HEPA filter failure detection is to monitor pressure drop across the HEPA filter.
HEPA filters will only be installed and used where venting will occur inside of buildings.

**Attachment I**

**Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore: Addendum 02 Fine Particle Air Emission Control Update Version 2**

# *NorthMet Mine and Ore Processing Facilities Project*

## *Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore*

## *Addendum 02*

## *Fine Particle Air Emission Control Technology Update*

***Prepared for***
***PolyMet Mining Inc.***

***December 2011***
***Version 2***

BARR

# *NorthMet Mine and Ore Processing Facilities Project*

## *Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore*

## *Addendum 02*

## *Fine Particle Air Emission Control Technology Update*

***Prepared for***
***PolyMet Mining Inc.***

***Version 2 – December 2011***

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# Mineral Fibers Data Related to the Processing of NorthMet Deposit Ore

# Addendum 02

# Fine Particle Air Emission Control Technology Update

# Version 2 – December 2011

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Large Table 1 Listing of Emission Units Associated with Crushing and Concentrating and Proposed Equipment to Control Fine Particle Emissions

# 1.0 Introduction

The October 2005 Scoping Decision Document for the NorthMet project Environmental Impact Statement (EIS) identified that the "… EIS will provide information about the presence of fibers in the NorthMet deposit . …". Since February 2006 fibers-related information has been submitted to the Minnesota State Agencies (Department of Natural Resources, MDNR; Pollution Control Agency, MPCA; Department of Health, MDH) for their review and consideration. The report entitled *NorthMet Mine and Ore Processing Facilities Project, Fibers Data Related to the Processing of NorthMet Deposit Ore* (June 2007), hereafter referred to as the "2007 Mineral Fibers Report", provided the bulk of the fibers-related data and information.

Amphibole and serpentine mineral fibers are of primary interest for this project. Overall, amphibole mineral fibers were found to represent a relatively small percent of the mineral fibers associated with the processing of NorthMet ore (Flotation Pilot Testing in July and August 2005); amphibole mineral fibers were approximately 9 percent of the fibers identified from all collected samples of ore, tailings and flotation process water. Serpentine mineral fibers were not identified in samples of ore, tailings or process water collected from the Flotation Pilot Testing. However, PolyMet's petrographic observations indicate that serpentine minerals are about two percent of the minerals associated with the waste rock from the NorthMet Project.

Data provided in the 2007 Mineral Fibers Report indicates that more about 95 percent of the mineral fibers identified in samples collected from the Flotation Pilot Testing were 3 microns or smaller in size, with most being less than 2 microns in size. Therefore, $PM_{2.5}$ (fine particulate) is being used as a surrogate for all mineral fibers, including amphibole and serpentine mineral fibers.

Ongoing discussions between PolyMet and the state agencies resulted in proposed project changes, including an agreement by PolyMet to further reduce potential emissions of fine particles. Addendum 01 to the 2007 Mineral Fibers Report was provided to the Minnesota State Agencies in September of 2007. That addendum reflected the proposed project changes at that time and provided summary information on fine particle emission control technology. The summary information on fine particle emission control technology was obtained from the original review of fine particulate controls that was detailed in a separate report entitled *Emission Control Technology Review for NorthMet Project Processing Plant* (October 2007 submittal to the MPCA). The available information at that time identified that baghouses provided the best control for fine particulates.

PolyMet agreed to install emission controls in the Crushing Plant that are consistent with the best available control technology (BACT) used in the metallic ore processing industries for fine particulates (Addendum 01 to the 2007 Mineral Fibers Report).

In February 2009 Addendum 01 to the *Emission Control Technology Review for NorthMet Project Processing Plant* (October 2007) was prepared and provided an updated emission control technology review. Since the February 2009 addendum, PolyMet has proposed several refinements for controlling fine particle emissions associated with the proposed project. These changes include the use of cartridge filters for some emission units and the recycling of building air to reduce energy consumption and to reduce $NO_x$ emissions from the space heaters to be used for building heating. Other changes to the Project have also been proposed by PolyMet. The project as currently proposed is described in NorthMet EIS Draft Alternative Summary Revised March 4, 2011 and NorthMet Project Description Version 3 submitted September 13, 2011.

Because of the proposed changes to the Project, the MPCA requested an update to the emission control technology review to provide information for the Supplemental Draft Environmental Impact Statement (SDEIS) to account for any advances in $PM_{2.5}$ control technology since February 2009 and to ensure that the particulate emission control equipment selection for the Project is consistent with other projects currently going through Prevention of Significant Deterioration (PSD) review in Minnesota. This updated review of fine particle emission control technologies is provided in a revised addendum to the *Emission Control Technology Review for NorthMet Project Processing Plant* report (November 2011). With the proposed control technologies, potential $PM_{2.5}$ emissions from the Crushing Plant are estimated to be about 134 tons/year (potential emissions based on equipment with a design processing rate of 100,000 tons/day). Actual emissions associated with a processing rate of 32,000 tons/day are expected to be lower.

Information from the November 2011 emission control technology review update for fine particles is summarized in this second addendum to the June 2007 Mineral Fibers Report.

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after acceptance by the Lead Agencies. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

# 2.0 Update to Emission Control Technologies for Ore Crushing

Ore crushing and handling sources at the Plant Site have the potential to release mineral fibers to air. A brief overview of potential emission sources is provided below. The updated technology selection for sources of fine particulate air emissions is also summarized below. Additional details on the control technology evaluation are provided in the November 2011 Revised Addendum 01 to the *Emission Control Technology Review for NorthMet Project Processing Plant.*

## 2.1 Overview of Plant Site Operations and Sources of Particulate Air Emissions

Crude ore is delivered to the plant by rail car. Rail cars are tipped to unload the ore into the coarse ore crusher. Coarse ore crushing consists of two stages of gyratory crushing (primary and secondary crushing). After coarse ore crushing, the ore is transported into the coarse ore storage bins via pan feeders and conveyors. The two stages of fine ore crushing (tertiary and quaternary) are fed by vibratory feeders from the crude ore bins. Ore is screened after the first fine crushing stage allowing ore that is small enough to bypass the second stage. Ore from the fine ore crushers is fed to the fine ore storage bins via conveyors. Fine ore is transported from the fine ore bins to milling via vibratory feeders and conveyors. The final ore size reduction step is accomplished by wet milling. Wet milling occurs in rod mills followed by ball mills. The milled ore is conveyed to ore concentration in an ore/water slurry.

Sources of particulate matter, $PM_{10}$ and $PM_{2.5}$, in the crushing section of the plant include crushers, screens, vibratory and pan feeders, and material drops. All crushing and screening equipment and conveyor transfer points will be enclosed and ventilated to dust control equipment. Fine particulates collected by dust control equipment will be recovered to the process by adding to the ball mills, with the exception of the Tripper Cars Dust Collectors. Dust collected by the Tripper Car Dust Collectors will drop into the ore storage bin associated with the Tripper Car. No solid waste stream is generated. No particulates are emitted from wet milling as the addition of water to the ore prevents dust formation.

With regard to mineral fibers, the emissions of potential concern from the crushing operations are in the fine particulate, $PM_{2.5}$, fraction. Particulate emissions that are expected to be associated with the Plant Site ore crushing sources are expected to be essentially 100% filterable (i.e. no condensable particulate emissions).

## 2.2 Control Technology Review and Selection

A recent search (June 10, 2011) of the U.S. EPA's RACT/BACT/LAER Clearinghouse (RBLC) database was conducted. That search included all $PM_{2.5}$ determinations since January 1, 2000, and the RBLC search output included $PM_{10}$, PM and TSP limits as well as $PM_{2.5}$ limits. The information provided from the RBLC database identified that for solids material handling and processing types of sources similar to those proposed for the Plant Site, baghouses (i.e., fabric filters) were typically identified as BACT because they are the most effective for both coarse particulate matter ($PM_{10}$) and for fine particulates ($PM_{2.5}$). In fact the performance differential between fabric filters and other emission control technologies is more pronounced for finer filterable particulate sizes (i.e., fabric filters capture more of the fine particles than do other control technologies). The results from the RBLC database search are provided in the November 2011 revised addendum to the *Emission Control Technology Review for NorthMet Project Processing Plant* report.

In summary, the RBLC database identifies that fabric filters are considered to be the best controls currently used in the metallic ore processing industries for fine particles.

## 2.3 Considerations for Control of Fine Particle Emissions

The November 2011 revised addendum to the *Emission Control Technology Review for NorthMet Project Processing Plant* report includes an updated and more detailed discussion on fabric filters, including additional types of filter media for filter bags and cartridges that are now available. The information presented here is a brief summary of items considered pertinent to the control of fine particles from air emission sources associated with ore crushing.

In this addendum, the term "fabric filter" is used as a generic term to indicate filter bags or cartridge filters. A fabric filter (baghouse or cartridge filter) consists of a number of individual filters (filter bags or cartridges) placed in parallel inside of an enclosure. Particulate matter is collected on the surface of the bags or cartridges as the gas stream passes through them. The dust cake which forms on the filter media from the collected particulate can contribute significantly to increasing the collection efficiency.

Overall, when considering emission rate, cartridge filter systems can be considered to perform in a manner consistent with conventional filter bags. However, the size of cartridges is limited, which means that a cartridge filter cannot be used in applications where large volumes of air must be treated.

The main operating limitation of a fabric filter is that its operating temperature is limited by the bag material. Most commonly used filter bag materials are limited to 250ºF – 300º F. Lower temperatures can be accommodated at ambient moisture levels (i.e. processes where appreciable quantities of water are not added to the exhaust gas). Fabric filters do not operate well when there is a significant amount of liquid phase water in the stream being treated. The moisture causes the particulates to form a very thick, wet and heavy cake that plugs the bags and cannot be removed. The plugging significantly reduces or blocks the airflow increasing the pressure drop across the bags or completing making the unit inoperable. High moisture levels can also weaken some bag materials (e.g. polyester) due to hydrolysis, resulting in reduced bag life.

In summary, fabric filters are most effective controlling sources with filterable particulates and are less effective controlling moist hot exhaust streams with condensable particulates. In addition, fabric filter media is more effective at removing submicron particles than electrostatic precipitators (ESPs) or wet scrubbers.

# 3.0 Proposed Control for Fine Particle Emissions Associated with Ore Crushing

PolyMet has agreed to install emission controls on ore crushing operations which are consistent with the best controls currently used in the metallic ore processing industries. This will ensure that emissions of fine particulate matter from ore crushing sources are controlled by state of the art emission controls consistent with recent BACT determinations in similar industries.

For the ore crushers and associated material handling sources, PolyMet proposes fabric filter (baghouse or cartridge filter) controls with a design specification of 0.0025 grains per dry standard cubic foot of air (gr/dscf) as measured by U.S. EPA Method 5. Fabric filters are the best choice for this application because the exhaust from the crushing operations will be at essentially ambient temperature and moisture, so there is no need to cool the gas stream to remove condensable particulate matter and problems due to the formation of a wet particulate cake are not expected to occur. Large Table 1 provides a listing of the Crushing Plant emission sources and the proposed control equipment.

PolyMet has also agreed to use cartridge filters followed by High Efficiency Particulate Air (HEPA) filters for controlling fine particulate matter for selected sources when recycling controlled emissions exhaust streams back into buildings (Large Table 1). HEPA filters are used when exhaust air from the fabric filter is routed back into the building to provide an added level of assurance that worker exposure to inhalable dust is minimized. In this case the venting of exhaust air back into a building provides a benefit of reduced heating fuel demand that offsets the additional cost and energy usage associated with rerouting of air back into a building. According to manufacturer's data, estimated efficiency of a combination of cartridge and HEPA filters for fine particulate matter is 99.97%[1]. For those emission units that will be vented indoors, audible alarms will be installed on the pressure drop meters. As described in the MPCA's August 16, 2010 memorandum, if an alarm is triggered, the emissions unit will either be shut down or the emissions will be vented outdoors and not indoors. It

[1] The 99.97% control efficiency the manufacturer lists for its HEPA filter is based on a specific test* procedure for measuring HEPA filter performance. The HEPA filter is tested using a thermally generated oil based aerosol with a particle size of 0.3 microns. Inlet aerosol concentration for the test must be 0.15 to 0.18 gr/dscf (80 to 100 mg/l). In comparison, ore crushing dust in the cartridge filter exhaust will be vs. 0.0025 gr/dscf or less.

*Institute of Environmental Science and Technology (IEST) Recommended Practice IEST-RP-CC01 (Type A, C or D)

should be understood that the triggering of an alarm does not mean that particulate emissions would have zero control. Rather, the triggering of an alarm means that the pressure drop has gone outside of the specified range but the control equipment (i.e., the cartridge filter + HEPA filter) is still operating and capturing fine particles. However, some adjustment is needed to the equipment to bring it back into the specified range for the pressure drop. The November 2011 Revised Addendum to the *Emission Control Technology Review for NorthMet Project Processing Plant* provides additional details on the agreement with MPCA regarding recycling controlled emissions exhaust back into buildings.

When baghouse/cartridge filter exhaust is vented to the atmosphere, residual dust in the filter exhaust mixes with the ambient air and disperses. Therefore, inhalable dust concentrations at the facility boundary are significantly reduced. Air quality modeling studies previously completed and soon to be updated for the SDEIS have shown that $PM_{2.5}$ emissions from the facility will meet ambient air quality standards. Therefore, the use of HEPA filters would provide little if any benefits for reducing exposure to fine particulates outside the facility boundary, while increasing cost and energy usage.

Equipment performance is expected to be verified through air emissions testing. Performance testing is expected to be conducted at periodic intervals during plant operations. Overall, the use of fabric filters to control potential fine particle emissions from sources associated with ore crushing at the Plant Site are expected to further reduce the potential for mineral fibers to be released to ambient air.

Ambient air concentrations of mineral fibers are currently being monitored in Hoyt Lakes. Baseline ambient air monitoring for mineral fibers was initiated voluntarily by PolyMet in May 2008 at a site located near the wastewater treatment plant in Hoyt Lakes. The monitoring location was approved by the MPCA and the monitoring is being conducted according to MPCA methodology. A 96-hour sample is collected every twelfth ($12^{th}$) day and is analyzed according to MDH specifications by a MDH-certified laboratory. Ambient air monitoring for mineral fibers will also be conducted for one year after facility start up. The mineral fibers data collected after the facility start up will provide comparison data to the baseline conditions.

# 4.0 Previously Submitted Reports on Fibers and Fine Particle Emissions

PolyMet Mining, 2007. NorthMet Mine and Ore Processing Facilities Project; Fibers data related to the processing of NorthMet deposit ore. Prepared by Barr Engineering Company. June 2007.

PolyMet Mining, 2007. Addendum 01, Supplemental Information to the Draft Report on Fibers Data Related to the Processing of NorthMet Deposit Ore. Prepared by Barr Engineering Company. September 2007.

PolyMet Mining 2007. Emission Control Technology Review for NorthMet Project Processing Plant. Prepared by Barr Engineering Company. October 2007.

PolyMet Mining 2009. Emission Control Technology Review for NorthMet Project Processing Plant. Addendum 01. Prepared by Barr Engineering Company. February 2009.

PolyMet Mining, 2011. Emission Control Technology Review for NorthMet Project Processing Plant. Revised Addendum 01. Version 2. Prepared by Barr Engineering Company. November 2011.

# Large Tables

## Large Table 1 Listing of Emission Units Associated with Crushing and Concentrating and Proposed Equipment to Control Fine Particle Emissions

| System | Equipment Served | Existing Control Equipment | Proposed Control Equipment (primary control / secondary control) | Performance Specification for Primary Control Device (grains per dry standard cubic foot) | Must Vent Inside? | Could Vent Inside? |
|---|---|---|---|---|---|---|
| | | | | | | |
| **Coarse Crushers** | | | | | | |
| North rail dump | North 60" crusher | Baghouse for 60" crusher | Upgraded baghouse | 0.0025 gr/dscf | No | No |
| North crushing | North distribution box and 36" crushers | Baghouse for 60" crusher | Cartridge | 0.0025 gr/dscf | No | No |
| South rail dump | South 60" crusher | Baghouse for 60" crusher | Upgraded baghouse | 0.0025 gr/dscf | No | No |
| South crushing | South distribution box and 36" crushers | Baghouse for 60" crusher | Cartridge | 0.0025 gr/dscf | No | No |
| North pan feeders | North pan feeder aspiration | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| South pan feeders | South pan feeder aspiration | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North pan feeder discharge | North transfer to conv. 1A | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North pan feeder discharge | North transfer to conv. 1B | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| South pan feeder discharge | South transfer to conv. 1A | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| South pan feeder discharge | South transfer to conv. 1B | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| **Drive House** | | | | | | |
| Conveyor transfer point | Conveyor 1A&2A | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| Conveyor transfer point | Conveyor 1B&2B | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| **Fine Crushers** | | | | | | |
| 2A tripper car dust collection | 2A tripper car | none | Cartridge w/ HEPA | 0.0025 gr/dscf | Yes | Year-round |
| 2B tripper car dust collection | 2B tripper car | none | Cartridge w/ HEPA | 0.0025 gr/dscf | Yes | Year-round |
| West tripper car discharge bins | West coarse ore bins | Baghouse + wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| East tripper car discharge bins | East coarse ore bins | Baghouse + wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| West fine crushers 1 and conveyance | W1 crushing line | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| West fine crushers 2 and conveyance | W2 crushing line | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| East fine crushers 1 and conveyance | E1 crushing line | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |
| Conveyor 3A, 3B, & 4B transfer point | Conveyor 3A, 3B, to 4B | Wet scrubber | Cartridge w/ HEPA | 0.0025 gr/dscf | No | Heating season only |

| System | Equipment Served | Existing Control Equipment | Proposed Control Equipment (primary control / secondary control) | Performance Specification for Primary Control Device (grains per dry standard cubic foot) | Must Vent Inside? | Could Vent Inside? |
|---|---|---|---|---|---|---|
| **Concentrator** | | | | | | |
| Conveyor transfer point | Conveyor 4B and 5N (North Transfer Point) | Wet scrubber | Cartridge | 0.0025 gr/dscf | No | No |
| 5N tripper car dust collection | 5N tripper car | none | Cartridge w/ HEPA | 0.0025 gr/dscf | Yes | Year-round |
| Analytical lab | Analytical lab dust collection | Wet scrubber | Cartridge | 0.0025 gr/dscf | No | No |
| North bin ventilation #1 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #2 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #3 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #4 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #5 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #6 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #7 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| North bin ventilation #8 | North fine ore bins | 1 of 3 wet scrubbers | 1 of 8 Cartridge w/ HEPA | 0.0025 gr/dscf | No | Year-round |
| Bin discharge conveyance section 1 | North concentrator lines 1-3 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | 0.0025 gr/dscf | No | No |
| Bin discharge conveyance section 2 | North concentrator lines 4-6 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | 0.0025 gr/dscf | No | No |
| Bin discharge conveyances section 3 | North concentrator lines 7-9 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | 0.0025 gr/dscf | No | No |
| Bin discharge conveyances section 4 | North concentrator lines 10-12 | 1 of 3 wet scrubbers | 1 of 4 Cartridge | 0.0025 gr/dscf | No | No |
| | | | | | | |
| | | | | | | |
| **Notes** | | | | | | |
| Cartridge filter as stated in vendor information is 99.99% efficient on particles sized 0.5 micron and larger. | | | | | | |
| HEPA filter as stated in vendor information is 99.97% efficient for particles sized 0.3 micron and larger. | | | | | | |
| Recommended HEPA filter failure detection is to monitor pressure drop across the HEPA filter. | | | | | | |
| HEPA filters will only be installed and used where venting will occur inside of buildings. | | | | | | |
| Performance specification of 0.0025 gr/dscf does not include additional potential removal of particulate from the use of HEPA filters (i.e., HEPA filters as a secondary control). | | | | | | |
| This table only lists dust collectors that will operate at the commencement of operations. Additional, redundant, equipment is included in the emission inventory and impact analyses completed to date and is planned to be included in the air emission permit for the facility. | | | | | | |

**Attachment J**

**Mercury Control Technology Review for NorthMet Project Processing Plant**

# *Mercury Emission Control Technology Review for NorthMet Project Processing Plant*

***Prepared for***
***PolyMet Mining Inc.***

***February, 2012***
***Version 2***

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# *Mercury Emission Control Technology Review for NorthMet Project Processing Plant*

## February, 2012

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# 1 Executive Summary

The proposed NorthMet Project (Project) will be a new source of mercury emissions to the air. The "Implementation Plan for Minnesota's Statewide Mercury Total Maximum Daily Load", dated October 2009, requires that new and modified sources of mercury "Employ the best mercury control available". This report is an evaluation of mercury emission control alternatives to verify that best available emission controls have been selected.

Estimated potential mercury emissions from the Project are 4.6 lbs per year. Sources of mercury emissions from the proposed project include:

- The autoclave in the Hydrometallurgical Plant (Autoclave)
- Ore crushing and grinding equipment in the Beneficiation Plant
- Fugitive dust emissions
- Combustion of gaseous fuels for space heating and limited process use.

The Hydrometallurgical Plant will use an Autoclave as part of a process to extract nickel, cobalt, gold and platinum group metals (PGM) from ore concentrate. The proposed project includes a two stage wet scrubbing system to control emissions of mercury and other pollutants from the Autoclave. Controlled mercury emissions from the Autoclave using the proposed two stage wet scrubbing system are calculated to be 4.1 pounds of mercury per year, or about 90% of Project mercury emissions. The concentration of controlled mercury emissions from the Autoclave is calculated to be 1.65 e-5 gr/dscf.

Several mercury control technologies used in the non-ferrous metal mining industry were evaluated, but most were found to be technically infeasible because the mercury concentration in the controlled Autoclave exhaust will be lower than what is feasible with these control systems. Activated carbon may be technically feasible for mercury control in this application, but the Autoclave exhaust will need to be cleaned and dried before treatment with activated carbon. A control cost evaluation was performed on activated carbon controls. Because controlled mercury emissions from the proposed two stage wet scrubbing system will be so low, the use of activated carbon controls will not be economically feasible. The control cost of activated carbon controls for the Autoclave would be $397,000 per pound of mercury. In its evaluation of mercury controls for the gold mining Maximum Achievable Control Technology (MACT) standard 40 CFR 63 Subpart EEEEEEE, the United States Environmental Protection Agency (USEPA) determined that costs above $40,000 per ton mercury

removed were not cost effective. No other mercury control system is capable of reducing mercury emissions lower than the proposed two stage wet scrubbing system. Therefore, the proposed two stage wet scrubbing system meets the test of being the best available mercury control system for the Autoclave.

Mercury emissions from ore grinding and crushing are in the form of particle bound mercury and will be controlled by fabric filters which have already been identified as the most effective emission controls for particulates in the "Emission Control Technology Review for NorthMet Project Processing Plant" dated October, 2007 and the February 2012 addendum (version 3).

Fugitive mercury emissions are in the form of particle bound mercury. Fugitive particulate emissions will be controlled by work practices specified in the NorthMet fugitive dust control plan. Measures specified in the dust control plan will be consistent with best practices used for fugitive dust control in the metallic ore mining industry.

The Project will use gaseous fuels for space heating and steam generation. Gaseous fuels are considered clean fuels, and have the lowest mercury content of any available fuel for these applications.

# 2 Introduction and Background

## 2.1 Purpose of Study

The proposed NorthMet Project (Project) will be a new source of mercury emissions to the air. The "Implementation Plan for Minnesota's Statewide Mercury Total Maximum Daily Load", dated October 2009, requires that new and modified sources of mercury, that have the potential to emit more than three pounds per year to the air, "Employ the best mercury control available".

The purpose of this report is to document that the proposed mercury control strategy for the Project meets the MCPA's policy requirement to use the best mercury control available per the criteria specified for new and modified sources in Appendix 6 of the implementation plan. Item 1 on page 1 of this appendix defines mercury control requirements as "the best control technically feasible considering environmental, energy and economic impacts".

This report focuses on the Plant Site, where there is the greatest potential for mercury emissions. There is also the potential for a small amount of mercury (~ 0.1 lb/year) to be emitted as a component of fugitive dust at the Mine Site. Fugitive dust at the Mine Site will be controlled with an approved fugitive emission control plan, and further discussion of the Mine Site was not considered necessary in this report.

## 2.2 Source Description

PolyMet Mining Inc. (PolyMet) plans to construct and operate a mine area near the town of Babbitt, MN, to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailing Basin near Hoyt Lakes, MN and to build an ore processing facility at the former LTVSMC site. The project description is provided in the March, 2011 Draft Alternative Summary for the NorthMet Project Environmental Impact Statement (EIS) and the NorthMet Project Description, version 3, submitted September 13, 2011.

The EIS Co-lead Agencies (Minnesota Department of Natural Resources, US Army Corps of Engineers, and US Forest Service) have concluded the proposed project requires a Supplemental Draft Environmental Impact Statement (SDEIS) and that the proposed approach for addressing mercury emissions should be described in the SDEIS.

Estimated potential mercury emissions from the Project are 4.6 lbs per year. Sources of mercury emissions from the proposed project include:

- The autoclave in the Hydrometallurgical Plant (Autoclave)
- Ore crushing and grinding equipment in the Beneficiation Plant
- Fugitive dust emissions
- Combustion of gaseous fuels for space heating and limited process use.

The Hydrometallurgical Plant will use an Autoclave as part of a process to extract nickel, cobalt, gold and platinum group metals (PGM) from ore concentrate. The proposed project includes a two stage wet scrubbing system to control emissions of mercury and other pollutants from the Autoclave system vent. The mercury control evaluation study will evaluate the effectiveness of the proposed emission control system versus other potential mercury emission control technologies. Controlled mercury emissions from the Autoclave system using the proposed two stage wet scrubbing system are calculated to be 4.1 pounds of mercury per year. The scrubber effluent is recycled within the hydrometallurgical process to conserve water. Water and waste solids discharged from the process which may contain mercury are sent to the Hydrometallurgical Residue Facility. Water from the residue facility is recycled back to the hydrometallurgical process. Please see NorthMet Project Residue Management Plan[1] for details on how solid residues from the Hydrometallurgical Plant, which may contain mercury, will be safely managed.

Ore crushing and grinding will generate particulate emissions which contain trace amounts of mercury. The Project will utilize fabric filters (baghouses and cartridge filters) to control particulate emissions from these sources. Dust collected from the fabric filters will be returned to the process for metallic mineral recovery. The use of fabric filters will ensure that emissions of particulate matter and particle bound mercury emissions are controlled at levels consistent with recent BACT determinations for the metallic ore processing industry. The performance of fabric filter controls proposed for the Project was documented in the report "Emission Control Technology Review, Addendum 01 Version 3" dated February, 2012, and no further review is necessary to show that fabric filters represent the best mercury control technology for ore crushing and grinding operations. Potential controlled mercury emissions from ore crushing and grinding operations are calculated to be 0.001 pounds per year.

[1] PolyMet Mining, Inc. NorthMet Project Residue Management Plan. Version 1. October 31, 2011.

The Project will use gaseous fuels for space heating equipment and the small amount of process fuel usage. Gaseous fuels have the lowest mercury content of fossil fuels available for use in space heating, and are considered clean fuels. Use of gaseous fuels represents the best mercury control technically feasible for fuel combustion through the use of clean fuels as a pollution prevention technique. Potential mercury emissions from fuel combustion in space heating equipment are calculated to be 0.50 pounds per year.

Fugitive dust emissions may be generated from transportation of Tailings Basin construction material, material handling of LTVSMC tailings used in dam construction and wind erosion at the Flotation Tailings Basins. The fugitive dust from these sources contains trace amounts of particle bound mercury. PolyMet will prepare and implement a fugitive dust control plan that describes the measures PolyMet will take to control these emissions. Dust control measures listed in the plan will be consistent with best management practices and dust control techniques used by other mining facilities in the area. A draft dust control plan is located in Attachment K of the "Emission Control Technology Review for NorthMet Project Processing Plant" dated October, 2007. Potential controlled mercury emissions associated with fugitive dust are calculated to be 0.025 pounds per year.

Flotation concentrate products may also contain a trace amount of mercury, but this material will be damp and handled indoors, so fugitive emissions are not expected to occur. The emission inventory and air dispersion modeling assume a dedicated ventilation system, with dust control, for these activities as a worst case, but this equipment will only be installed if necessary. The worst case emissions were estimated at 0.0005 pounds per year.

## 2.3 Forms of Mercury Emissions

Mercury can be emitted to the atmosphere in three forms:

- Particle bound mercury
- Oxidized mercury
- Elemental mercury

Particle bound mercury is, as its name implies, mercury which is chemically bound up in dust particles. An example of particle bound mercury is the dust from ore crushing. Mercury exists as a trace element commonly found in metallic ores. When ore is crushed to facilitate further processing, the dust generated during crushing will also contain trace amounts of mercury. Because the mercury

is bound up in the ore dust particles, the mercury can be captured along with the dust particles in a particulate control device such as a baghouse.

Elemental mercury is pure mercury. Elemental mercury is released when mercury containing materials are combusted or processed at high temperatures. Under these conditions, mercuric compounds break down and pure mercury is released in a gaseous state. Because it is a gas, it cannot be captured efficiently in a particulate control device. Elemental mercury is not water soluble; so; it cannot be easily captured in a wet scrubber. Elemental mercury can be captured directly by adsorption using activated carbon. Alternatively, it can be oxidized by chemical reactions and then captured in an absorber or wet scrubber.

Oxidized mercury is mercury which through chemical reactions has given up some of its electrons so that is has a positive electrical charge. In this form, mercury will bond with halogens or sulfides to form a salt. Elemental mercury can be oxidized by chlorides, bromides or sulfur compounds. Oxidized mercury is water soluble; so, it can be captured in an absorber or wet scrubber.

## 2.4 Non-Ferrous Ore Processing

Several types of mercury control technologies were developed to control mercury emissions from non-ferrous metal ore processing. These mercury emission control technologies were included in the evaluation of potential mercury control technologies for use on the Autoclave exhaust. The Nevada Department of Environmental Protection (NDEP) and the United States Environmental Protection Agency (USEPA) have recently evaluated mercury emissions from gold mining operations. Information from these reviews was also included in the review of mercury control options for the Autoclave. The following section provides background information on sources of mercury and mercury emission control technologies used in non-ferrous metallic ore processing.

In non-ferrous metallic ores containing metals such as copper, zinc, tin and lead, the metals are often found in chemical complexes containing sulfur. The sulfur must be removed before the ore can be processed into pure metals. The traditional method of driving off the sulfur is roasting the ore in ovens at temperatures of 1,000° F or more. The sulfur is released from the ore primarily as sulfur dioxide. The roasting process also drives off any carbonaceous material in the ore which could inhibit downstream processing. If sulfur dioxide in the oven exhaust is present in sufficient concentrations, it can be converted to sulfuric acid and sold as a byproduct. The oven exhaust stream must be cooled cleaned and dried before it can be processed into sulfuric acid.

If mercury is present in the ore, it will be volatilized in the roasting ovens and it will be exhausted primarily as elemental mercury. Particle bound and oxidized mercury in the oven exhaust will be removed by particulate controls in the gas cleaning and cooling system. Elemental mercury will pass through these steps, and if not removed, will contaminate the sulfuric acid by-product. To prevent mercury contamination of the sulfuric acid byproduct, the industry developed mercury emission control technologies. All of the gas phase mercury removal processes developed for non-ferrous metal production were designed for removing mercury from the clean/dry oven exhaust prior to entering the sulfuric acid plant.

Alternatively, some non-ferrous metallic ores can be processed in autoclaves to oxidize the sulfur and to prepare the ore for further processing. In preparation for processing in an autoclave, the ore is ground and mixed with water to form a slurry. The slurry is pumped in to the autoclave where pure oxygen is injected. The autoclave operates at temperatures of 350° F to 400° F and a pressure of 300 to 500 pounds per square inch (PSI). Under these conditions, the oxygen reacts with the sulfur to form sulfuric acid. Because autoclaves operate at much lower temperatures than roasting ovens, most mercury is in either particle bound or oxidized form. Upon exiting the autoclave, the slurry goes to a depressurization vessel where non condensable gases are separated from the slurry. As the pressure is reduced in the depressurization vessel, some slurry water vaporizes to form steam. As a result, the depressurization vessel, also referred to as a flash vessel, exhaust is composed primarily of steam and the non condensable gases (carbon dioxide, nitrogen and oxygen) comprise only ten to twenty five percent of the off gas. This off gas will also contain small amounts of sulfur dioxide and mercury. The depressurization vent is scrubbed to remove particulates and other contaminants prior to being exhausted to the atmosphere.

## 2.5 Recent Regulatory Evaluations of Mercury Emission Controls for the Gold Mining Industry

Gold mining is a non-ferrous metal ore processing industry which can be a significant source of mercury emissions. Gold ore, depending on its composition, may be processed in roasting ovens or in autoclaves. Recent regulatory evaluations of the gold mining industry can provide valuable information on the cost and effectiveness of mercury emission control options for the Autoclave. It must be noted that potential mercury emissions from the Project are less than one tenth of the mercury emissions from a typical autoclave used to process gold ore, so the reduced mercury emission rate is a significant factor when comparing mercury control options for the Project versus the mercury control in the gold mining industry.

A majority of the gold mines in the United States are located in the State of Nevada. The NDEP has studied mercury emissions from gold processing and beginning in May, 2006 implemented a mercury reduction program for thermal processing units located at precious metal mines. As a result, the NDEP has collected a significant amount of information on the cost and performance of several mercury control technologies. The NDEP website contains a database of performance test results on several types of mercury controls used in various stages of the gold production process. One of the air quality permits issued under the mercury reduction program includes a mercury control evaluation for an autoclave system similar in size to that proposed for the Project.

The USEPA recently evaluated mercury emission control options for gold mining under the 40 CFR Part 63 program for control of Hazardous Air Pollutants. Per 40 CFR Part 63 requirements for establishing emission standards, the USEPA reviewed information on mercury emission control technologies in use at gold mines to identify the top emission control systems in operation today, and developed mercury emission standards based on the top performing facilities. The results of this evaluation are summarized in the preamble to the proposed regulations published on April 28, 2010 in the Federal Register Volume 75, No. 81 pages 22470 -22497 and the final regulations published on in Federal Register Volume 76 No. 33 pages 9450 – 9489. Please note that standards issued under 40 CFR 63 Subpart EEEEEEE are not applicable to the Project because the project is intended to produce nickel, cobalt and PGM concentrates as its primary products and the small amount of gold contained in the PGM concentrate is below the deminimus amount specified for the regulation to apply.

# 3 Emission Control Technology Options

## 3.1 Description of Emission Control Trains for Non-ferrous Ore Processing

Vent streams from non-ferrous metal ore processing can contain high levels of particulates as well as gaseous pollutants. For those streams with high concentrations of particulate matter, multiple stages of emission control may be required. After primary controls and before second and/or third stage mercury controls, additional gas conditioning and fine particulate removal systems may be needed. To simplify the review of multi stage emission control trains, emission controls have been grouped in first, second and third stage controls. Figure 1 and Figure 2 at the end of this section are block flow diagrams showing emission control trains for ore roasting and autoclaves systems. Figure 3 is a block flow diagram of a mercury control system for the Autoclave system as proposed. Attachments A and B contain examples of gas treatment systems for sulfuric acid plants at non-ferrous ore processing facilities. Attachment A is the Autotec gas treatment and conditioning system. Attachment B contains Hugo Petersen gas conditioning and mercury removal systems.

**First stage emission controls**

Typically particulate controls are the first stage in the emission control system; this is done so that particulate matter will not adversely affect downstream processes and second and/or third stage emission control systems. Particulate controls also control particle bound mercury, and in some cases oxidized and some elemental mercury are removed.

**Second stage emission controls**

The second stage mercury controls are designed to control relatively high mercury concentrations. Historically, these controls were designed to treat non-ferrous metal processing off gas streams prior to being used as feedstock for sulfuric acid production. In second stage controls, gas phase mercury is absorbed into a scrubbing liquid and, in most cases; the mercury then reacts with chemicals in the scrubbing solution for permanent capture.

In some cases, gaseous mercury concentrations are high enough that mercury can be captured by condensation. Condensation occurs when a gas is cooled to temperatures below the dew point of chemical compounds in the gas. In gold processing, mercury condensers are typically used when

gold concentrate is heated to remove mercury (retort furnaces) which has been concentrated along with the gold.

Condensation can also be used to remove excess water from gas streams. This is done in cases where the water content of the off gas stream would adversely affect the operation of an emission control system by diluting reagents in the scrubbing solution or interfering with the adsorption process in activated carbon controls. In this report, condensation of water is classified as gas conditioning to differentiate it from mercury condensation.

**Third stage emission controls**

Third stage mercury controls evaluated are controls best suited to controlling streams with low mercury concentrations. These technologies may also be used effectively as polishing controls downstream of controls used in high mercury concentration applications. In third stage controls, gas phase mercury is captured by adsorption (activated carbon) and/or chemical reaction.

## 3.2 Mercury Emission Control Options for Autoclave Exhaust

**Particulate (first stage) controls evaluated include:**

- Wet Scrubbers and Venturi Scrubbers
- Fabric Filters (baghouse or cartridge filter)
- Dry Electrostatic Precipitators (Dry ESPs)
- Wet Electrostatic Precipitators[2] (Wet ESPs)
- Cyclones and Mechanical Collectors

**Absorption/Chemical Reaction (second stage) controls evaluated include:**

- Wet scrubbers and venturi scrubbers
- Sodium hypochlorite scrubbers
- Boliden Norzink Process (calomel scrubbers)
- Outokumpu Process (sulfuric acid scrubbing)
- Bolkem Process (sulfuric acid scrubbing)
- Sulfide Precipitation (hydrogen sulfide reagent)
- Hg Condensation

[2] Wet ESPs may also be included in gas conditioning systems downstream of the primary particulate control system.

**Adsorption/Chemical Reaction (third stage) controls evaluated include:**

- Activated Carbon
- Sulfur Impregnated Activated Carbon
- Selenium Filter

**Condensation:**

- Heat Exchangers for Mercury Condensation

Figure 1 on the following page is a block flow diagram of a mercury control system for a gold ore roaster. Its design is similar to other non-ferrous ore processing system as described in Section 2.4. There are two gold ore roasting systems in Nevada which are equipped with similar mercury emission control systems. One system has a dry ESP followed by a wet scrubber for primary particulate control; the other system has a venturi scrubber. These systems remove particle bound and oxidized forms of mercury. After primary particulate control, the gas stream is cooled and then goes through a wet ESP for fine particulate control and some additional mercury removal. After the fine particulates are removed, the gas goes through fluoride and mercury removal systems. Only one of the facilities has a fluoride scrubber. Both facilities use calomel scrubbers for mercury control. The calomel scrubbers can remove the elemental mercury which could not be effectively captured in the upstream control systems. After mercury scrubbing; one plant's off gas serves as feed to a sulfuric acid plant; the other plant's exhaust is clean enough to vent directly to atmosphere.

Figure 2 on the following page is a block flow diagram of a mercury control system for gold ore autoclaves. All gold ore autoclave systems in Nevada are equipped with venturi scrubbers as the primary controls for mercury and other pollutants. Most existing gold autoclaves vent to atmosphere after the venturi scrubber. For additional mercury control, an activated carbon adsorption system can be added as a polishing mercury emission control. However, the autoclave exhaust is to hot and its moisture content is too high for activated carbon. Therefore, additional gas conditioning equipment is needed to cool and reduce the humidity of the autoclave exhaust to meet carbon adsorption system operating requirements.

Figure 3 on the page following Figure 1 and Figure 2 is a block flow diagram of a mercury control system for the Autoclave as proposed. To incorporate activated carbon controls, a gas conditioning system would be required between the packed bed scrubber outlet and the activated carbon bed.

**Figure 1 Example Gold Ore Roaster Mercury Emission Control System**

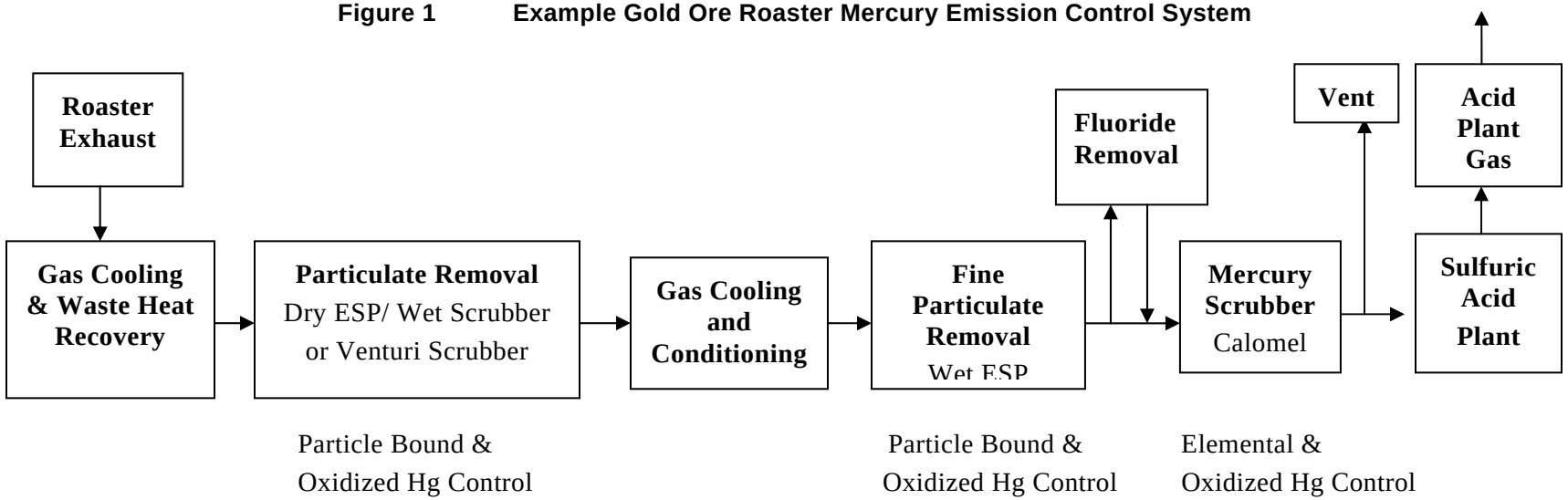



**Figure 2 Example Gold Ore Autoclave Mercury Emission Control System**

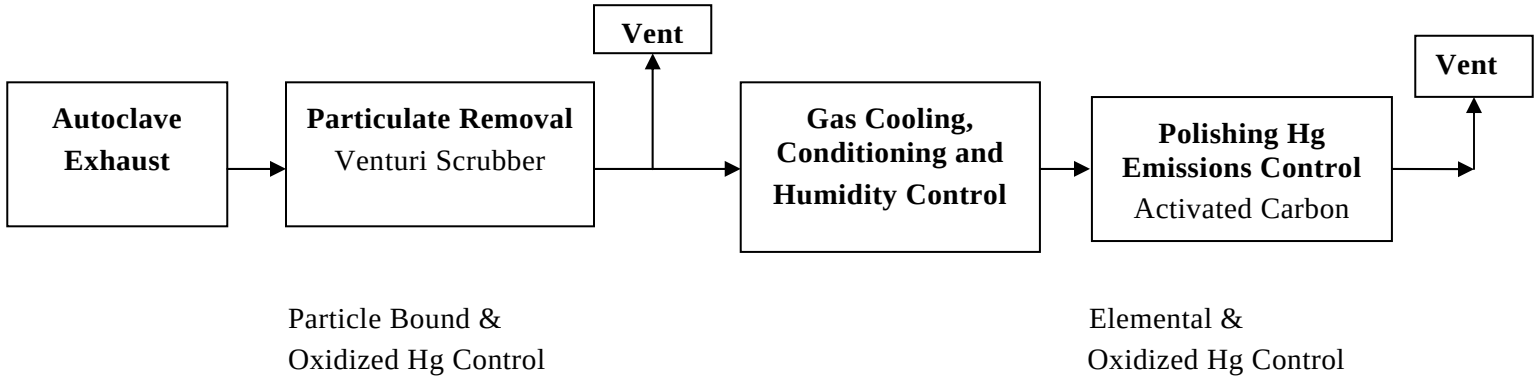
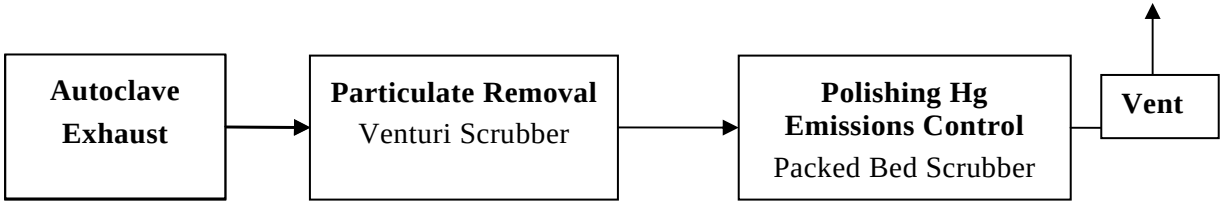


**Figure 3 Project Proposed Autoclave Mercury Emission Control System**




Particle Bound & Oxidized Hg Control

Particle Bound & Oxidized Hg Control

# 4 Technical Feasibility of Emission Control Technologies

## 4.1 Autoclave Exhaust Conditions

Table 4-1 below is a comparison of the design data for the Autoclave vent stream vs. the vents off of two gold mine autoclave systems. The Goldstrike mine is located in Elko, Nevada; the Placer Dome Campbell mine is located in Balmertown, Ontario Canada. All three systems have similar temperatures and high moisture contents. Flow rates for the Project are similar to the Barrick Goldstrike mercury control system designed to accommodate the flow from all six autoclaves. The Project's proposed two stage scrubber system vent has mercury concentrations which are about one tenth of the single stage scrubber exhaust at Placer Dome and Barrick gold mines. To meet the 40 CFR Part 63 Subpart EEEEEEE standards, Barrick will install an activated carbon mercury control system like the one shown in Figure 2. Assuming a 90% control rate for activated carbon, the Barrick mercury concentration would be reduced levels similar to the Autoclave exhaust with two stage scrubbing.

**Table 4-1 Comparison of Autoclave Exhaust Steams**

| Autoclave Vent Stream vs. Gold Mine Autoclave Vent Streams | | | |
|---|---|---|---|
| | **Project Design** | **Placer Dome Campbell Mine[1]** | **Barrick Goldstrike Mine[2]** |
| **Controls** | **Two stage Venturi/Packed Bed Scrubber** | **Single Stage Venturi Scrubber** | **Single Stage Packed Bed Scrubber** |
| **Composition Mole %** | | | |
| N2 | 3.3% | 4.7% | |
| CO | | 0.01% | |
| CO2 | 5.2% | 0.2% | |
| O2 | 4.1% | 10.7% | |
| H2O | 87.5% | 84.5% | 71.7% |
| Total | 100.0% | 100.0% | |
| **Temperature F** | 202 | 185 | 194 |
| **Flow** | | | |
| ACFM | 37,268 | 5,955 | 51,760 |
| SCFM | 29,724 | 4,875 | 41,761 |
| DSCFM | 3,302 | 757 | 11,820 |

| Autoclave Vent Stream vs. Gold Mine Autoclave Vent Streams | | | |
|---|---|---|---|
| | **Project Design** | **Placer Dome Campbell Mine[1]** | **Barrick Goldstrike Mine[2]** |
| **Controls** | **Two stage Venturi/Packed Bed Scrubber** | **Single Stage Venturi Scrubber** | **Single Stage Packed Bed Scrubber** |
| **Exhaust Mercury Conc** | | | |
| gr/dscf | 1.65E-05 | 2.06E-04 | 1.45E-04 |
| $mg/Sm^3$ | 0.037 | 0.464 | 0.326 |

1. Emissions Summary and Dispersion Modeling Report, Appendix E dated February, 2003 for Placer Dome – Campbell Mine.
2. Calculated from data in the Barrick Goldstrike autoclave permit application. See footnote 4.

## 4.2 First Stage Mercury Control Options

### 4.2.1 Venturi Scrubbers/Wet Scrubbers

Wet scrubbers, also termed particulate scrubbers, remove particles from process exhaust gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. The droplets transport the particulate out of the gas stream.

Scrubbers may capture particulates through the following mechanisms:

- Impaction of the particle directly into a target droplet;
- Interception of the particle by a target droplet as the particle comes near the droplet; or
- Diffusion of the particle through the gas surrounding the target droplet until the particle is close enough to be captured.

Scrubbers are generally classified according to the liquid contacting mechanism used. The most common scrubber designs are spray-chamber scrubbers, cyclone spray chambers, orifice and wet-impingement scrubbers, and venturi scrubbers. Wet scrubbers require a waste water discharge or recycling of scrubber water to the process. Scrubber control efficiency for particulate matter under normal loading conditions typically is in the 98 – 99+ percent range. Scrubber efficiency is a function of pressure drop across the scrubber. So, higher collection efficiencies will consume more electrical power to operate the scrubber blower. Reduced efficiencies will occur when the inlet particle concentration is low.

A venturi scrubber enhances particulate removal through turbulent mixing. The inlet to the venturi is a conical shaped section which tapers from the inlet duct diameter down to the venturi throat. The venturi throat is a narrow cylindrical section. Gas velocity must increase to pass through the narrow opening in the

venturi throat. As a result of the increase in gas velocity, highly turbulent flow patterns are created. Water injected into the throat is broken into fine droplets and mixed intimately with gases by the turbulent flow. Particulate matter, mercury and other pollutants the off gas are captured by the water droplets and removed. The venturi outlet is a tapered section which has an increasing diameter. This reduces the venturi outlet gas velocity and turbulence and which allows the water droplets to combine and form larger droplets. When the gas enters the settling chamber the enlarged water droplets are separated from the off gases. A demister at the settling chamber outlet captures entrained water droplets to minimize the amount of free water in the venturi scrubber exhaust.

Wet scrubbers are feasible in this application. As noted above, all gold ore autoclave systems in Nevada use venturi scrubbers. No active U.S. gold mines outside the state of Nevada use autoclaves. One gold mining autoclave application in Canada (the Campbell Mine) uses a packed bed scrubber.

### 4.2.2 Baghouses

A fabric filter (baghouse or cartridge filter) consists of a number of fabric bags or cartridges placed in parallel inside of an enclosure. Particulate matter is collected on the surface of the bags as the gas stream passes through them. A dust cake forms on the outside of the filter as particles are collected. The dust cake provides additional particle filtration which contributes to the overall baghouse particulate collection efficiency.

The main operating limitations of a baghouse are that the material collected must be dry and operating temperature is within the temperature limitations of the bag material. If the off gas is saturated with water and/or it contains free water, the filter cake will become wet and blind off the filter, stick to the filter media or clog up the dust hoppers and dust removal system.

The Autoclave exhaust will be saturated with water and will contain free water droplets. Therefore, a baghouse is not feasible on the autoclave exhaust. No gold ore autoclave systems use baghouses or cartridge filters as particulate controls.

### 4.2.3 Dry Electrostatic Precipitators

A dry electrostatic precipitator applies electric forces to separate suspended particles from the flue gas stream. In an ESP, an intense electrostatic field is maintained between high-voltage discharge electrodes, typically wires or rigid frames, and grounded collecting electrodes, typically plates. A corona discharge from the discharge electrodes ionizes the gas passing through the precipitator, and gas ions subsequently ionize the particles. The electric field drives the negatively charged particles to the collecting electrodes.

Periodically, the collecting electrodes are rapped mechanically to dislodge collected particulate matter, which falls into hoppers for removal.

ESP installations are not feasible in applications where the combination of sparking and dry material creates the potential for dust explosion or in wet applications where the presence of liquid water could cause shorting of the electrodes.

The Autoclave exhaust will be saturated with water and will contain free water droplets. Therefore, a dry ESP is not feasible on the Autoclave exhaust. Dry ESPs are used for particulate control in gold ore roasting. No gold ore autoclave systems use dry ESPs as particulate controls.

### 4.2.4 Wet Electrostatic Precipitators

A wet electrostatic precipitator operates in the same manner as a dry ESP; it applies electric forces to separate suspended particles from the flue gas stream. Particle removal in a wet ESP is accomplished with water sprays instead of mechanical cleaning methods. Electrical grids are depowered during cleaning to prevent shorting. As a result of using water sprays, wet ESPs generate wastewater which must be treated to remove suspended particles and dissolved solids. Alternatively, scrubber water can be recycled to the process if this is allowed by process chemistry.

Wet ESP control efficiency under normal loading conditions typically is in the 98 - 99+ percent range. Reduced efficiencies will occur when the inlet particle concentration is low. Outlet particle concentrations of filterable particulates as measured by USEPA Method 5 can be as low as 0.005 gr/dscf.

Wet ESPs are used for fine particulate control in gold ore roasting. No gold ore autoclave systems use wet ESPs for particulate control. Use of a wet ESP on the Autoclave exhaust may be feasible.

### 4.2.5 Cyclones/Mechanical Collectors

Mechanical collectors use a variety of mechanical forces to collect particulate matter:

- Inertial separators use inertia and gravity to remove larger particles from smaller ones.
- Cyclones use centrifugal force to separate particulate matter from gas streams.

Drop-out boxes are typically used as inertial separators. Larger particles are trapped in drop-out boxes as the inertia they contain forces them to go straight as the rest of the gas stream turns to flow into and out of the drop-out box. Particles are also removed by gravitational settling in the drop-out box. Inertial

separators can only remove the larger dust particles (>75 microns). They are typically used upstream of other control devices in high inlet dust loading cases.

Cyclone separators are designed to remove particles by inducing a vortex as the gas stream enters the chamber, causing the exhaust gas stream to flow in a spiral pattern. Centrifugal forces cause the larger particles to concentrate on the outside of the vortex and consequently slide down the outer wall and fall to the bottom of the cyclone, where they are removed. The cleaned gas flows out of the top the cyclone.

If off gas entering a cyclone or mechanical collector is saturated with water and/or it contains free water, the dust will become wet and stick to the dust collector walls and/or clog up the dust removal system.

The autoclave exhaust will be saturated with water and will contain free water droplets. Therefore, mechanical separators and cyclones are not feasible on the autoclave exhaust. No gold ore autoclave systems use cyclones or mechanical collectors for particulate control.

## 4.3 Second Stage Mercury Emission Controls

Most second stage mercury control systems use absorption. As noted above, water based scrubbers can be used to effectively capture particle bound mercury. Oxidized mercury is water soluble, so water based absorbers (wet scrubbers) can be used for enhanced oxidized mercury control. The removal efficiency of absorption systems can be enhanced through the use of additives and reagents to increase the solubility of the mercury and/or chemically bond with the mercury to permanently capture it.

One gas phase mercury control system was also identified. In this process, a chemical reaction results in formation of a solid phase mercury compound that is removed from the off gas stream by particulate emission controls.

### 4.3.1 Venturi Scrubbers/Wet Scrubbers

The most common wet scrubber designs are spray-chambers, packed bed towers, tray tower absorbers and venturi scrubbers. For emission control by absorption, gas/liquid contact is a key factor in maximizing the amount of gaseous pollutants which can be absorbed by the scrubbing solution. Spray towers and venturi scrubbers use water sprays to generate liquid surface area which contacts contaminated gas flowing through the spray tower or venturi scrubber. Packed towers are filled with specially shaped objects (packing) to provide a large area for gas liquid contact. The scrubbing liquid is pored over the top of the packing material and trickles down through the bed coating the outside of the packing. Contaminated gas flows up through the tower and flows over, around and through openings in the packing so that contaminants in the

gas can be absorbed by the scrubbing liquid flowing over the packing. Tray tower scrubbers have a number of internal trays. Each tray has a weir which holds scrubbing liquid on top of the tray and it has openings in the tray which force the contaminated gas to flow up through the liquid on each tray. The weir system on the trays allows the scrubbing liquid to flow down through the tower over each tray. The contaminated gas flows up through the tower contacting the scrubbing liquid on each tray.

Venturi scrubbers and wet scrubbers are feasible second stage mercury controls for the Autoclave exhaust.

### 4.3.2 Sodium Hypochlorite Scrubber

Sodium hypochlorite can be used to oxidize elemental mercury; thus making it water soluble and available for capture by absorption in a wet scrubber. In Nevada, there is one gold mine[3] where sodium hypochlorite is added to a wet scrubber to enhance mercury removal. Scrubbers must maintain a hypochlorite concentration of 1,000 ppm. Stack test data from the scrubber outlet has an average controlled mercury concentration of 1.68 e-4 gr/dscf[4]. The Autoclave scrubber outlet concentration is calculated to be 1.65 e-5 gr/dscf, which is ten times less than the mercury concentration at the outlet of the hypochlorite scrubber. Because the Autoclave scrubber outlet mercury concentration is so low, the use of sodium hypochlorite is considered technically infeasible for mercury control on the Autoclave exhaust.

In addition, the additional chlorine in the scrubber discharge could have an adverse impact on processes using water recycled from the autoclave scrubber.

### 4.3.3 Boliden Norzink Process (Calomel Scrubber)

The Boliden Norzink process uses a mercuric chloride solution which reacts with elemental mercury to form a mercuric chloride precipitate, known as calomel. Thus, the Boliden Norzink process is often referred to as a "calomel" scrubber. The reaction is as follows:

$$HgCl_{2\ (H2O\ solution)} + Hg_{(gas)} \rightarrow Hg_2Cl_{2\ (solid)}$$

Calomel produced by this reaction may be sold for the production of elemental mercury or disposed of. A portion of the calomel collected from the process may be regenerated to mercuric chloride for reuse in the scrubber using chlorine gas.

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[3] Newmont Mining Corporation - Twin Creeks Mine uses sodium hypochlorite scrubbers to remove mercury from its carbon kiln exhaust streams.

[4] Data from NDEP Mercury Emissions Management System Online located on the NDEP mercury website at http://ndep.nv.gov/bapc/hg/clearinghouse.html

The Boliden Norzink Process was originally developed as a pretreatment step to prepare non-ferrous metal processing off gas in sulfuric acid production plants. It is the most widely used mercury control technology used in non-ferrous metallic ore processing. The United Nations Program Environment November 2010 report[5] on controlling mercury emissions states that the Boliden Norzink process has a mercury control efficiency of 90% to 95% in base metal smelting operations. This process is used to control mercury emissions from roasting operations at two gold mining facilities in Nevada. The Gold Quarry mine uses calomel scrubbers to pre-treat the feed to a sulfuric acid plant. The Goldstrike mine uses calomel scrubbing only for mercury control.

The Nevada MACT[6] analysis for autoclave operation at the Barrick Goldstrike mine reports that calomel scrubbing can reduce mercury concentrations down to 1 e-5 gr/dscf to 2 e-5 gr/dscf. This report also states that calomel scrubbers have not been used to control mercury emissions from gold ore processing autoclaves. The NDEP Mercury Emission Data Management System (MEMS) Database shows that the average mercury concentration from the Goldstrike calomel scrubber was 2.94 e-4 gr/dscf. The Autoclave scrubber outlet concentration is calculated to be 1.65 e-5 gr/dscf, which is within the reported limit on mercury control exhaust streams from calomel scrubbers and ten times less than the average mercury concentration at the outlet of the Goldstrike ore roasting calomel scrubber system. Because the Autoclave scrubber outlet mercury concentration is so low, the use of calomel scrubbers is considered technically infeasible for mercury control on the Autoclave exhaust.

The Gold Quarry mine results are not representative for this application because testing was conducted at the exhaust of the sulfuric acid plant. In a sulfuric acid plant, the sulfuric acid removes additional mercury. Therefore the reported results are lower than what is achievable with calomel scrubbing alone.

### 4.3.4 Outokumpu Process

The Outokumpu process removes mercury in non-ferrous ore processing off gas streams by absorption in sulfuric acid by the following reaction:

$$Hg + H_2SO_4 + \tfrac{1}{2} O_2 \rightarrow HgSO_4 + H_2O$$

The Outokumpu process is used to pre-treat smelter off gas prior use of the off gas as feedstock in a sulfuric acid plant. The off gas is scrubbed with an 80% to 90% sulfuric acid solution at a temperature range of

[5] Study on mercury sources and emissions, and analysis of cost and effectiveness of control measures "UNEP Paragraph 29 study"

[6] Application for Mercury Air Quality Operating Permit to Construct, Appendix 3 - Nevada MACT Analysis dated February, 2008, prepared for Barrick Goldstrike Mines Inc. Elko, NV. by Air Sciences Inc

265° F to 300° F. Mercury sulfate is recovered as a precipitate from the scrubbing solution. Estimated mercury control using this method on high concentration streams is 90%.

Use of this process would require PolyMet to bring additional sulfuric acid site and would require additional neutralization equipment to treat the spent sulfuric acid.

The web site "Sulphuric Acid on the Web™ (ww.sulphfuric-acid.com) reports in the Gas Cleaning System – Mercury Removal page[7] that the Outokumpu process has a mercury control efficiency of 90%, which slightly less than the Boliden Norzink process (calomel scrubber). The best performance the Outokumpu process could achieve would be 1 e-5 gr/dscf to 2 e-5 gr/dscf versus the Autoclave scrubber outlet concentration of 1.65 e-5 gr/dscf. Therefore, the Outokumpu process would be considered technically infeasible on the Autoclave exhaust.

### 4.3.5 Bolkem Process

The Bolkem process removes mercury in non-ferrous ore processing off gas streams by absorption in sulfuric acid by the following reaction:

$$H_2SO_4 + Hg \rightarrow Hg_2SO_4$$

The Bolkem Process is also used to pre-treat smelter off gas prior to use of the off gas as feedstock in a sulfuric acid plant. The off gas is scrubbed in two drying towers in series with sulfuric acid solutions of 80% $H_2SO_4$ and 93% $H_2SO_4$ at a temperature range of less than 120° F. The mercurous sulfate is oxidized to mercuric sulfate by oxygen in the strong acid solution (93%). A bleed stream of the 93% acid is treated with sodium thiosulfate to precipitate the mercury as mercuric sulfide.

Use of this process would require PolyMet to bring additional sulfuric acid site and would require additional neutralization equipment to treat the spent sulfuric acid.

The web site "Sulphuric Acid on the Web™ reports that the Bolkem process has a mercury control efficiency of approximately 90%, slightly less than the Boliden Norzink process (calomel scrubber). Therefore, the Bolkem process would be considered technically infeasible for the same reasons stated above for a calomel scrubber.

[7] The address of the mercury removal page is http://www.sulphuric-acid.com/techmanual/GasCleaning/gcl_hg.htm

### 4.3.6 Sulfide Precipitation

Sulfide Precipitation is a gas phase mercury control process. Sulfide precipitation can be used to pre-treat non-ferrous ore processing off gas prior use of the off gas as feedstock in a sulfuric acid plant. Hydrogen sulfide ($H_2S$) gas is injected into the smelter off gas stream at a stoichiometric ratio of 1.5 to 2.0. Mercuric sulfide is formed by the following reactions:

$$2\ H_2S + SO_2 \rightarrow 3\ S + 2\ H_2O$$
$$S + Hg \rightarrow HgS_{(solid)}$$
$$H_2S + Hg \rightarrow HgS_{(solid)} + H_2$$

Mercuric sulfide particles are recovered in downstream particulate emission controls

Use of this process would require PolyMet to generate hydrogen sulfide gas on site, and to install gas cleaning equipment to remove residual $H_2S$ from the off gas stream after sulfide precipitation is complete.

The web site "Sulphuric Acid on the Web™ reports that the sulfide precipitation process has a mercury control efficiency of approximately 90%, slightly less than the Boliden Norzink process (calomel scrubber). Therefore, sulfide precipitation would be considered technically infeasible for the same reasons stated above for a calomel scrubber.

### 4.3.7 Selenium Scrubber

A selenium scrubber process removes mercury in non-ferrous ore processing off gas by the reaction of amorphous selenium in a 20% to 40% solution of sulfuric acid. Mercury vapors are captured in the sulfuric acid solution by absorption in a packed column.

The mercury - selenium reaction is as follows:

$$Hg + Se \rightarrow HgSe$$

Use of this process would require PolyMet to bring additional sulfuric acid on-site and would require additional neutralization equipment to treat the spent sulfuric acid. Is would also require the use of selenium, a hazardous material.

The web site "Sulphuric Acid on the Web™ (ww.sulphfuric-acid.com) reports in the Gas Cleaning System – Mercury Removal page[8] that the selenium scrubbers have a mercury control efficiency of approximately

[8] The address of the mercury removal page is http://www.sulphuric-acid.com/techmanual/GasCleaning/gcl_hg.htm

90%, slightly less than the Boliden Norzink process (calomel scrubber). Therefore, selenium scrubbing is considered technically infeasible for the same reasons stated above for a calomel scrubber.

### 4.3.8 Mercury Condenser

In gold processing, mercury condensers are typically used when gold concentrate is heated to remove mercury (retort furnaces) which has been concentrated along with the gold. Condensation occurs when a gas is cooled to temperatures below the dew point of chemical compounds in the gas. The Nevada MACT[9] analysis for autoclave operation at the Barrick Goldstrike mine reports that mercury condensation can reduce mercury concentrations down to 6.1 e-3 gr/dscf. The Autoclave scrubber outlet concentration is calculated to be 1.65 e-5 gr/dscf. Because the Autoclave scrubber outlet mercury concentration is so low, the use of mercury condensers is not considered technically feasible for mercury control.

## 4.4 Third Stage Mercury Emission Controls

Third stage mercury controls are controls best suited to controlling streams with low mercury concentrations. These technologies may also be used effectively as polishing controls downstream of controls used in high mercury concentration applications. In third stage controls, gas phase mercury is captured by adsorption (activated carbon) and/or chemical reaction.

### 4.4.1 Gas conditioning requirements

The effectiveness of the thirds stage mercury controls being evaluated is limited by the temperature, and moisture content of the gas being treated. Excessive particulate matter may also reduce the effectiveness of mercury controls. The temperature and water content of a gas steam may be reduced by quench cooling with water injection or/or through the use of heat exchangers. Air, water and refrigerants may be used as cooling media in heat exchanger systems. Wet ESPs are typically used for fine particulate control upstream of second stage mercury controls in non-ferrous metal ore processing due to the moisture content of the off gas downstream of quench cooling systems. After cooling and drying, gas reheating may be required to adjust the final relative humidity of the off gas before third stage treatment.

### 4.4.2 Activated Carbon

The mercury compounds in the waste gas stream are adsorbed on the surface of the activated carbon by intermolecular forces. All forms of mercury can be captured using activated carbon. Due to the low volume of off gas, activated carbon beds are used for mercury control in the gold mining industry. Due to similar off

[9] Application for Mercury Air Quality Operating Permit to Construct, Appendix 3 - Nevada MACT Analysis dated February, 2008, prepared for Barrick Goldstrike Mines Inc. Elko NV. by Air Sciences Inc

gas characteristics of gold autoclave exhaust and the Autoclave exhaust, carbon beds are an appropriate option for treating the Autoclave exhaust.

Carbon adsorption rates are limited by the moisture content of the off gas. Capillary water condensation can occur in the activated carbon pores. Most adsorption sites are located within the pore space of activated carbon, and the presence of liquid water due to capillary condensation effectively blocks off these adsorption sites. In its analysis for activated carbon control of mercury emissions from autoclaves in the gold mining industry (FR 75, No. 81 Page22483), USEPA notes that because the autoclave venturi exhaust is saturated with water, "a refrigeration unit or condenser would be needed to remove water that would otherwise adversely affect the adsorptive capacity of the carbon adsorber".

The MACT analysis for controlling mercury emissions from the Barrick Goldstrike mine, referenced in footnote 4, included one option where a large carbon bed was proposed instead of a refrigeration system to dry the autoclave off gas before a normal sized carbon adsorption bed. However, this analysis noted that it was uncertain whether this approach was feasible. This is because mercury adsorption rates slow significantly in air steams which have relative humidity above 60% to 80%. Literature from Scotia International of Nevada, Inc, a vendor who provides activated carbon mercury controls for the gold mining industry, indicates that at higher relative humidity conditions, reactions in the activated carbon bed drop down to 1% to 5% of the normal reaction rate. A copy of this presentation is located in Attachment D Therefore, use of carbon adsorption without a refrigeration system to dry the autoclave exhaust is not considered a viable option.

Activated carbon adsorption is considered technically feasible in this application provided that gas conditioning is used to dry the gas sufficiently to prevent liquid water deactivation of the activated the carbon.

### 4.4.3 Sulfur Impregnated Activated Carbon

The effectiveness of carbon adsorption for mercury control can be improved through the use of sulfur impregnated carbon. Mercury reacts with the sulfur to form mercury sulfide (HgS). Mercury sulfide has a lower vapor pressure than elemental mercury and is more readily adsorbed by the activated carbon. In the case of mercury, chemisorptions occurs and the mercury becomes chemically bound to the carbon

Sulfur impregnated activated carbon also has a nominal design operating temperature of 100° F to 130° F and a recommended moisture level is 60% to 80% relative humidity. Therefore gas conditioning is required if sulfur impregnated activated carbon is used for mercury control on an autoclave exhuast stream.

### 4.4.4 Selenium Filter

A selenium filter works in the same way as a selenium scrubber. Mercury vapors react with amorphous selenium with the following reaction:

$$Hg + Se \rightarrow HgSe$$

A selenium filter can effectively hold up to 10% to 15% of its theoretical mercury capacity and then it must be regenerated. The web site "Sulphuric Acid on the Web™ (ww.sulphfuric-acid.com) reports in the Gas Cleaning System – Mercury Removal page[10] that the selenium filters have a mercury control efficiency of 90% as a third stage mercury control, which is about the same as activated carbon. Outotec, a Finnish company, markets selenium filters as third stage controls for pre-treatment of smelter off gas before the off gas is used as sulfuric acid plant feedstock. The Outotec web site does not list a mercury control efficiency for selenium filters, but it does claim the use of a selenium filter will reduce the mercury content of the sulfuric acid from a range of 0.3 ppm to 0.5 ppm Hg down to 0.05 ppm Hg which is consistent with a 90% mercury control rate.

Installation of this process would require PolyMet to use selenium, a hazardous material as a reagent in a selenium filter. Spent selenium filter media would have to be sent off site for regeneration or disposal.

## 4.5 Technical Feasibility Summary

Due to the high moisture content of the Autoclave exhaust, dry controls such as baghouses and fabric filters are technically infeasible. Wet scrubbers are suitable and first or second stage mercury controls. Wet EPSs are also feasible and are well suited for fine particulate control in gas conditioning systems. Activated carbon controls are feasible as third stage mercury controls, but will require use of gas conditioning systems to cool and dry the Autoclave exhaust before it can be introduced into an activated carbon mercury control system. Selenium filters may also be feasible, but they do not offer a significant benefit in mercury control efficiency or significantly reduce gas conditioning requirements.

[10] The address of the mercury removal page is http://www.sulphuric-acid.com/techmanual/GasCleaning/gcl_hg.htm

# 5 Evaluation of Technically Feasible Controls

## 5.1 First Stage Controls

Venturi scrubbers, wet scrubbers and wet ESPs are all feasible controls which can provide a high level of particulate control.

Because autoclaves operate at high pressure (300 - 500 psi), the autoclave off gas must be de-pressured prior to first stage treatment. Some of this pressure can be used to operate a venturi scrubber whereas the off gas steam must be fully de-pressured to use other wet scrubbing systems or a wet ESP. Gold mine autoclave systems in the United States all use venturi scrubbers. PolyMet proposes to use a venturi scrubber for its first stage mercury control.

## 5.2 Second Stage Controls

Venturi scrubbers, wet scrubbers and wet ESPs are all feasible controls which can provide a high level of particulate control and some level of absorption to capture soluble mercury compounds. Because first stage controls are primarily for particulate control, particulate control in the second stage is less important. Wet scrubber designs such as spray-chambers, packed bed towers and tray tower scrubber offer the advantage of providing sufficient gas/liquid contact to promote efficient absorption of soluble mercury vapors. Most mercury from autoclaves is in the form of oxidized mercury which is water soluble. Therefore, spray-chambers, packed bed towers and tray towers scrubbers are the best alternative for second stage mercury controls in this application. PolyMet proposes to use a packed bed scrubber for its second stage mercury control.

The estimated mercury control efficiency for the proposed scrubber system is 25% for elemental mercury and 90% for particle bound and oxidized mercury. Based on limited Project related available data on mercury speciation, a control efficiency of 25% was assumed in the emission inventory for the Autoclave Vent and 63% for the Autoclave Flash Vessel.[11] Actual performance is expected to be better than the values used in the emission inventory, based on typical speciation of autoclave mercury emissions.

[11] Mercury collected in pre-train knockout during pilot plant testing assumed to be in a particle bound or oxidized form; mercury detected in train or upper bound based on detection limit assumed to be in elemental form due to absence of project specific data to the contrary (i.e. worst case assumption).

## 5.3 Third Stage Controls

Activated carbon controls are technically feasible if used in combination with a gas conditioning stream to dry and cool the autoclave exhaust. The next step is to determine whether or not activated carbon controls are economically feasible. As noted in Section 4.1, the Autoclave exhaust properties are similar to the gold ore autoclave exhaust streams. However, the mercury content is approximately one tenth of both the gold ore autoclaves (1.65 e-5 vs. 1.45 e-4 gr/dscf) and the Autoclave water content is 87.5% vs. 71.1% at the Barrick Goldstrike mine. Given these similarities, it is reasonable to use cost information from the Barrick Goldstrike NDEP MACT analysis as a basis for the Project cost evaluation. A capital cost of $8,320,000 is estimated for activated carbon control for the Project using the six tenths power law factor to account for economy of scale, and the ratio of flow rates from each system in actual cubic feet per minute. Annual operating costs of $1,464,000 per year were estimated using the flow rate ratio for power costs and USEPA control cost manual[12] factors for labor (Barrack hourly pay rates), maintenance, overhead and indirect operating costs. Costs were adjusted to account for regional differences in electric prices. As noted in the Barrick Goldstrike MACT analysis, the most significant cost is the electrical power needed to operate the gas conditioning system. This results in an estimate mercury control cost of $397,000 per pound mercury which is economically infeasible when compared to the USEPA cost analysis in the gold mining MACT analysis. Control cost calculations are located in Attachment C. In its cost analysis of mercury controls for gold mining in FR 76 No 33 page 9465 USEPA determined that $11,000 per pound mercury removed was feasible for carbon control on gold mining autoclaves, but in the proposed rules at FR 75 No. 81 pages 22,483 USEPA determined that $44,000 per pound mercury was not cost effective for additional controls on melt furnaces and that $100,000 per pound of mercury for additional carbon controls on autoclaves was not feasible. Therefore, the cost of carbon controls on the Autoclave is economically infeasible at $397,000 per pound of mercury removed.

As noted above, a selenium filter may be feasible for use as a third stage mercury control, but they do not offer any advantages over activated carbon controls for mercury control. Selenium filters require a dry gas feed, so gas conditioning costs are expected to be similar to activated carbon controls. Selenium filters are expensive produce and regenerate, so it is likely that selenium filters would be even more expensive than activated carbon. Lastly, selenium is a hazardous material; so, its use would create the potential for adverse environmental impacts.

PolyMet proposes no third stage mercury control.

[12] EPA/452/B-02-001 Carbon Adsorbers September, 1999

# 6 Conclusion

The proposed mercury control system for the Autoclave is a venturi scrubber for the first stage scrubber and a packed bed scrubber as the second stage mercury control. Use of a venturi scrubber as a first stage control has the advantages of being able to utilize the Autoclave exhaust pressure to enhance particulate control; other wet scrubbing systems cannot do this. In the United States, all gold mining applications use venturi scrubbers; so, selection of a venturi scrubber is consistent industry practices. Data on mercury control on autoclaves for other types of mining were not readily available.

The proposed second stage mercury control for the Project is a packed bed scrubber. This type of wet scrubber is most effective at removing gaseous pollutants; so, it will be effective at removing any oxidized mercury which has not been captured in the venturi scrubber. No gold mining facilities in the United States have two stage wet scrubbing systems for mercury control.

Chemical scrubbing systems have been identified by the USEPA as a viable third stage mercury control for gold mining autoclave systems in the United States. However, the Autoclave exhaust is projected to have mercury concentrations at levels which are equal to the exhaust gas concentrations of gold mining autoclave systems with chemical scrubbing systems. Activated carbon controls would be technically feasible at for the Project, but, like gold mining, a gas conditioning system would be required to dry and cool the Autoclave off gas. Using the cost data in the Barrick Goldstrike NDEP MACT analysis as a reference, PolyMet has shown that activated carbon controls are not economically feasible. Because so little mercury will be in the Autoclave exhaust after passing through a venturi scrubber and a packed bed scrubber, the cost of further reducing mercury emissions on a $/ton mercury removed exceeds the mercury control cost deemed economically feasible by USEPA in its review of mercury emission controls for the gold mining industry.

Therefore, the two stage wet scrubber system proposed for the Project provides the level of mercury control which meets Minnesota Pollution Control Agency’s policy requirement to install best available mercury controls.

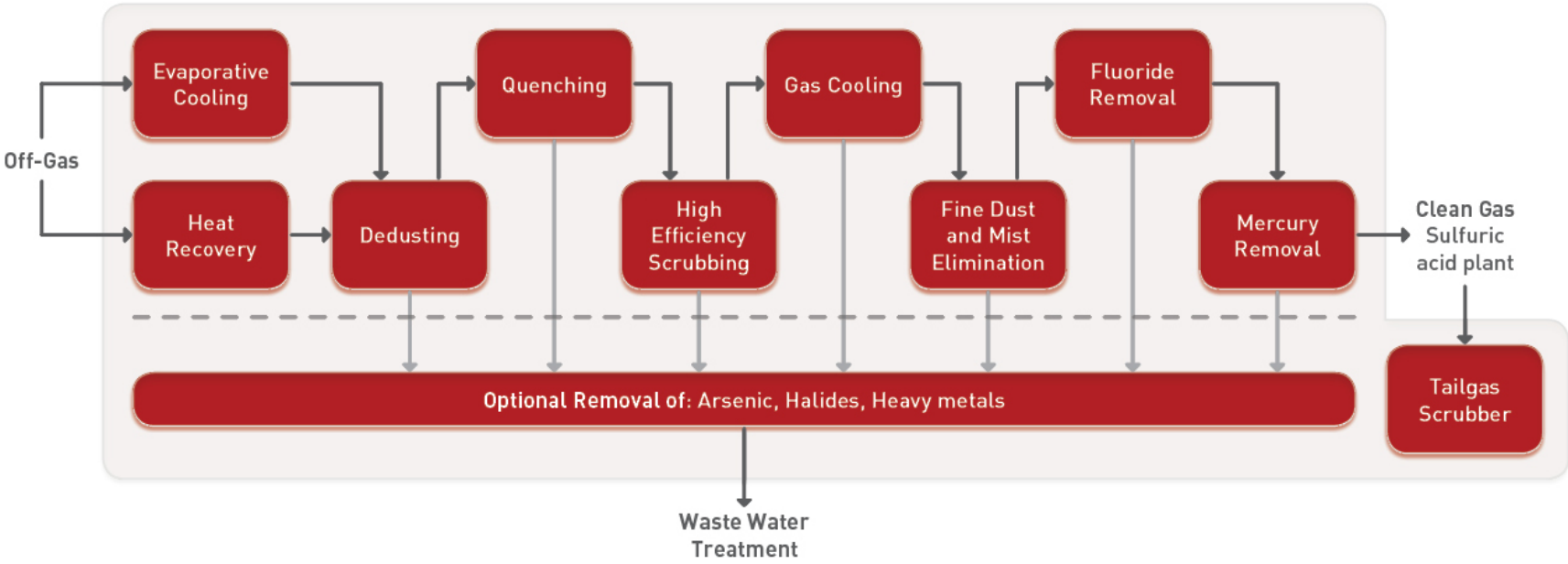
# Attachments

# Attachment A

## Autotec Gas Treatment and Conditioning System

Attachment A

Outotec Gas Cleaning System Flow Diagram



# Attachment B

## Hugo Petersen Gas Conditioning and Mercury Removal Systems

# HUGO PETERSEN - COMPETENCE IN GAS CLEANING SYSTEMS DOWNSTREAM NONFERROUS METALURGICAL PLANTS

Axel Schulze
HUGO PETERSEN

## The Company

HUGO PETERSEN has developed from the traditional firm of the same name that was established in 1906 in Berlin and is an engineering company specialising in general plant engineering now based in Wiesbaden.
HUGO PETERSEN has many years wide-ranging experience in process plant engineering, primarily in the field of **Sulphuric Acid Processes** and **Gas Cleaning**.
Together with its main shareholder, Chemieanlagenbau Chemnitz GmbH (CAC), a company with over 40 years experience in the international plant engineering business, HUGO PETERSEN implements turnkey new plants from initial consultancy right through to commissioning.
In addition, HUGO PETERSEN can offer its clients improvements and revamps of existing plant systems.
Initial consulting, planning and implementation take place within the context of a lean company organisation with experienced engineers and specialists.
In all respects, many years of experience guarantee expertise over a wide range of possible applications.
For clients from the chemicals and metallurgical industries, as well as those in metals processing, HUGO PETERSEN GmbH's breadth of experience means not just an efficient introduction to new methods and processes, but also their full implementation.

In addition, along with design and construction for individual components, the company's range of services also covers supply of complete plants, as well as modernisation projects and revamps in line with local conditions and existing quality requirements
With own technologies and patents in the field of gas cleaning and sulphuric acid, supplemented by licences and cooperation projects, HUGO PETERSEN ensures expertise over a wide range of applications.
With specialists and expert knowledge in these fields of application, HUGO PETERSEN is your partner of choice, supporting you and bringing your acid, and project to a successful conclusion.

## Gas Cleaning Plant (GCP)

Components and Arrangement of Gas Cleaning Plants downstream Nonferrous Metallurgical Plants mainly depending on the following terms:

- Gas Conditions of the upstream Process
- Sulphuric Acid Quality
- Requirements of Local Authorities

Generally HUGO PETERSEN Design has the following principles:

- Low Pressure Drop
  → low operation costs as well as reduced wear and tear

- Self adaptable Process Operation
  → reduces manual or control loops impact, means less operational problems and high efficient operation as no risk of bad control

- No movable Parts in the Gas Stream
  → less maintenance

- High corrosion resistant Material
  → extended life cycle of the plant

Based on the different requirements the choice of single units and arrangements can be subdivided as follows:

## Conventional Arrangement

- Pre-quench Tower for Gas Conditioning and Preliminary Cooling
- Post-quench Tower for Gas Conditioning and Secondary Cooling
- Cooling Tower for Gas Condensation and HF-Removal
- Primary and Secondary Wet Electrostatic Precipitator (WESP) for remaining Dust and Mist Removal

## High Dust Arrangement

- Pre-quench Tower
- Jet Scrubber or Post-quench Tower incl. PETERSEN Spray Separator (PSS)
- Primary WESP
- Cooling Tower
- Secondary WESP

## Additional Mercury and / or Heavy Metal Removal

- Calomel Process
- Thiosulphate Process
- Activated Coke Filter

## Tail Gas Scrubbing

- Hydrogen Peroxide Scrubber (SUPER$^{OX}$)
- Ammonium Scrubber

## Conventional Arrangement

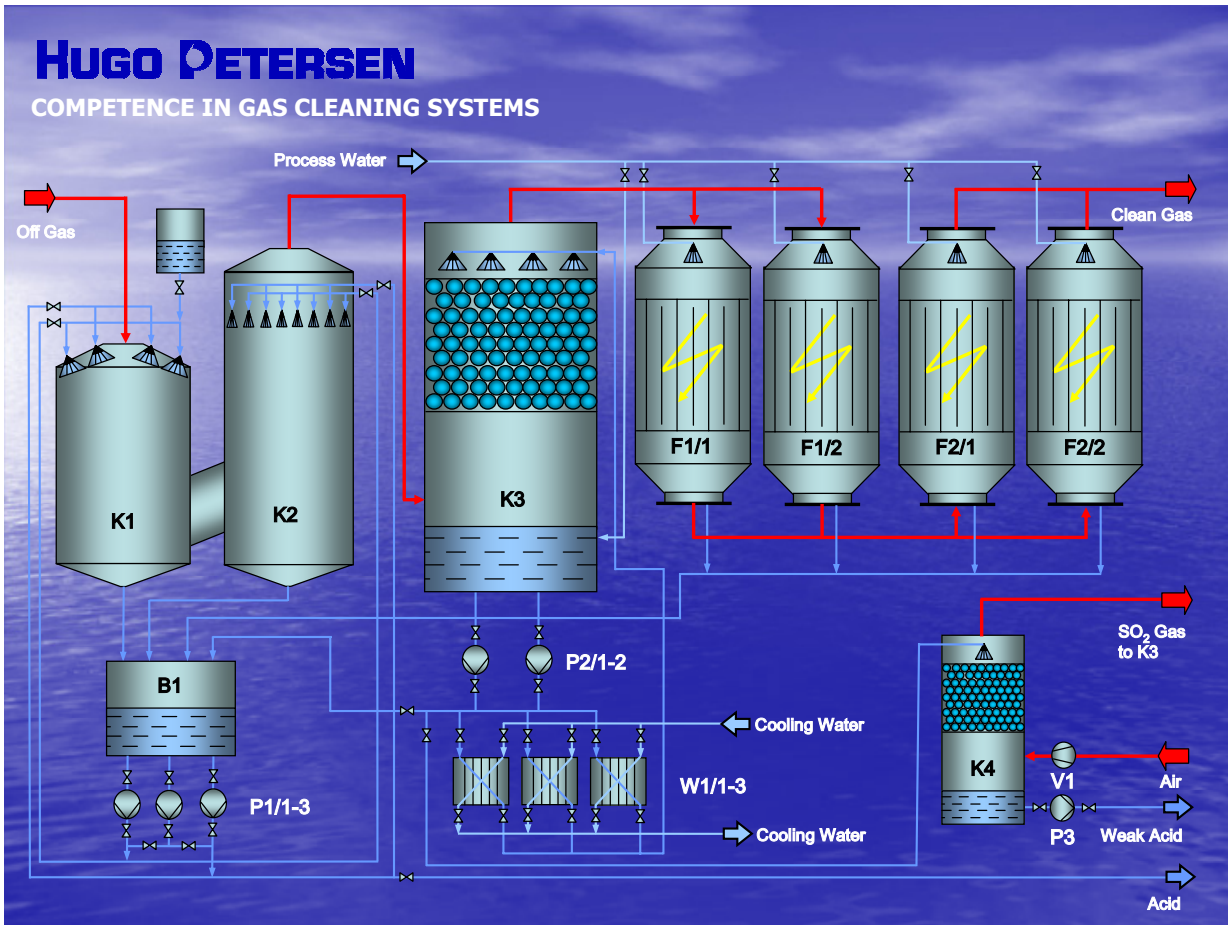
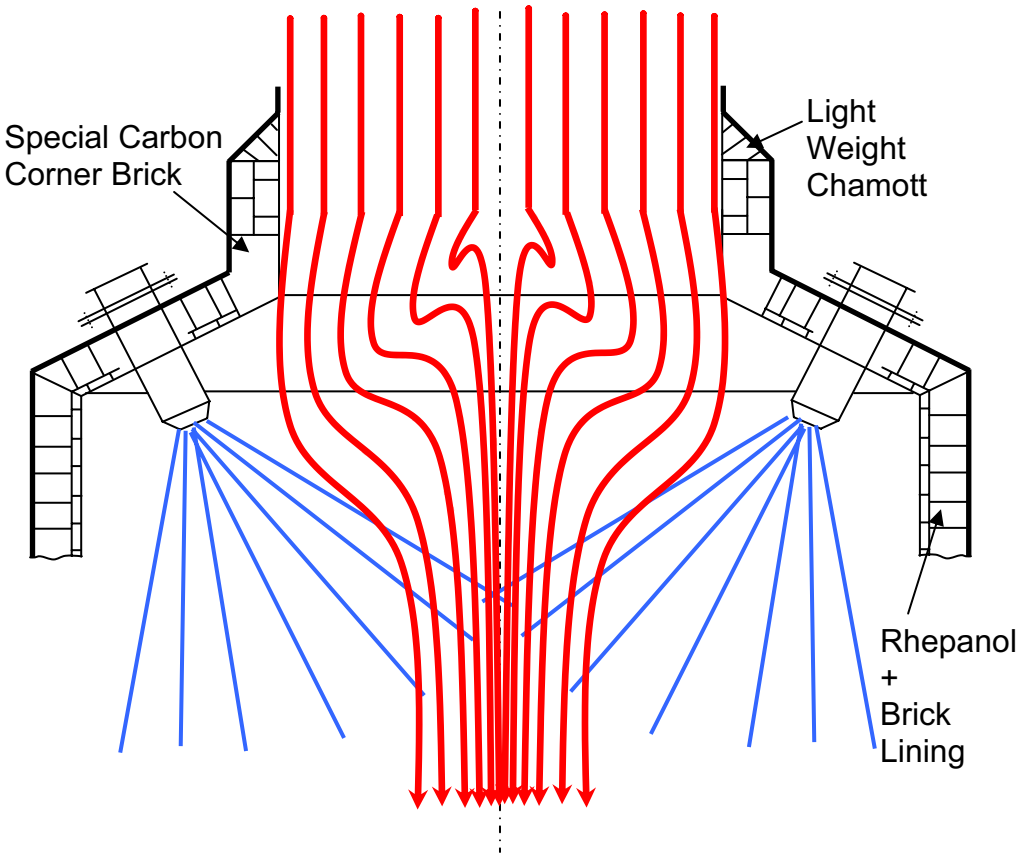



Diagram 1: Conventional Arrangement incl. $SO_2$-Stripping Tower

The hot gases from the upstream plant are led via hot dust precipitators to the top inlet of the pre-quench tower K1 which is a void tower. At the downward flow the hot gases are cooled down by app. 10 up to 50 weight % sulphuric acid.
Due to the special design of the pre-quench tower enabling an internal re-circulation, a safe cooling down is achieved by partial evaporation of the circulation liquid.
Due to this spraying the gas temperature is reduced to the equilibrium of the vapour pressure of the circulated sulphuric acid depending on the acid concentration.




Principle scheme of the gas flow on top of the Pre-quench tower

The gases leave the pre-quench tower K1 and enter the post-quench tower K2.
In both towers partly dust, HCl and HF are removed as well as Arsenic, Antimony etc.
The remaining part of the sprayed liquid is collected in the bottom part of the quench towers and led via the quench liquid pump tank B1 which serves the pumps P1.
Two separate lines, each with one pump, serves the sprays at the pre-quench tower and the spray lines of the post-quench tower. The flow rate to the spray nozzles of the pre-quench tower is monitored, and in case of failure of one line the other line serves enough liquid for safe and uniform cooling down of the gases.
Due to partial evaporation the circulation system has always a need for liquid which is fed by a cross flow from the fluoride scrubbing tower K3.

Downstream the post-quench tower an optional additional gas stream, coming from the Stripping Tower K4 is mixed with the cooled and pre-cleaned gases.
The mixed gases enter the cooling tower K3 wherein the gases pass a packed bed which is irrigated with cooled liquid. Due to the intense contact between the gas and the liquid within the packed bed the gas temperature is reduced down to normally between ranges of 30 – 40 °C.

When cooling down also partial condensation takes place and all liquids are collected in the base part of the tower K3 which is acting as pump tank for the circulation pumps P2.
Due to the low temperature the main part of HCl, as well as the remaining part of arsenic, is removed in the scrubbing tower.

The circulation liquid pass a set of acid coolers W1 wherein the heat is transferred to cooling water and the temperature of the circulation liquid is reduced to the required temperature. Downstream the coolers the liquid is evenly distributed by sprays or optional via an acid

irrigation system on the top of the packing of the cooling tower. The condensed water vapour is discharged dependent on the level of the quench-tower pump tank to the pump tank of the quench towers.

The remaining amount of liquid is discharged in dependence of the cooling tower bottom liquid level, either directly to the waste water treatment or via the above mentioned $SO_2$-Stripper K4 to the waste water treatment.
After passing the cooling tower K3 the gases are lead to the two stages wet electrostatic precipitator system.

The wet electrostatic precipitator system in our example consists of totally four precipitators arranged in series consisting of two primary and two secondary WESP's.
The mist and droplet laden gases enter the shell at the top of the first stage WESP's (F1/1-F1/2) and passes through guide vanes and two perforated plates which distribute the gas evenly throughout the shell.

The gases then flow downward through the collector tubes and exit centrally through the bottom of the shell of the WESP's.

The second stage WESP's (F2/1-F2/2) are connected to the first stage WESP's by gas ducts, so that the gases flow from the bottom of the first stage WESP's to the bottom of the second stage WESP's.

The bottom vestibule of the second stage WESP's is equipped with guide vanes and two perforated plates as well, to assure that the gas is evenly distributed throughout the collection tubes.

The gases leave the second stage WESP's through the top vestibule to the downstream drying tower.

In the electrostatic precipitator systems mainly the remaining acid mist and dust are removed to the required emission data.

While it is imperative that the gases flow upward in the second stage to prevent re-entrainment, it is beneficial to have the gas flow downward in the first stage. In effect, the gases at the inlet of the first stage carry a lot of coarse entrained droplets from the cooling system upstream of the WESP-system which will provide a so called "self-cleaning effect" on the collecting surface and reduce the danger of built-up of solids on the collecting surface to a minimum.

As the gas enters the intense electrical field induced between the electrodes and the collector tubes by the high voltage electrode, particles suspended in the gases become charged and migrate under the influence of electrostatic forces towards the collection surfaces.

The accumulated mist particles or droplets form a liquid film on the grounded collector surface and are drained back to the pump tank of the quench towers.

The electrostatic field is established by stepping up low voltage alternating current (AC) in a transformer to a high voltage and then rectifying it to direct current (DC) with a rectifier. The rectified current is then delivered to a system of high voltage electrodes which are suspended

in the centre of each of the uniformly spaced collecting pipes. The high voltage system is electrically insulated from the collecting pipes by special porcelain insulators.

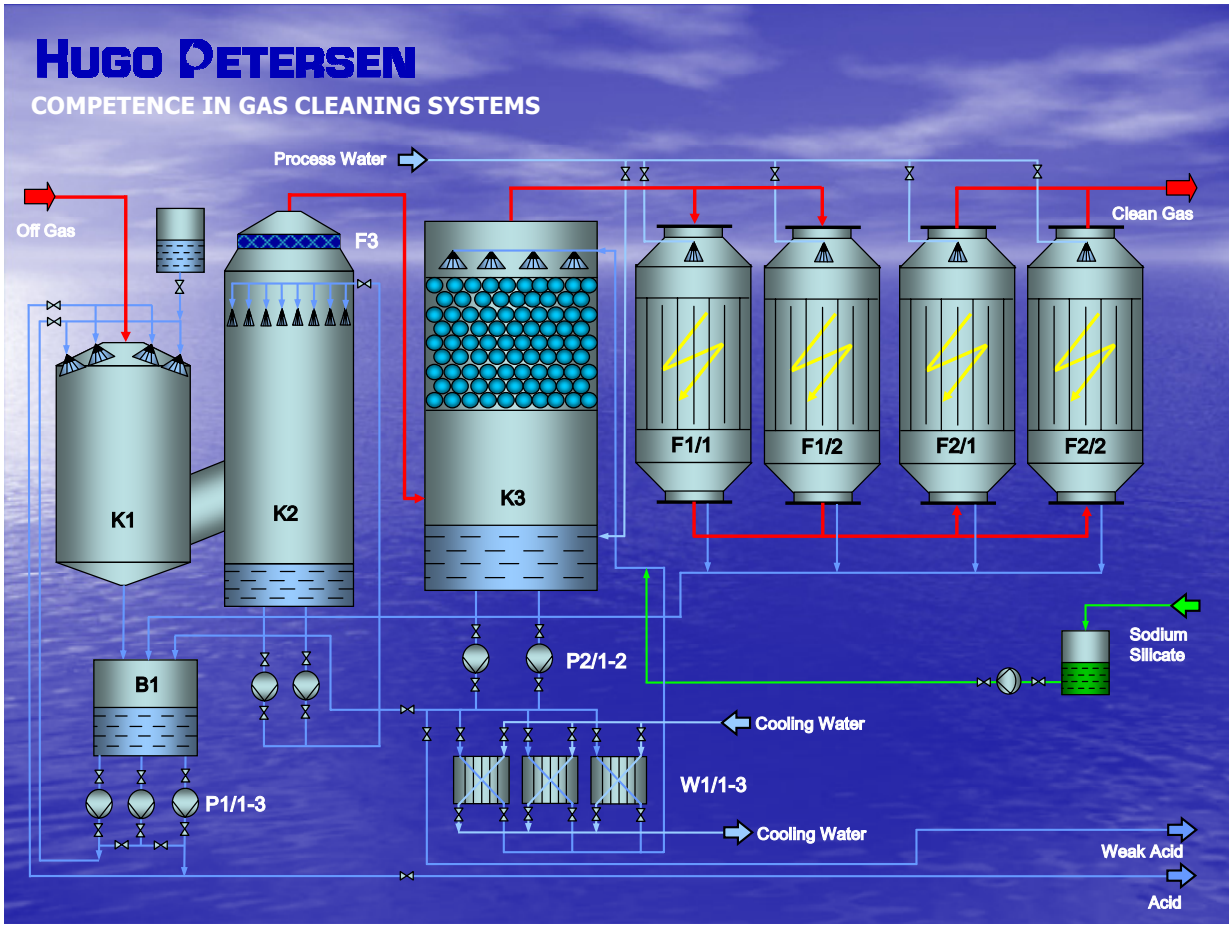
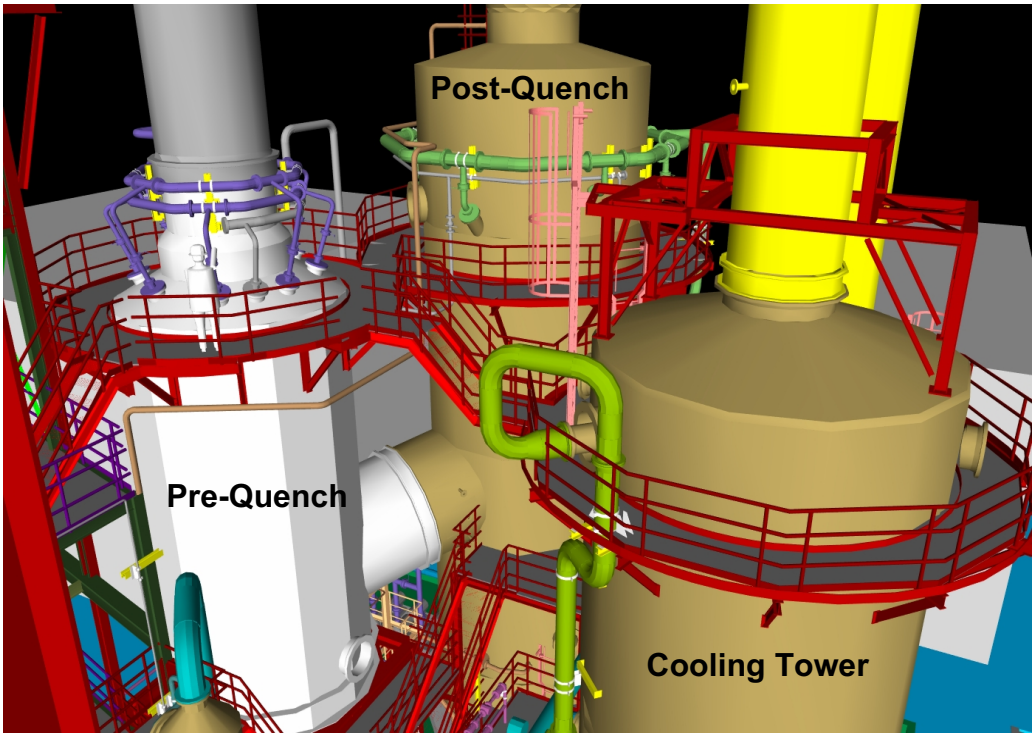


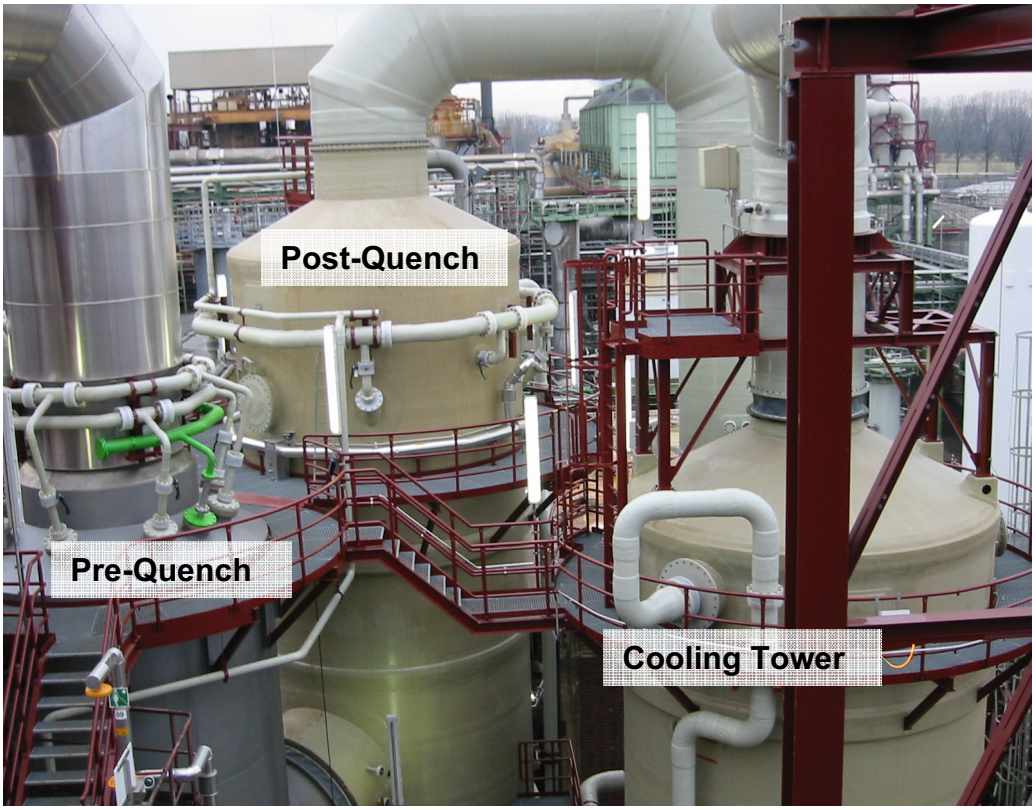

Diagram 2: Conventional Arrangement incl. HF-Removal and separated Quench Tower Circulation

The separation of the liquid circuits of the quench towers allows running the two quench systems with different concentrations of sulphuric acid to increase the concentration of the discharged acid by keeping the outlet temperature of the post-quench tower at low level and to avoid a carry over of concentrated sulphuric acid to the cooling tower.
By adding sodium silicate to the circulation system of the cooling tower fluorides in the off gas can be nearly completely removed.

The main benefits of the HUGO PETERSEN Gas Cleaning Design are:

- Safety Operation due to different independent liquid circuits
- High Availability
- Minimized Control and Operating Efforts
- Minimized Process Water Consumptions
- High Removal Efficiencies
- Space Saving Arrangement




Typical Arrangement of a Pre- / Post-Quench incl. Cooling Tower

## High Dust Arrangement

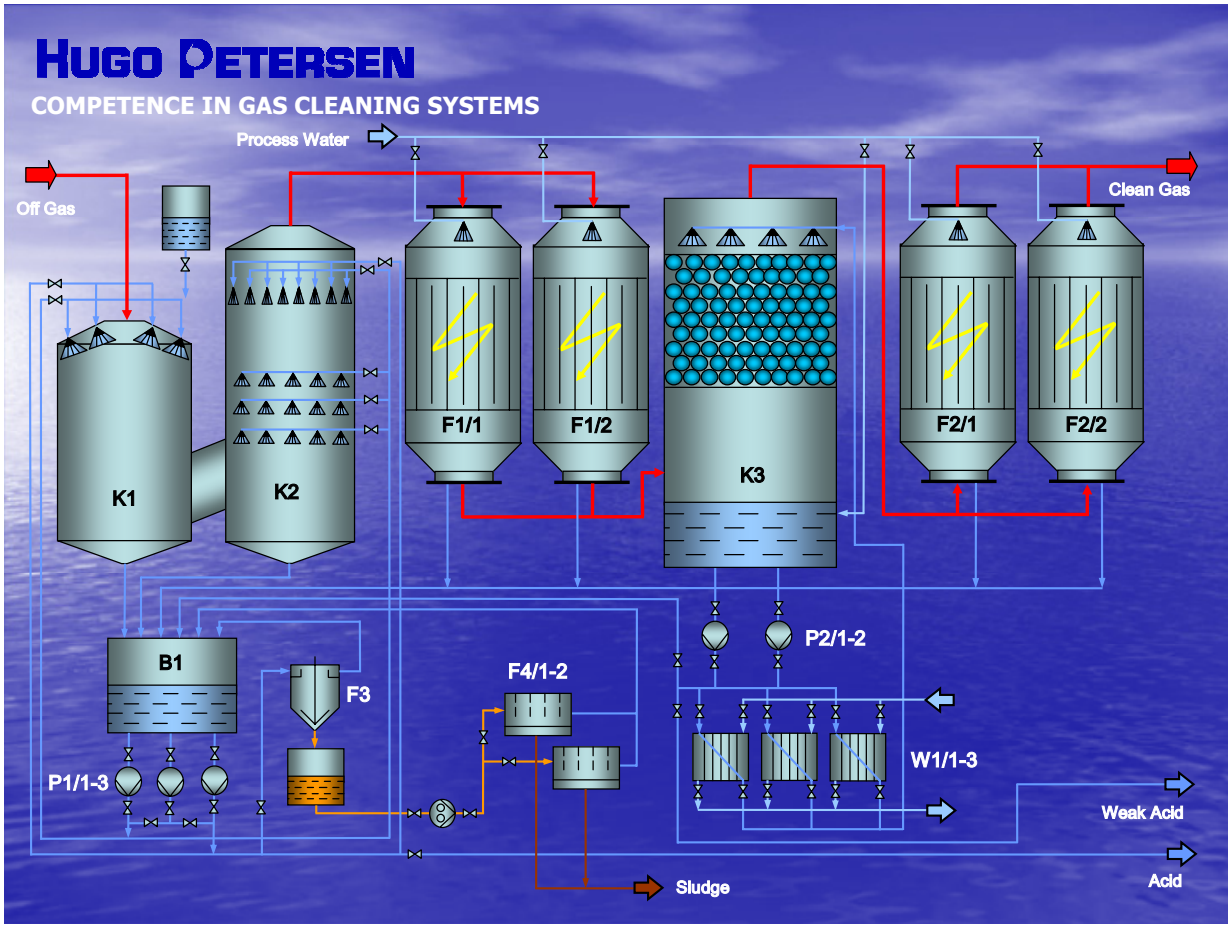



Diagram 3: High Dust Arrangement incl. PPS-System

The post quench-tower is designed as a PETERSEN-Spray Scrubber (PSS) with totally four scrubbing stages, working with high pressure to remove main parts of dust, mist and arsenic components.

The PSS is designed for maximum flow to achieve an efficiency rate of app. 95 % to due big sized particles.

In case of lower gas flow rates, the removal efficiency will increase due to the increasing of the liquid / gas relation.

A further modification is the arrangement of the first wet electrostatic precipitation system F1/1-2 upstream the cooling tower K3 to remove remaining solid contents as it is required to produce a clean weak acid.

The circulation liquids of the quench towers and the flushing liquids of the WESPs are continuously discharged via a sludge precipitator F3 and a redundant filter press system F4/1-2 to keep a constant solid content in the liquids.
The removed sludge can be disposed in the upstream process.

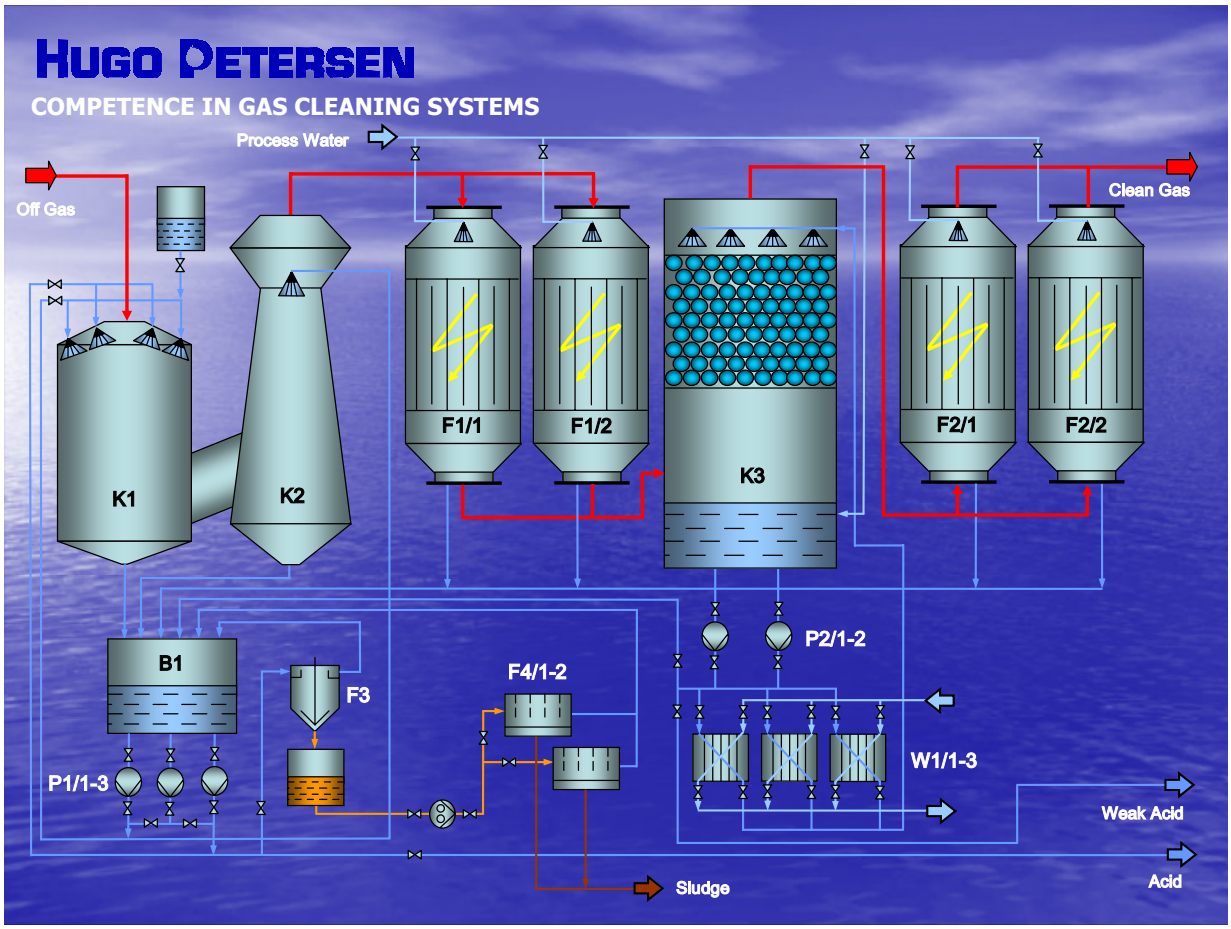



Diagram 4: High Dust Arrangement incl. Jet Scrubber Unit

This arrangement should be preferred in case of low or medium gas flow rates.
The main benefit of both installations is the low pressure loss as the removal energy is brought in by the liquid.
A further benefit is that there is no need for regulation in case of unsteady gas flow rates.

## Mercury / Heavy Metal Removal Systems

In general the remaining mercury content of the feed occurs partially in vapour form and, depending on the operation temperature of the cooling units, partially as particulates.
The particulates are nearly totally separated in the wet electrostatic precipitators, the mercury vapour appear as a contaminant in the product sulphuric acid as it is absorbed by strong acid in the downstream drying and absorption units due to the following reactions:

1. Reaction between dissolved mercury in the acid and elementary mercury in the roaster gas

$$HgSO_4 + Hg^0 \rightarrow Hg_2SO_4$$

2. Oxidization of the formed mercurous sulphate by strong acid and oxygen in the gas to mercuric sulphate

$$Hg_2SO_4 + H_2SO_4 + \tfrac{1}{2}\, O_2 \rightarrow 2HgSO_4 + H_2O$$

## Calomel Process

The Calomel Process is based on the oxidation of mercury vapour by mercury chloride to form microbus chloride (calomel) due to the main chemical reactions:

Packed Bed Tower: $Hg^0 + HgCl_2 \rightarrow Hg_2Cl_2$ (calomel)

Regeneration: $Hg_2Cl_2 + Cl_2 \rightarrow 2\ HgCl_2$

The mercury containing cleaned gas downstream the final wet electrostatic precipitation units passes through a packed bed tower K4 where a solution of mercury chloride is circulated via pumps.

A double stage mist eliminator at the top of the tower prevents the carry over of scrubbing solution.

During the reaction between the gas and scrubber solution insoluble Hg chloride (calomel) is precipitated. A part of the calomel containing solution is pumped to the Settler F1.

There the product (calomel) is isolated from the system by decantation as a heavy sludge. A portion of the calomel is then separated from the process.

The remaining calomel is re-oxidized in the chlorinator vessel B1 with the oxidant chlorine ($Cl_2$) dosed by an injection mixer R1 and via circulation pumps to Hg chloride ($HgCl_2$).
A strong solution of Hg chloride (HgCl2) is prepared in this manner and stored separately in the strong solution vessel B2 via suction filter F2.

The solution is fed into the circulation system via diaphragm dosing pumps at a rate that corresponds to the consumption according to the calomel process reaction.

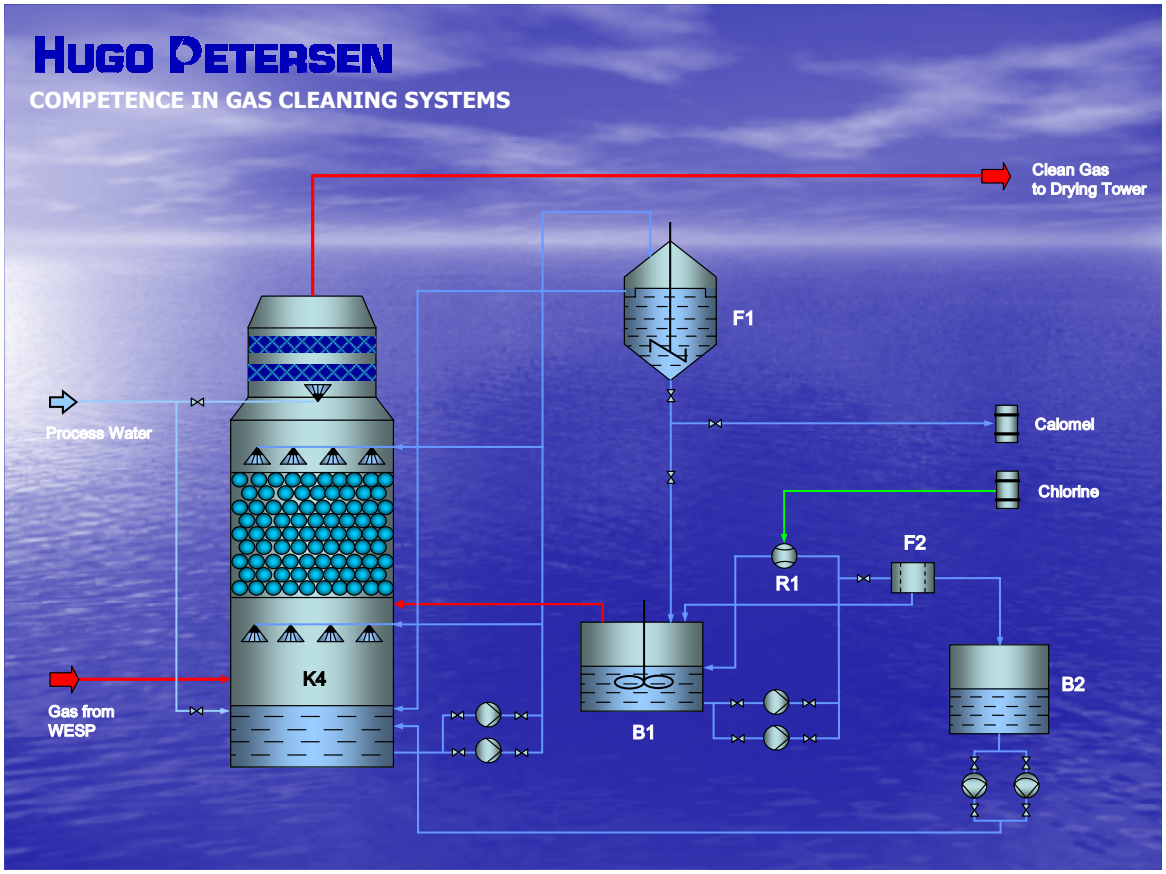



Diagram 5: Typical Arrangement of the Calomel Process

Main Benefits:

- Most popular Method for Removing Mercury
- High Efficiency (Sulphuric Acid with less than 0.5 ppm Mercury can be produced from a gas containing 150 ppm mercury)

**Thiosulphate Process**

The absorption efficiency of mercury depends on the acid strength and acid temperature. The lower the acid temperature and the higher the acid concentration, the higher is the absorption efficiency.

To avoid an accumulation of mercury in the product acid it is essential to absorb the mercury vapour in a two stages drying tower unit K1 / K2 running with different acid concentrations whereas the acid concentration in the second drying tower should be higher than the acid concentration of the downstream absorption units.

The mercury containing acid of the drying towers has to be cleaned before discharging into the absorption circuits.

Therefore the acid streams are gathered and treated in reaction units with Sodium-Thiosulphate ($Na_2S_2O_3$ x 5 $H_2O$).

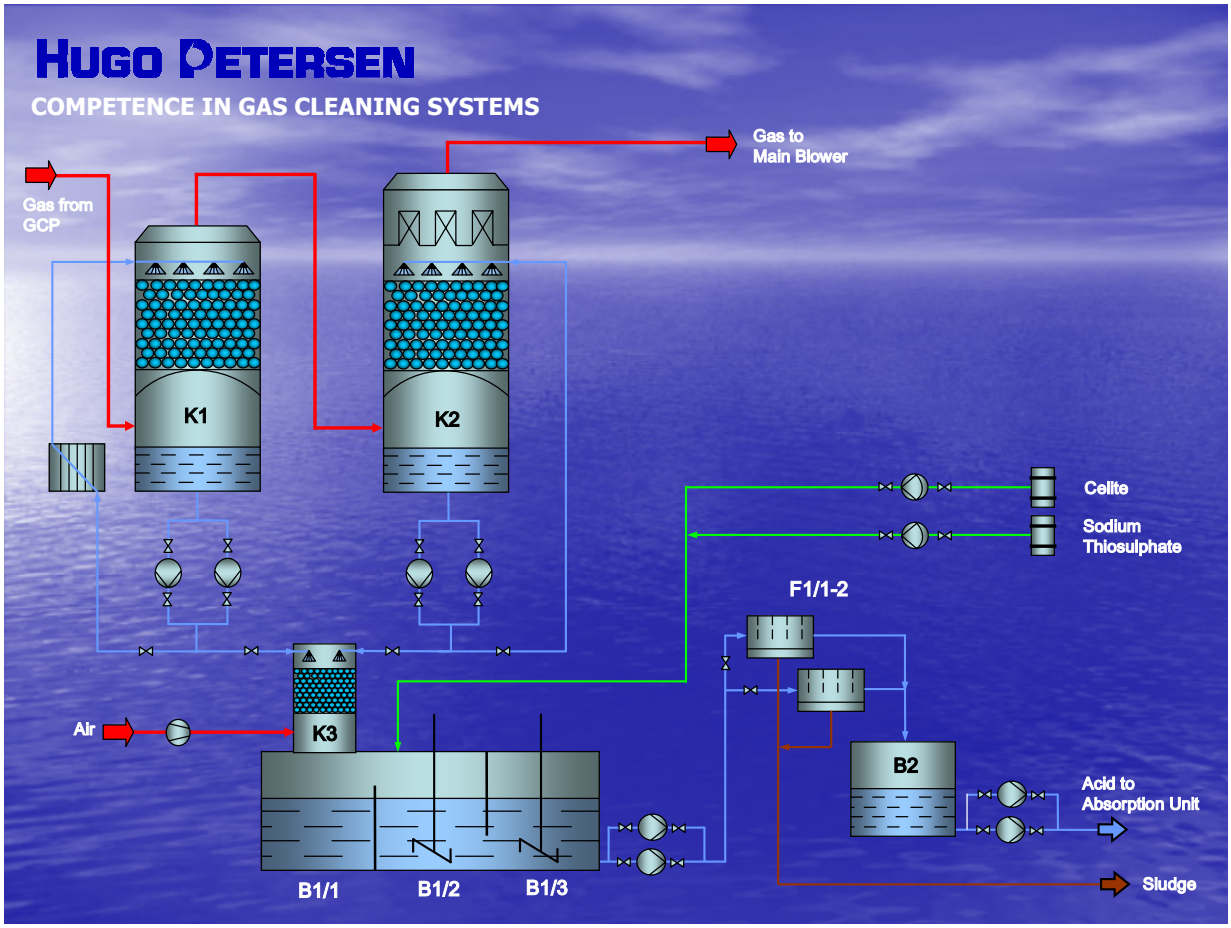



Diagram 6: Thiosulphate Acid Purification Process

The total amount of acid of both drying towers is stripped with air in the stripping tower K3 to remove the dissolved sulphur dioxide before being sent to the sampling vessel B1/1.

Afterwards the stripped acid is discharged to the reaction tank B1/2 in which a solution of 40 % sodium thiosulphate and celite as a filter aid medium are added by stirring.
Sulphur is formed according to the reaction:

$$H_2SO_4 + Na_2S_2O_3 \rightarrow S + SO_2 + Na_2SO_4 + H_2O$$

The sulphur reacts with the mercury in the acid to form mercuric sulphide, which is precipitated.

The temperature in this stage is nearly 50 °C and the acid concentration is about 80 weight-percent.

The treated acid overflows to a maturing tank B1/3 also equipped with a stirrer in which the reaction is completed.

As some sulphur dioxide and even some hydrogen sulphide are formed in the purification process, the tanks have to be ventilated.

From the maturing tank the acid is pumped via the acid pumps to the filter press F1/1-2 where the precipitates are removed.

The deposit collected in the filter press contains about 40 % solids and 60 % acid. The deposit could be re-circulated to the pyro-metall-unit.

The cleaned clear acid is finally discharged into a regenerated acid tank B2 and can be discharged to the absorption units.

**Activated Lignite Coke Adsorber**

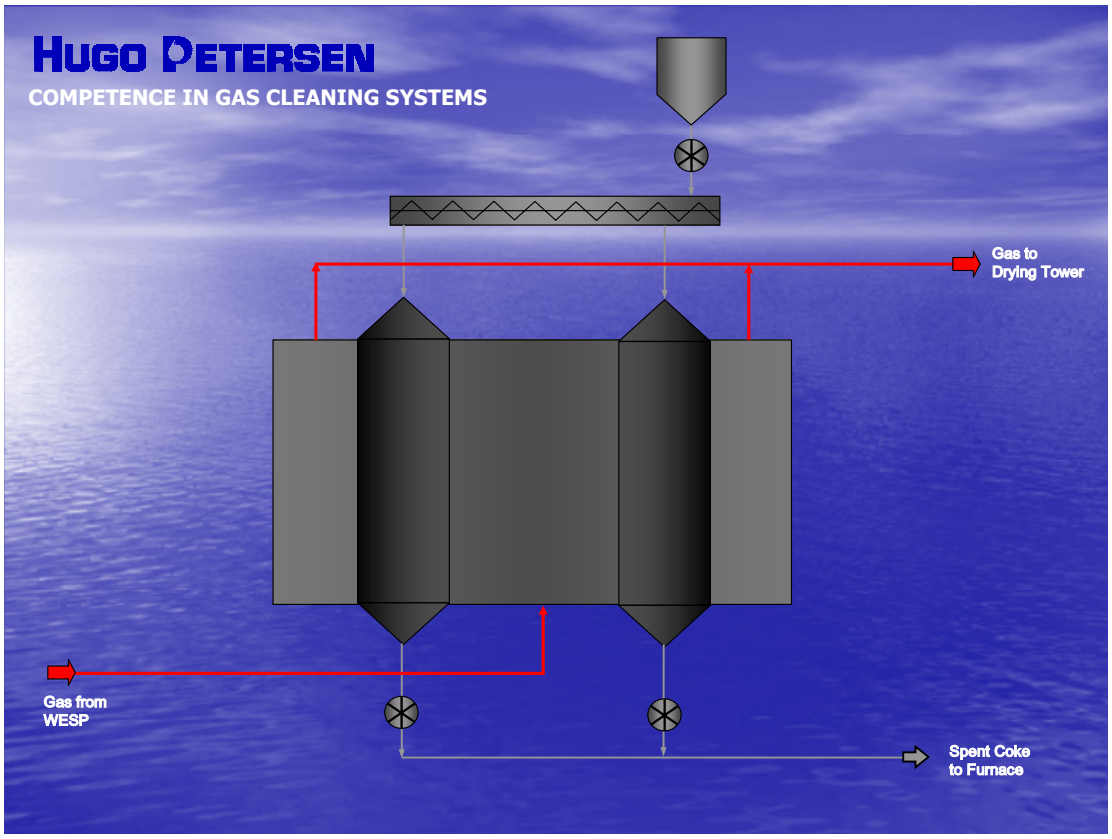



Diagram 7: Activated Coke Filter

An adsorber working with activated lignite coke or hearth furnace coke located downstream the final wet electrostatic precipitation system is able to reduce emissions of $Hg^0$ and $Hg^{2+}$ to the required values in wet operation.

Furthermore the remaining contents of As, Cu, Fe, Pb, Zn, Sb and Cd, as well as organic solvents or various hydrocarbons are reduced.

Due to its high adsorption capacity a minimum of adsorbent is used.
The spent adsorbent can be disposed in the upstream furnace.
Depending on the amount of contaminants in the gas the fixed bed has to be moved discontinuously.

Advantages of an activated lignite coke adsorber in comparison to an activated carbon adsorber:

Operating of the activated HOK adsorber below the dew-point of the wet $SO_2$ gas means no developing of so called "hot spots".

- No fire- and explosion-detections and -protections are required
- No minimum-flow gas necessary
- No inertizing of the adsorbent necessary
- No cost- and energy-intense reheating necessary of the wet $SO_2$ gas above the dew-point
- No Residues for Disposal
- Low operating-costs

## Tail Gas Scrubbing

Tail gas scrubbing as a means of polishing off-gases from chemical processes, but specially sulphuric acid plants, is a well-known process step, which HUGO PETERSEN has developed to a grade of quality and level, that economically and environmentally the plants will be ready for the future approaches of environmental protection agency acts.

**Hydrogen Peroxide Scrubber ($SUPER^{OX}$)**

The $SUPER^{OX}$-Process is a treatment technology based on sulphuric acid mixed with $H_2O_2$, which guarantees the absorption of $SO_2$ and oxidation to sulphuric acid as follows:

$$H_2O_2 + SO_2 + H_2O \rightarrow H_2SO_4{*}H_2O$$

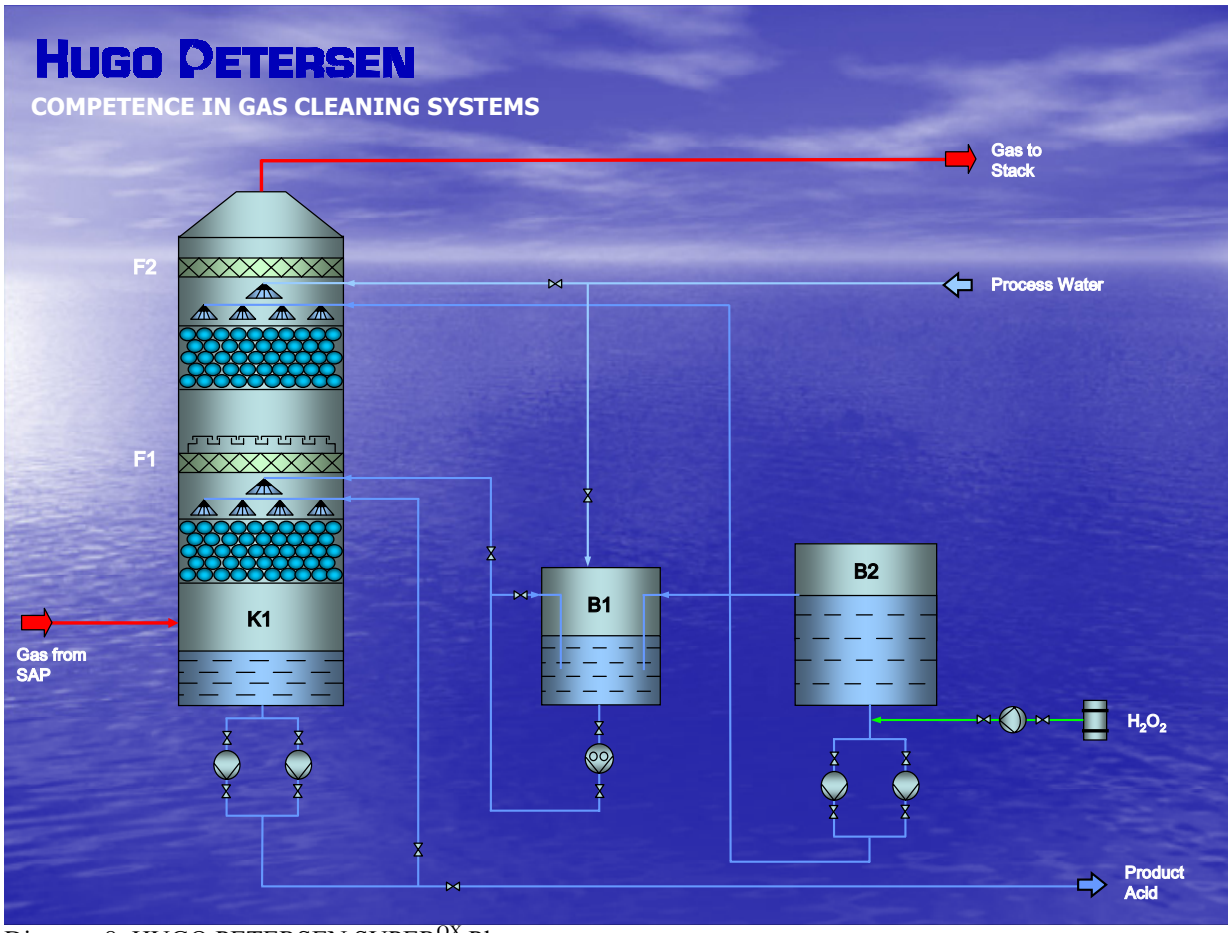



Diagram 8: HUGO PETERSEN SUPER$^{OX}$ Plant

The special design guarantees a sulphuric acid concentration of 50-60% by extreme low remaining $H_2O_2$ in the product stream.

The produced sulphuric acid can be used as dilution medium in the absorption section of the upstream sulphuric acid plants.

To minimize the $H_2O_2$ content of the discharged sulphuric acid, as well as to reach a high acid strength, each scrubbing tower exists of two stages.

The gas from the upstream plant is entering the scrubbing tower K1 in counter current flow to the liquids at the bottom and passing the first packing stage.

At the first stage the process gas is cooled down to its saturation temperature by circulation of 50 - 60 % sulphuric acid.

The amount of used process water depends on the $SO_2$-inlet content of the process gas and on the amount of produced sulphuric acid.

At the first stage the remained $H_2O_2$ of the upper second stage is reduced by oxidation of sulphuric dioxide as well.

The liquids of the first stage are collected in the scrubbing tower sump, circulated via pumps and distributed above the packing layer via a liquid irrigation system to ensure the distribution of washing acid over the packed bed and to avoid the formation of additional acid mist.

In dependence on the $SO_2$ content of the process gas an amount of 50 - 60 % sulphuric acid is discharged to the sulphuric acid plant.

Downstream the first stage the process gas is lead and distributed via a droplet separator F1 and an intermediate bottom to the second stage.

In the second stage the main part of sulphuric dioxide is removed by circulation of washing acid with an even higher $H_2O_2$-content than in the first stage.

Due to the lower acid concentration the gas temperature decreases and an additional amount of water is evaporated as well.

The liquid of the second stage is collected in an extra tank B2, circulated via two pumps and distributed in the same way as in the first stage.

The continuous hydrogen peroxide dosing via a dosing pump is controlled by a $SO_2$-measurement located downstream the peroxide scrubbers and an external gas-flow-rate signal. The hydrogen peroxide is dosed in the circulation circuit of the second stage at the suction side of the circulation pump to get a better intimate mixing.

The process gas finally enters a wire-mesh droplet separator F2 before it is lead to the stack. Depending on the design of the stack an additional gas-reheating system will be required.

The main benefits of the SUPER$^{OX}$ process are:

- No Waste Products
- High Concentration of Product Acid
- Nearly no remaining Peroxide in the Product Acid
- High Flexibility concerning required Emission Values
- Space Saving Arrangement

**Ammonium Scrubber**

The ammonium sulphate process is based on the following reactions:

$$2\ NH_3 + SO_2 + H_2O \rightarrow (NH_4)_2SO_3$$

And the oxidation with sulphuric acid:

$$(NH_4)_2SO_3 + H_2SO4 \rightarrow (NH_4)_2SO_4 + SO_2 + H_2O$$

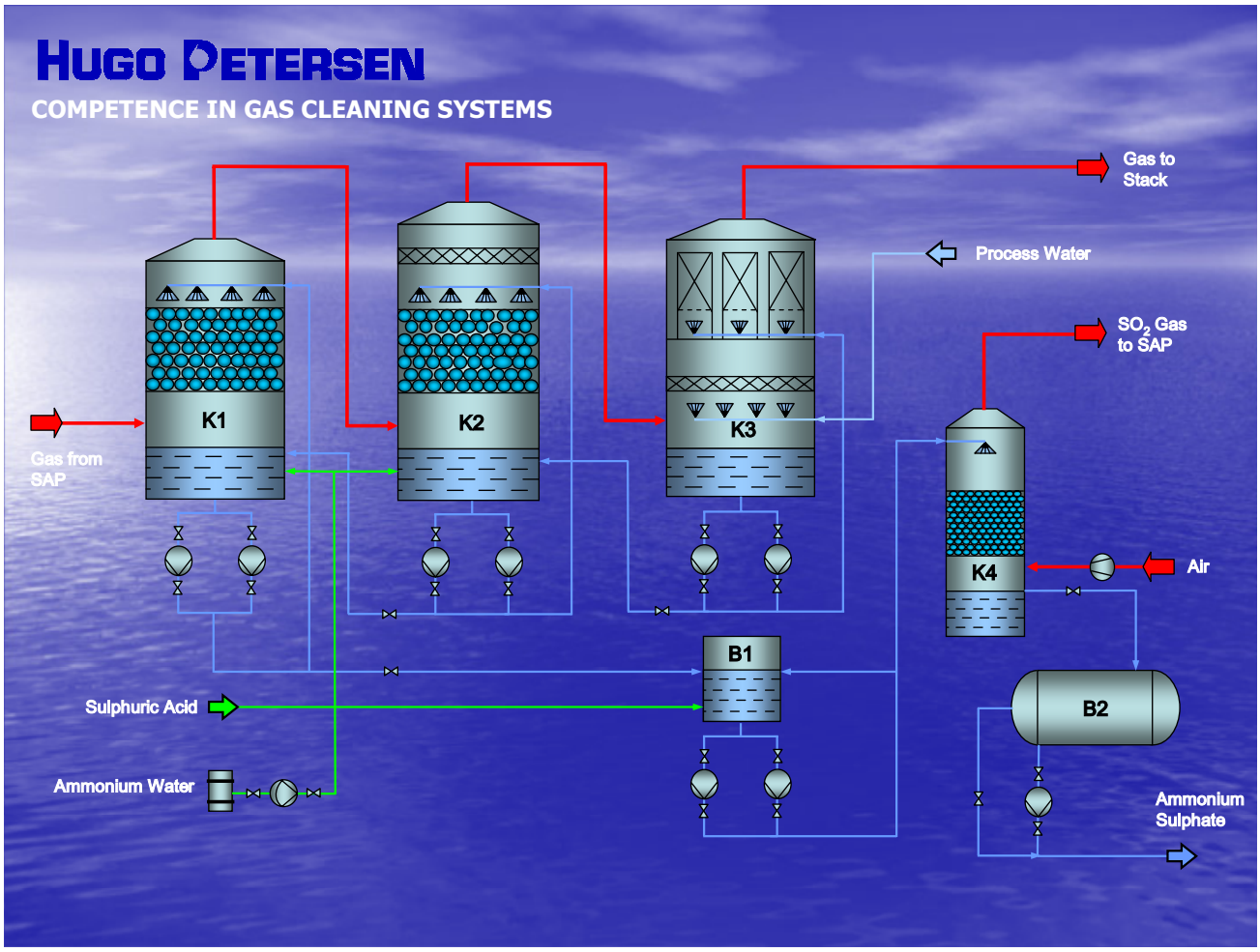



Diagram 9: Ammonium Sulphate Scrubbing Plant

The gas from the upstream plant is entering the scrubbing tower K1 in counter current flow to the liquids at the bottom and passing the packing.

$SO_2$ is absorbed by adding ammonium water and formation of ammonium sulphite.
The pre-cleaned gas is led to the second tower K2 where the remaining $SO_2$ is absorbed in the same way.

The continuous ammonium water dosing in both scrubbing towers is controlled via pH-value of the circulation liquids.

The second scrubbing tower is operating at lower concentrations to minimize the ammonium content in the cleaned gas.

Downstream the second scrubbing unit a final tower K3 is installed for elimination of ammonium sulphite mist.
The mist elimination system consists of two stages, a first wire-mesh stage continuously flushed with process water and a second candle filter stage, flushed with circulation liquid.
Alternatively to the final tower K3 a WESP-system can be installed as well.

The ammonium sulphite containing liquids of the towers K2 and K3 are level controlled discharged to the first scrubbing tower K1 where the liquid concentration is increased due to water vaporization.

Depending on the temperature and water content of the incoming gas concentrations more than 40 weight-percent are achievable.

The high concentrated ammonium sulphite liquid is discharged to the reaction vessel B1 where the liquid is oxidized to ammonium sulphate by adding of sulphuric acid of the upstream plant.

In the stripping K4 the due to the reaction formed $SO_2$ is separated from the liquid with ambient air.

Due to the high vapour pressure of $SO_2$ above the liquid an outlet concentration of 15 Vol-% of the stripping gas can be reached.
The $SO_2$ gas is finally led back to the sulphuric acid plant.

Optionally an amount of $SO_2$ gas can be re-circulated upstream the first scrubbing tower to increase the production of ammonium sulphate, if required.
The produced ammonium sulphate is discharged via overflow from the stripping tower to the storage tank B2.

The main benefits of the ammonium sulphate process are:

- No Waste Products
- Variable Production Rates in case of Recirculation

Let us come to together and develop the optimal solution for you!

**The Author**



**Axel Schulze**, Managing Director, HUGO PETERSEN GmbH

More than 25 years professional experience in design management, process design, erection supervision, commissioning of gas cleaning and $H_2SO_4$-plants in Germany and overseas

**Sulphuric Acid Plants**

- Cinkarna – Celje, Slovenia
  Start-up commissioning and test run sulphuric acid plant of 500 to/day
- Th. Goldschmidt - Mannheim, Germany
  Start up commissioning of sulphuric acid plant of 200 to/day, utilisation of $SO_2$ and $NO_x$ containing the Petersen Fattinger process for sulphuric acid and nitric acid included commissioning of pilot plants, start up and test procedures

- Research and development for $SO_2$ concentration and recovery plants for production of liquid $SO_2$ and deviates as sulphuric acid ammonia sulphate $SO_3$ and elemental sulphur
- Sales and presentation of Hugo Petersen's sulphuric acid technology in Europe and overseas
- UST-Kamenogorsk, Kazakhstan,
  Process design management for gas cleaning plant downwards zinc and lead smelter, responsible for preparation and performing of the final guarantee test of a 928 to/day sulphuric acid plant downwards of a copper smelter incl. heavy metal and effluent treatment plant
- ENAMI – Chile
  Process design manager for complete sulphuric acid plant, including heavy metal removal (Hg, Se, As) and effluent treatment plant, process design management for gas cleaning plant (dry and wet cleaning process), for removal of Hg, As, $SO_2$, HCl, NOx, HF, HBr, downwards of burning process for contaminated earth.
- Cinkarna - Slovenia
  Design manager and project manager for the expansion and modification of 240 to/day sulphuric acid plant,
- Outokumpu - Finland
  Preparation of basic design for the tender of sulphuric acid plant R7
- Outokumpu - Finland
  Engineering Management of gas cleaning plant R6 for sulphuric acid plant downwards a copper smelter

# Attachment C

## Mercury Control Cost Calculations

**Attachment C, Revised 2/24/2012**
**PolyMet Mercury Control Evaluation for NorthMet Project**
**Activated Carbon Control Cost Using Barrick Goldstrike 2007 Cost Estimate**

| | | | | | Barrick Goldstrike | NorthMet |
|---|---|---|---|---|---|---|
| **Capital Cost** [1] | | | | | **$10,133,000** | **$8,320,000** |
| **Direct Operating Costs** | **$/hr** | **Hr/Shift** | **Shift/day** | **Day/yr** | **Annual Cost** | **Annual Cost** |
| Operating Labor + 15% for Supervision [2] | $12.00 | 0.5 | 2 | 360 | $4,968 | $4,968 |
| Maintenace Labor [2] | $13.20 | 0.5 | 2 | 360 | $4,752 | $4,752 |
| Maintenance Materials [7] | 100% of Maintenance Labor | | | | $4,752 | $4,752 |
| Utilities [3, 4] | Ref Elec ¢/kW | 9.0 | MN Elect ¢/kW | 6.5 | $620,142 | $322,479 |
| **Total Direct Opearting Costs** | | | | | **$634,614** | **$336,951** |
| **Indirect Operating Costs** [5] | | | | | | |
| Overhead | 60% | of labor and maint materials | | | $8,683 | $8,683 |
| Administrative charges | 2% | of Total Capital Investment | | | $202,660 | $166,400 |
| Property tax | 1% | of Total Capital Investment | | | $101,330 | $83,200 |
| Insurance | 1% | of Total Capital Investment | | | $101,330 | $83,200 |
| Captal Recovery [6] annual int rate/equipment life | 7% | 20 | yrs / CRF -> | 0.0944 | | $785,349 |
| **Total Indirect Operating Costs** | | | | | **$414,003** | **$1,126,832** |
| **Annual Operating and Maintenance Cost** | | | | | **$1,049,000** | **$1,464,000** |
| **Estimated Barrick Goldstrike Autoclave Mercury Emissions** | | 28.1 | lb Hg/yr | | | |
| **NorthMet Autoclave Annual Mercury Emissions** | | 4.1 | lb Hg/yr | | | |
| **Annual Mercury Reduction at 90% Control lb/yr** | | | | | | **3.7** |
| **Mercury Control Cost $/lb Hg removed** | | | | | | **$397,000** |
| | | | | | | |
| **Barrick Goldstrike Design Flow** | 51,760 | acfm | | | | |
| **NorhtMet Design Flow** | 37,268 | acfm | | | | |
| **Flow Ratio** | 0.720 | | | | | |

**NorthMet Cost Estimate Assumptions**

**1.** Use Barrick capital cost times ratio of flows in acfm to 0.6 power to account for economies of scale

**2.** Use Barrick labor and maintence materials costs - both units similar sized so labor expenses should be the same.

**3.** Use Barrick power cost times ratio of flow rates in acfm

**4.** Powercost adjusted by 2011 electricity prices industrial in MN (6.5 ¢/kW) , EIA 2011 year to date vs 9¢/kW used in Barrack Cost Analysis

**5.** Use EPA control cost manual factors for overhead, adminstration, property tax aind insurance

**6.** Captial recivery cost not included in Barrick Goldstrike analysis; added to NorthMet cost analysis per MPCA request

**7.** Activated carbon costs are not significant due to the low mercury emission rates. $124/yr (37 lbs) for Polymet and $941 lb/yr Barrick (280 lbs) assuming 10 lb ACI/lb Hg and $3.35/lb sulfur impregnated activated carbon. These costs fall well within the standard maitenance material cost allotment. Therefore, the current calculations do not need to be adjusted for differences in activated carbon consumption.

# Attachment D

# Scotia International of Nevada Mercury Control Presentation

# S.I.O.N.

## Scotia International of Nevada, Inc.

PRECIOUS AND BASE METAL RECOVERY SYSTEMS



EXPERIENCIA EN SISTEMAS DE RECUPERACION DE METALES PRECIOSOS


S.I.O.N.
Scotia International
of Nevada, Inc.
DESIGN, MANUFACTURE,
INSTALLATION AND START-UP
CARBON COLUMN SYSTEMS
WWW.SCOTIACORP.COM



# MERCURY REMOVAL FROM GAS STREAMS



S.I.O.N.
Sectia International of Nevada, Inc.



# MERCURY REMOVAL OVERVIEW

- Mercury is cyanide soluble and therefore is removed from the ore and follows through the process solution.
- Mercury is adsorbed onto the activated carbon in the same manner as the gold. Gold is adsorbed more strongly than mercury and therefore displaces some of the mercury on the loaded carbon.
- Some of the mercury is removed by stripping of the carbon and goes to the electrowinning circuit.
- The remaining mercury is left on the stripped carbon and is removed from the carbon during regeneration.

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# MERCURY CHEMISTRY

**VAPOR PRESSURE OF MERCURY**

Vapor pressure of mercury in mm. of Hg for temperatures from −38 to 400°C. Note that the values for the first four lines only, are to be multiplied by $10^{-4}$

| Temp. °C | 0 | 2 | 4 | 6 | 8 |
|---|---|---|---|---|---|
| | $10^{-4}$ | $10^{-4}$ | $10^{-4}$ | $10^{-4}$ | $10^{-4}$ |
| −30 | 4.78 | 3.59 | 2.66 | 1.97 | 1.45 |
| −20 | 18.1 | 14.0 | 10.8 | 8.28 | 6.30 |
| −10 | 60.6 | 48.1 | 38.0 | 29.8 | 23.2 |
| − 0 | 185. | 149. | 119. | 95.4 | 76.2 |
| + 0 | .000185 | .000228 | .000278 | .000335 | .000406 |
| +10 | .000490 | .000588 | .000706 | .000846 | .001009 |
| 20 | .001201 | .001426 | .001691 | .002000 | .002359 |
| 30 | .002777 | .003261 | .003823 | .004471 | .005219 |
| 40 | .006079 | .007067 | .008200 | .009497 | .01098 |
| 50 | .01267 | .01459 | .01677 | .01925 | .02206 |
| 60 | .02524 | .02883 | .03287 | .03740 | .04251 |
| 70 | .04825 | .05469 | .06189 | .06993 | .07889 |
| 80 | .08880 | .1000 | .1124 | .1261 | .1413 |
| 90 | .1582 | .1769 | .1976 | .2202 | .2453 |
| 100 | .2729 | .3032 | .3366 | .3731 | .4132 |
| 110 | .4572 | .5053 | .5576 | .6150 | .6776 |
| 120 | .7457 | .8198 | .9004 | .9882 | 1.084 |
| 130 | 1.186 | 1.298 | 1.419 | 1.551 | 1.692 |
| 140 | 1.843 | 2.010 | 2.188 | 2.379 | 2.585 |
| 150 | 2.807 | 3.046 | 3.303 | 3.578 | 3.873 |
| 160 | 4.189 | 4.528 | 4.890 | 5.277 | 5.689 |
| 170 | 6.128 | 6.595 | 7.093 | 7.626 | 8.193 |
| 180 | 8.796 | 9.436 | 10.116 | 10.839 | 11.607 |
| 190 | 12.423 | 13.297 | 14.203 | 15.173 | 16.200 |

| Temp. °C | 0 | 2 | 4 | 6 | 8 |
|---|---|---|---|---|---|
| 200 | 17.287 | 18.437 | 19.652 | 20.936 | 22.292 |
| 210 | 23.723 | 25.233 | 26.826 | 28.504 | 30.271 |
| 220 | 32.133 | 34.092 | 36.153 | 38.318 | 40.585 |
| 230 | 42.989 | 45.503 | 48.141 | 50.909 | 53.812 |
| 240 | 56.855 | 60.044 | 63.384 | 66.882 | 70.543 |
| 250 | 74.375 | 78.381 | 82.568 | 86.944 | 91.518 |
| 260 | 96.296 | 101.28 | 106.48 | 111.91 | 117.57 |
| 270 | 123.47 | 129.62 | 136.02 | 142.69 | 149.64 |
| 280 | 156.87 | 164.39 | 172.21 | 180.34 | 188.79 |
| 290 | 197.57 | 206.70 | 216.17 | 226.00 | 236.21 |
| 300 | 246.80 | 257.78 | 269.17 | 280.98 | 293.21 |
| 310 | 305.89 | 319.02 | 332.62 | 346.70 | 361.26 |
| 320 | 376.33 | 391.92 | 408.04 | 424.71 | 441.94 |
| 330 | 459.74 | 478.13 | 497.12 | 516.74 | 537.00 |
| 340 | 557.90 | 579.45 | 601.69 | 624.64 | 648.30 |
| 350 | 672.69 | 697.83 | 723.73 | 750.43 | 777.92 |
| 360 | 806.23 | 835.38 | 865.36 | 896.23 | 928.02 |
| 370 | 960.66 | 994.34 | 1028.9 | 1064.4 | 1100.9 |
| 380 | 1138.4 | 1177.0 | 1216.6 | 1257.3 | 1299.1 |
| 390 | 1341.9 | 1388.1 | 1431.3 | 1477.7 | 1525.2 |
| 400 | 1574.1 | | | | |

- Mercury is the only metallic element that is a liquid (m.p. -38°C) at room temperature. Gallium melts at 30°C.
- Mercury has a boiling point of 357°C (675°F).
- Mercury's vapor pressure is high for a metal but low compared to water. Mercury at 20°C is 0.0012 mmHg, where water has the same vapor pressure at -79°C. At 100°C, mercury has a vapor pressure of 0.2729 mmHg or the same as water at -68°C.

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# MERCURY CHEMISTRY

- The mercury in the gas stream can be elemental **(gaseous)** or particulate bound **(adsorbed onto particles).**
- Mercury's molecular weight is 200.59 g/mole and its density is 13.53 grams.
- Many metals are soluble in mercury and form amalgams (such as silver and mercury fillings for teeth).
- Mercury Sulfide ($Hg_2S$) is highly insoluble with a $K_{sp}$ of $10^{-54}$ **(mercurous sulfide)** but can oxidize to a slightly higher solubility compound metacinnabar (HgS).
- The chlorides of mercury, Calomel, **(mercurous)** $Hg_2Cl_2$ and **(mercuric)** $HgCl_2$ are also used for mercury recovery.

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# SULFUR AND MERCURY

- The basis for removal of mercury using sulfur is the reaction:

$$2\,Hg^0 + S^0 \rightarrow Hg_2S$$
$$Hg_2S + S^0 \rightarrow 2HgS$$

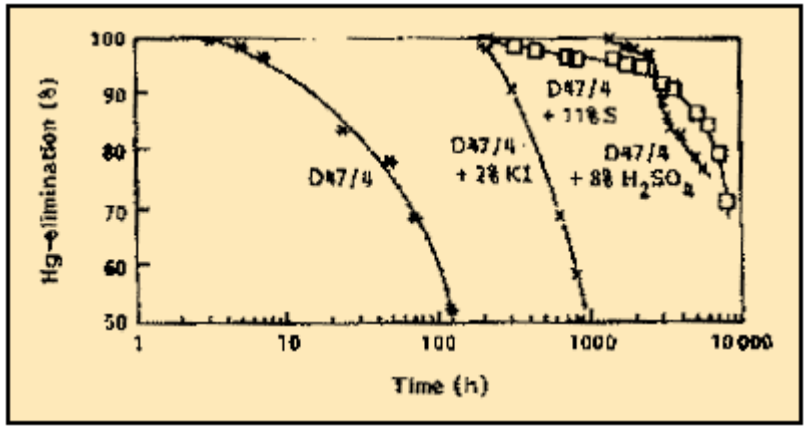
The mercury is transformed into a solid material with volatility reducing the vaporization hazards associated with mercury.

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# ACTIVATED CARBON AND IMPREGNATED CARBON

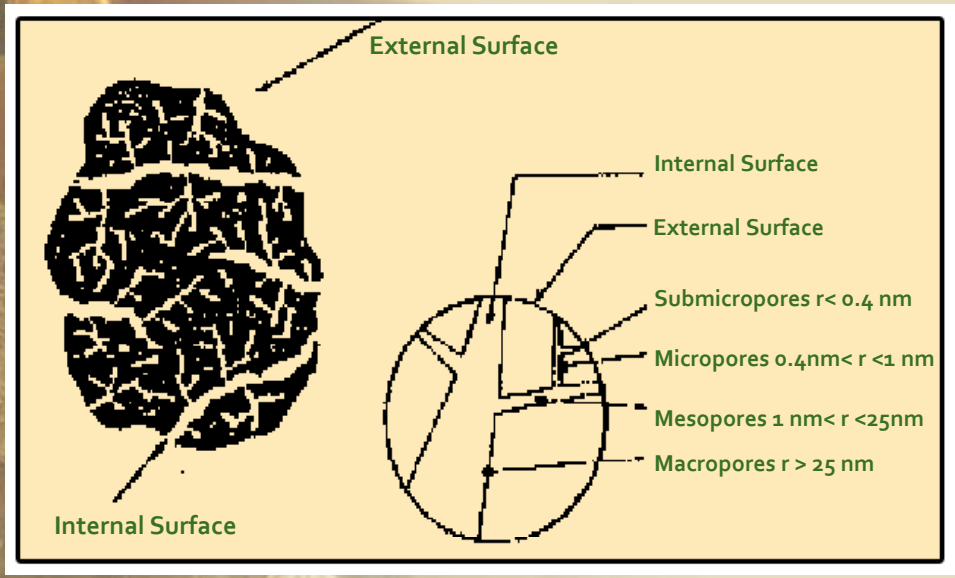
- Activated Carbon will adsorb gaseous mercury onto its surface.




Mercury elimination rates of non-impregnated and impregnated activated carbon



# ACTIVATED CARBON AND IMPREGNATED CARBON




- But other impregnates, such as, iodide, sulfuric acid or sulfur adsorb significantly more. The increased amount adsorbed is due to the high concentration of adsorbate on the activated carbon, KI (2%), $H_2SO_4$ (8%) and sulfur (11 to 15%). The sulfur reaction rate is higher, so it is commonly used for mercury treatment of gas streams.

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# ACTIVATED CARBON

- The extruded carbon used in making the 4mm pellets for impregnated carbon has a surface area between 1000 to 1100 $m^2/g$.

- The high internal surface area is why the carbon has a density of ~0.52 g/cc. This high surface area allows for the high adsorption of the reactants.

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# MERCURY ADSORPTION

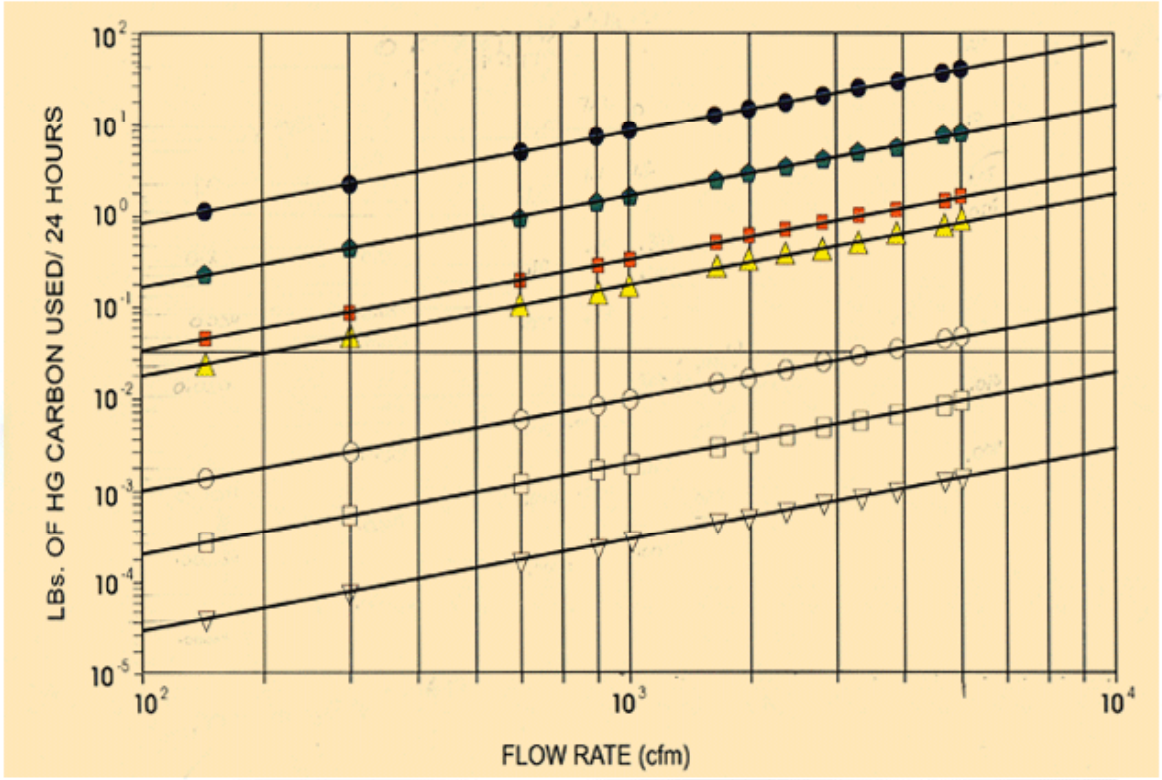
- The adsorption of mercury onto the sulfur surface is a chemisorption process. The chemisorption is the reason for the rapid reaction rates and the low transfer length **(2.7 inches for 98% adsorption)** at linear flow rates of 75 fpm.

- Depending on the mercury concentration in the gas stream **(0.001 ppm to 20 ppm),** the amount of carbon consumed **(becoming completely loaded)** ranges from 0.0007 to 18 pounds per 24 hours period at a flow rate of 3000 cfm.

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▽ 0.001 □ 0.007 ○ 0.05 △ 0.4 ■ 1.0 ⬟ 5.0 ● 20.0 [PPM MERCURY]

CARBON LINK
The Active Force in Carbon

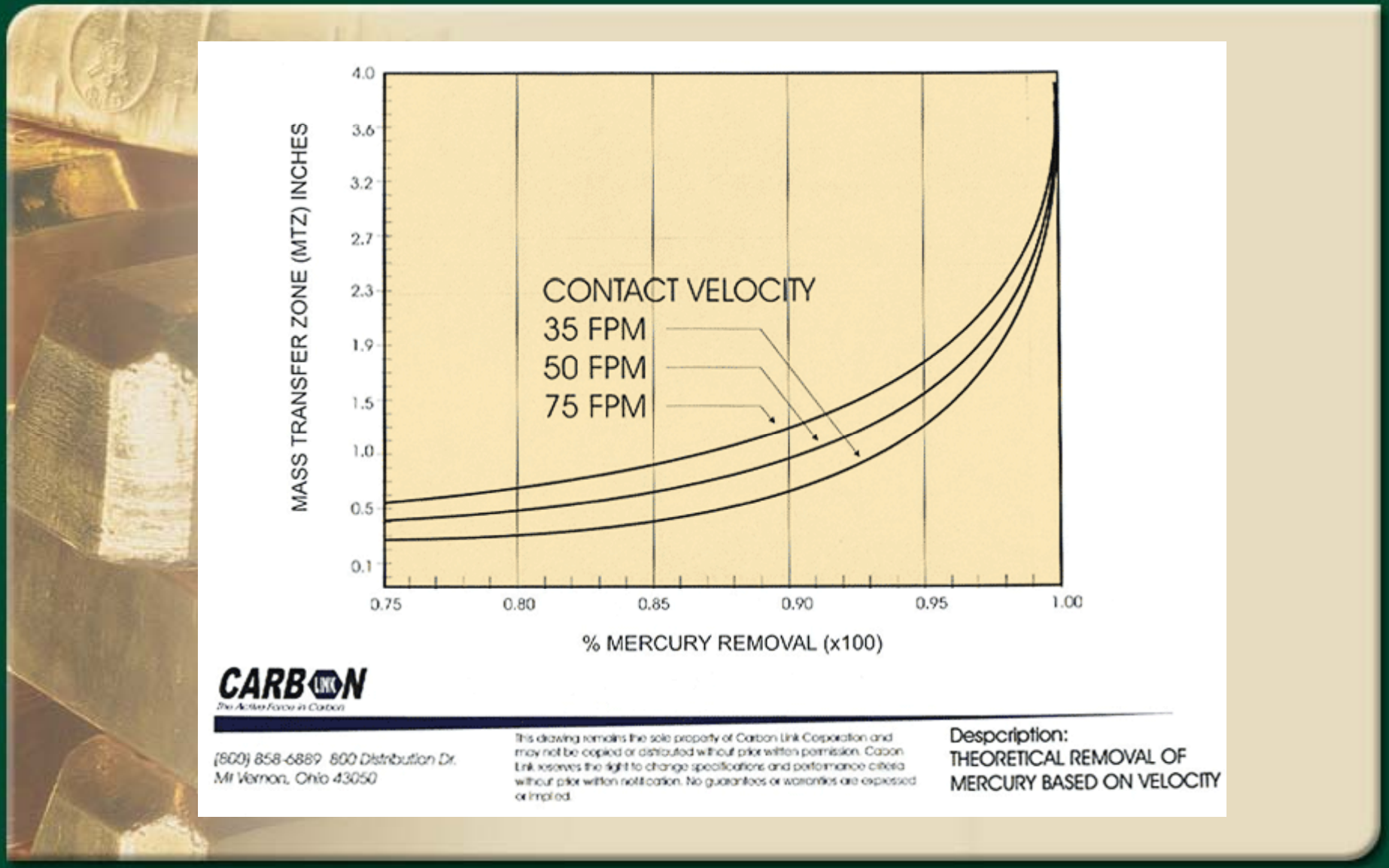
(800) 858-6889 800 Distribution Dr.
Mt Vernon, Ohio 43050

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Despcription:
THEORETICAL ESTIMATE OF LIFE FOR H3N

S.I.O.N.
Sectio International of Nevada, Inc.






CARBON LINK
The Active Force in Carbon

(800) 858-6889 800 Distribution Dr.
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Despcription:
THEORETICAL REMOVAL OF MERCURY BASED ON VELOCITY

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# TYPES OF SCRUBBERS

- Deep Bed Scrubbers handle the highest flow rates and mercury concentration. Bed depth is usually 4 feet deep **(depends on mercury concentration)** and have a maximum diameter of 13 feet **(10,000 cfm)**.
- Tray scrubbers contain about a quarter of the carbon as a deep bed would for the same flow, these units are used on low grade streams that have high volume, such as e-cells.
- The cylindrical unit can handle high flow rates in a smaller floor area and are used instead of tray units or as back up units to deep bed units. They cost less than deep beds but do not have as high of a loading capacity.
- The units are usually made of stainless steel **(316L)**.

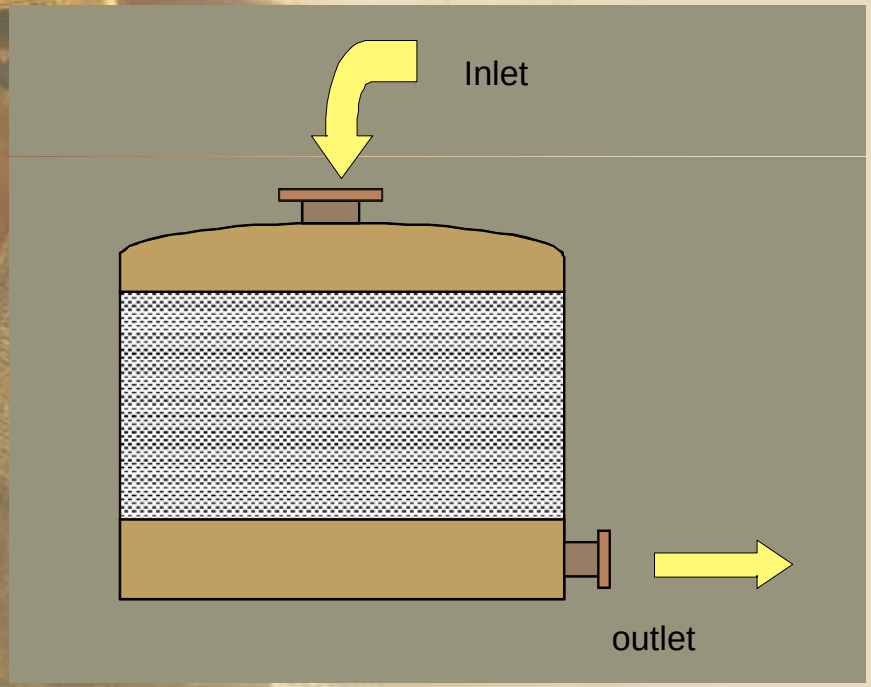
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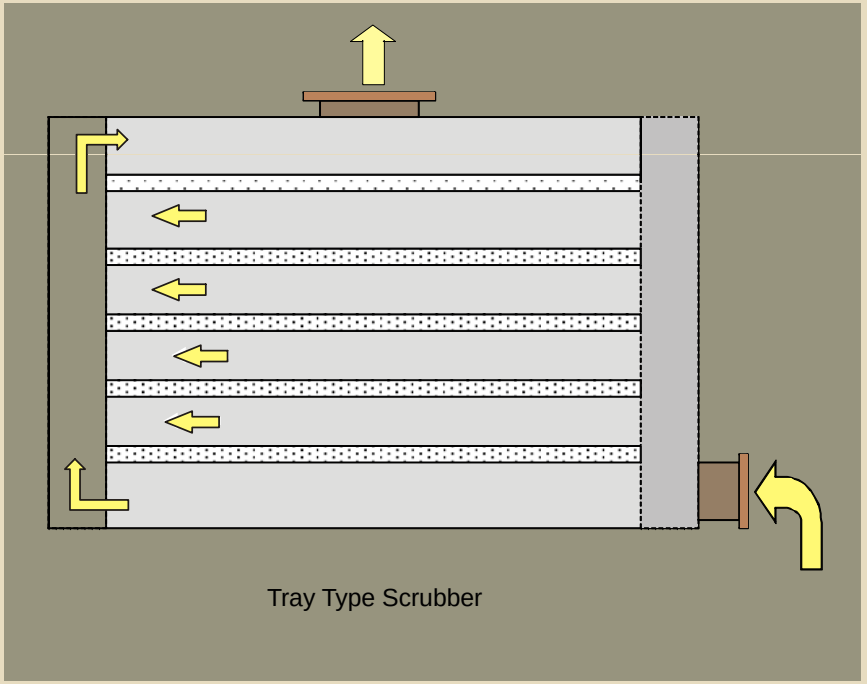






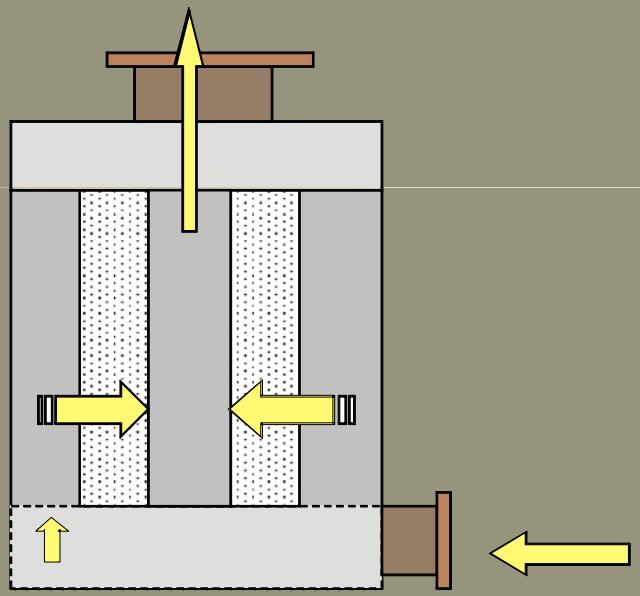
# SCRUBBER DESIGN (DEEP BED)

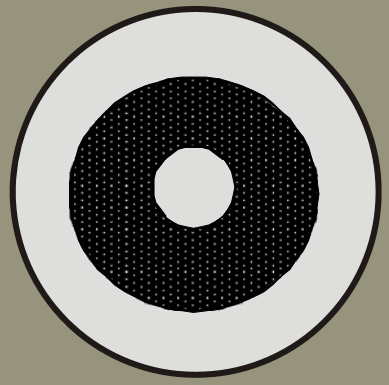




# CYLINDRICAL TOROID





Cylindrical Toroid

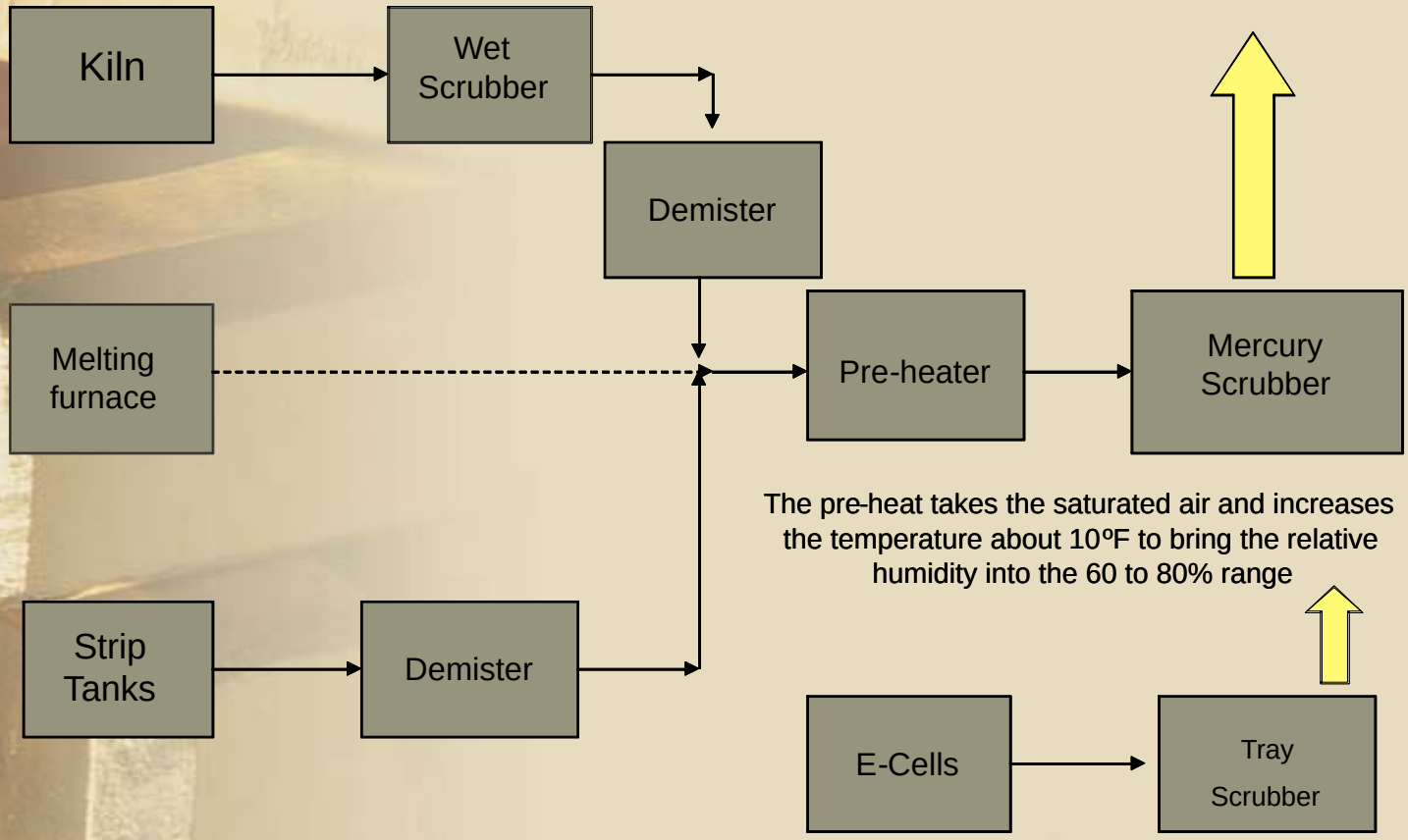
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# TYPICAL FLOW SHEET




The pre-heat takes the saturated air and increases the temperature about 10ºF to bring the relative humidity into the 60 to 80% range

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# TYPICAL TREATMENT SCHEME

- The air from the kiln is wet scrubber to remove any particulate matter from gas stream. It passes to a demister to remove any droplets of water. The gas is passed through a pre-heater to bring the relative humidity **(R.H)** down so water doesn't form in the deep bed.
- The air from the preg and barren strip tanks is passed through a demister and then flows into the pre-heater before it passes through the deep bed.
- The air from the melting furnace **(intermittent flow)** passes with the other gases into the deep bed scrubber.
- The air from the E-cells is passed through a tray scrubber.

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# DESIGN CRITERIA

- Air flow is limited to 75 fpm
- Relative humidity in the gas stream is maintained in the range of 60 to 80% (for maximum reaction rate, as moisture decreases the reaction rate slows and at high humidity the reaction rates slow significantly (1 to 5% of optimum RH%))
- A deep bed scrubber is designed to have the carbon changed two times or less per year. Tray scrubbers are usually designed to be changed 4 times or less per year.
- Air stream temperature is maintained as low as possible, since temperatures above 180°F increase the chances of causing auto-combustion of the sulfur impregnated carbon. Nominal design temperatures are usually below 130°F. Dilution air is usually used to decrease temperatures in the system.

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# TESTING CRITERIA

- Gas sampling is not recommended, since even with advanced equipment and trained samplers, reproducibility is not good. Additionally, gas stream sampling is an intricate, long process that doesn't lend itself to monthly testing.
- Monthly performance testing is a recommended method of testing. This testing involves taking carbon samples monthly from different levels of the deep bed or trays and analyzing the carbon for mercury loading.
- The reason to sample from the various levels of the tank is to watch the progressive increase in the amount of mercury loaded onto the carbon and predict when the carbon needs to be changed prior to breaking through the bed.

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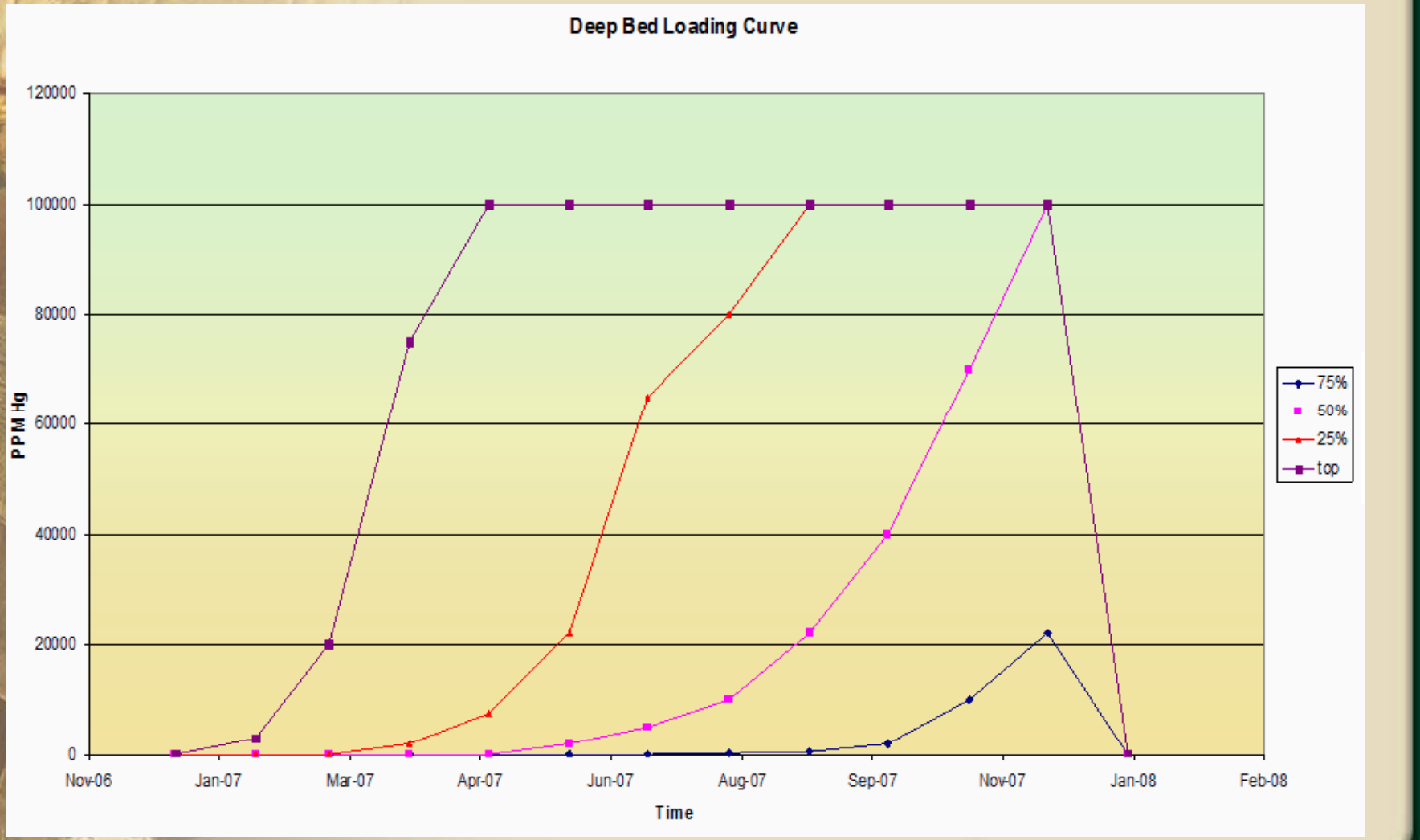
## Frqfhqwudwlrq#lq#ssp#Kj

| Wlph | Wrs | 58( | 83( | :8( |
|---|---|---|---|---|
| Jan 07 | 0 | 0 | 0 | 0 |
| Feb 07 | 3000 | 20 | 1 | 0 |
| Mar 07 | 20000 | 100 | 5 | 1 |
| Apr 07 | 75000 | 2000 | 15 | 5 |
| May 07 | 100000 | 7500 | 100 | 8 |
| Jun 07 | 100000 | 22000 | 2000 | 50 |
| Jul 07 | 100000 | 65000 | 5000 | 100 |
| Aug 07 | 100000 | 80000 | 10000 | 200 |
| Sep 07 | 100000 | 100000 | 22000 | 500 |
| Oct 07 | 100000 | 100000 | 40000 | 2000 |
| Nov 07 | 100000 | 100000 | 70000 | 10000 |
| Dec 07 | 100000 | 100000 | 100000 | 22000 |
| Jan 08 | 0 | 0 | 0 | 0 |

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# REVIEWING LOADING DATA

- As can be seen from the previous graph the loading is not constant, which is expected from a mine where ore grades are constantly varying.
- The maximum loading for this system appears to be 10% Hg, this concentrate will vary with conditions and carbon source.
- The carbon life is one year.

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# ADVANTAGES TO PERFORMANCE TESTING

- A skilled sampler is not required. A "grain thief" sampler is all that is required (plus PPE).
- There is little interruption to the process.
- The variability of the ore is addressed by the constant monthly testing.
- The frequent sampling lets the operational group plan when the carbon needs to be changed.
- Carbon analysis for mercury is a well known procedure and most certified labs are capable of performing this analysis.

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# CONCLUSIONS

- Mercury adsorption from gas streams that are 10,000 cfm or less is best accomplished by sulfur impregnated activated carbon.
- There is no specialized instrumentation or equipment necessary to operate as in the case of wet scrubbers.
- The system is passive and easily monitored.
- The method is economic and within the range of all types of operators **(large and small)**
- The technology is well known and understood.

**Attachment K**

**Air Emission Inventory Summaries**

**PolyMet - Hoyt Lakes, Minnesota**
**Table 1: Calculation of Potential Emissions - Processing Plant**

| Ref. No. | Stack No. | Unit No. | EU | Vent into building? | Type | Unit Name | Pollutant | PSD Applicability (Y/N) | HAP ? (Y/N) | [A] Maximum Hourly Rate | Units | [B] Maximum Annual Rate | Units | [C] Emission Factor, (lb/unit) | Emission Factor Units | Annual Days with precipitation (if applicable) | [E] Uncontrolled Emission Rate, (lb/hr) | [F] Uncontrolled Potential to Emit (PTE), (ton/yr) | [G] Implied Control Factor, (%) | [H] Controlled Potential to Emit (PTE), (ton/yr) | [I] Controlled Emission Rate, (lb/hr) | a | [L] Projected Actual Annual Rate | Units | Controlled Projected Actual Emission Rate (ton/yr) | b | [J] Permitted Grain Loading Limit, (gr/dscf) | [K] Design Stack Flow Rate, (acfm) | e | [M] Maximum Daily rate (if different than hourly * 24) | Units | Controlled Emission Rate (lb/day) | g | Controlled Emission Rate To Use For Modeling (lb/hr) | Controlled Emission Rate To Use For Modeling & Permitting (ton/yr) [JJM's col] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Totals for PSD Applicability (i.e. PSD Point Sources) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Criteria Pollutant Totals | | | | | | | PM10 | | | | | | | | | | 4195.19 | 18366.02 | | 216.38 | 51.44 | | | | 114.16 | | | | | | | | | 45.50 | 192.35 |
| | | | | | | | PM2.5 | | | | | | | | | | 4190.77 | 18346.83 | | 203.03 | 48.35 | | | | 114.68 | | | | | | | | | 44.86 | 189.75 |
| | | | | | | | SO2 | | | | | | | | | | 22.77 | 33.59 | | 6.98 | 16.70 | | | | 4.824 | | | | | | | | | 16.697 | 7.114 |
| | | | | | | | H2SO4/SO3 | | | | | | | | | | 112.62 | 491.76 | | 5.02 | 1.49 | | | | 4.557 | | | | | | | | | 1.488 | 5.017 |
| | | | | | | | Total PM | | | | | | | | | | 4213.69 | 18442.12 | | 262.37 | 63.06 | | | | 116.614 | | | | | | | | | 48.583 | 200.947 |
| | | | | | | | NOx | | | | | | | | | | 114.29 | 117.07 | | 89.36 | 107.96 | | | | 29.93 | | | | | | | | | 107.73 | 116.97 |
| | | | | | | | VOC | | | | | | | | | | 19.77 | 72.42 | | 48.79 | 14.37 | | | | 44.31 | | | | | | | | | 14.36 | 50.36 |
| | | | | | | | Carbon Monoxide | | | | | | | | | | 47.44 | 105.89 | | 105.89 | 47.44 | | | | 44.40 | | | | | | | | | 47.30 | 127.16 |
| | | | | | | | Pb | | | | | | | | | | 0.09 | 0.41 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| Toxic Air Pollutant Totals [10] | | | | | | | Hydrogen Sulfide | | | | | | | | | | 1.43 | 6.27 | | 1.88 | 0.43 | | | | 1.69 | | | | | | | | | 0.43 | 1.88 |
| | | | | | | | CS2 | | | | | | | | | | 1.16 | 5.10 | | 5.10 | 1.16 | | | | 4.44 | | | | | | | | | 1.16 | 5.10 |
| | | | | | | | TRS | | | | | | | | | | 2.59 | 11.36 | | 6.98 | 1.59 | | | | 6.13 | | | | | | | | | 1.59 | 6.98 |
| | | | | | | | Fluorides (as F) | | | | | | | | | | 0.79 | 3.48 | | 0.03 | 0.01 | | | | 0.14 | | | | | | | | | 0.17 | 0.12 |
| Plant Site Totals (Point and Fugitive Sources) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Criteria Pollutant Totals [6] | | | | | | | PM10 | | | | | | | | | | 6976.74 | 19126.58 | | 536.56 | 649.80 | | | | 408.70 | | | | | | | | | 505.57 | 428.38 |
| | | | | | | | PM2.5 | | | | | | | | | | 4471.60 | 18433.53 | | 245.69 | 110.86 | | | | 150.24 | | | | | | | | | 92.29 | 219.67 |
| | | | | | | | SO2 | | | | | | | | | | 22.77 | 33.59 | | 6.98 | 16.70 | | | | 4.82 | | | | | | | | | 16.70 | 7.11 |
| | | | | | | | H2SO4/SO3 | | | | | | | | | | 112.62 | 491.76 | | 5.02 | 1.49 | | | | 4.56 | | | | | | | | | 1.49 | 5.02 |
| | | | | | | | Total PM | | | | | | | | | | 15271.60 | 21081.79 | | 1135.66 | 2364.30 | | | | 1054.67 | | | | | | | | | 1841.65 | 896.33 |
| | | | | | | | NOx | | | | | | | | | | 114.29 | 117.07 | | 89.36 | 107.96 | | | | 29.93 | | | | | | | | | 107.73 | 116.97 |
| | | | | | | | VOC | | | | | | | | | | 19.77 | 72.42 | | 48.79 | 14.37 | | | | 44.31 | | | | | | | | | 14.36 | 50.36 |
| | | | | | | | Carbon Monoxide | | | | | | | | | | 47.44 | 105.89 | | 105.89 | 47.44 | | | | 44.40 | | | | | | | | | 47.30 | 127.16 |
| | | | | | | | Pb | | | | | | | | | | 0.12 | 0.50 | | 0.08 | 0.01 | | | | 0.08 | | | | | | | | | 0.01 | 0.08 |
| Toxic Air Pollutant Totals [7] | | | | | | | Antimony | | | | | | | | | | 0.0273 | 0.07 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Arsenic | | | | | | | | | | 0.19 | 0.31 | | 0.026 | 0.028 | | | | 0.03 | | | | | | | | | 0.02 | 0.03 |
| | | | | | | | Beryllium | | | | | | | | | | 0.01 | 0.01 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Cadmium | | | | | | | | | | 0.01 | 0.02 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Chromium | | | | | | | | | | 0.89 | 2.49 | | 0.11 | 0.08 | | | | 0.11 | | | | | | | | | 0.07 | 0.11 |
| | | | | | | | Cobalt | | | | | | | | | | 3.91 | 14.98 | | 0.19 | 0.14 | | | | 0.19 | | | | | | | | | 0.12 | 0.19 |
| | | | | | | | Manganese | | | | | | | | | | 32.71 | 37.13 | | 2.00 | 5.45 | | | | 2.61 | | | | | | | | | 4.55 | 2.00 |
| | | | | | | | Mercury | | | | | | | | | | 1.37E-03 | 5.68E-03 | | 2.27E-03 | 5.30E-04 | | | | 1.90E-03 | | | | | | | | | 5.28E-04 | 2.32E-03 |
| | | | | | | | Nickel | | | | | | | | | | 112.17 | 491.30 | | 4.72 | 1.06 | | | | 4.20 | | | | | | | | | 1.06 | 4.72 |
| | | | | | | | Phosphorus | | | | | | | | | | 1.77 | 7.74 | | 0.08 | 0.02 | | | | 0.04 | | | | | | | | | 0.02 | 0.08 |
| | | | | | | | Selenium | | | | | | | | | | 27.41 | 120.02 | | 1.12 | 0.26 | | | | 1.01 | | | | | | | | | 0.26 | 1.12 |
| | | | | | | | Barium | | | | | | | | | | 1.33 | 5.45 | | 0.11 | 0.04 | | | | 0.08 | | | | | | | | | 0.03 | 0.11 |
| | | | | | | | Boron | | | | | | | | | | 1.02 | 3.18 | | 0.06 | 0.07 | | | | 0.06 | | | | | | | | | 0.06 | 0.06 |
| | | | | | | | Copper | | | | | | | | | | 54.17 | 237.08 | | 2.39 | 0.53 | | | | 1.98 | | | | | | | | | 0.53 | 2.39 |
| | | | | | | | Molybdenum | | | | | | | | | | 0.02 | 0.08 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Vanadium | | | | | | | | | | 1.67 | 2.77 | | 0.13 | 0.24 | | | | 0.15 | | | | | | | | | 0.20 | 0.13 |
| | | | | | | | Zinc | | | | | | | | | | 1.52 | 6.41 | | 0.20 | 0.04 | | | | 0.17 | | | | | | | | | 0.03 | 0.20 |
| | | | | | | | Tellurium | | | | | | | | | | 0.40 | 0.82 | | 0.03 | 0.05 | | | | 0.03 | | | | | | | | | 0.04 | 0.03 |
| | | | | | | | Hafnium | | | | | | | | | | 0.02 | 0.04 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | POM | | | | | | | | | | 0.01 | 0.00 | | 0.00 | 0.01 | | | | 0.00 | | | | | | | | | 0.01 | 0.00 |
| | | | | | | | 2-Methylnaphthalene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | 3-Methylchloranthrene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | 7,12-Dimethylbenz (a)anthracene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Acenaphthene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Acenaphthylene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Anthracene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Benzo(a)anthracene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Benzo(a)pyrene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Benzo(b)fluoranthene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Benzo(g,h,i)perylene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Benzo(k)fluoranthene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Chrysene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Dibenzo(a,h)anthracene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Fluoranthene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Fluorene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Indeno(1,2,3-cd)pyrene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Phenanthrene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Pyrene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Benzene | | | | | | | | | | 0.02 | 0.01 | | 0.01 | 0.02 | | | | 0.00 | | | | | | | | | 0.02 | 0.01 |
| | | | | | | | Dichlorobenzene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Formaldehyde | | | | | | | | | | 0.02 | 0.06 | | 0.06 | 0.02 | | | | 0.01 | | | | | | | | | 0.02 | 0.07 |
| | | | | | | | Hexane | | | | | | | | | | 0.32 | 1.39 | | 1.39 | 0.32 | | | | 0.29 | | | | | | | | | 0.32 | 1.76 |
| | | | | | | | Toluene | | | | | | | | | | 0.01 | 0.00 | | 0.00 | 0.01 | | | | 0.00 | | | | | | | | | 0.01 | 0.01 |
| | | | | | | | Naphthalene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Xylene | | | | | | | | | | 0.01 | 0.00 | | 0.00 | 0.01 | | | | 0.00 | | | | | | | | | 0.01 | 0.00 |
| | | | | | | | MIBC | | | | | | | | | | 3.62 | 12.70 | | 12.70 | 3.62 | | | | 15.44 | | | | | | | | | 3.62 | 12.70 |
| | | | | | | | HF | | | | | | | | | | 0.15 | 0.68 | | 0.01 | 0.00 | | | | 0.01 | | | | | | | | | 0.00 | 0.01 |
| | | | | | | | HCl | | | | | | | | | | 30.90 | 51.17 | | 1.01 | 19.45 | | | | 0.90 | | | | | | | | | 19.45 | 1.01 |
| | | | | | | | Hydrogen Sulfide | | | | | | | | | | 1.43 | 6.27 | | 1.88 | 0.43 | | | | 1.69 | | | | | | | | | 0.43 | 1.88 |
| | | | | | | | CS2 | | | | | | | | | | 1.16 | 5.10 | | 5.10 | 1.16 | | | | 4.44 | | | | | | | | | 1.16 | 5.10 |
| | | | | | | | TRS | | | | | | | | | | 2.59 | 11.36 | | 6.98 | 1.59 | | | | 6.13 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Crystalline Silica | | | | | | | | | | 636.77 | 340.00 | | 45.36 | 130.80 | | | | 55.53 | | | | | | | | | 108.31 | 40.54 |
| | | | | | | | Fluorides (as F) | | | | | | | | | | 1.74 | 3.75 | | 0.12 | 0.20 | | | | 0.14 | | | | | | | | | 0.17 | 0.12 |
| | | | | | | | Acetaldehyde | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.001517555 | 0.00 |
| | | | | | | | Acrolein | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Propylene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Hexchrome | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | PGME | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | 1,3-Butadiene | | | | | | | | | | 0.00 | 0.00 | | 0.00 | 0.00 | | | | 0.00 | | | | | | | | | 0.00 | 0.00 |
| | | | | | | | Total HAP | | | | | | | | | | 211.48 | 731.53 | | 15.89 | 28.04 | | | | 13.92 | | | | | | | | | 27.10 | 16.28 |
| Greenhouse Gas Totals | | | | | | | Carbon Dioxide | | | | | | | | | | 39097.31 | 151994.45 | | 151994.45 | 39097.31 | | | | 64073.84 | | | | | | | | | 38864.37 | 75532.11 |
| | | | | | | | N2O | | | | | | | | | | 0.58 | 2.56 | | 2.56 | 0.58 | | | | 0.75 | | | | | | | | | 0.57 | 0.94 |
| | | | | | | | CH4 | | | | | | | | | | 0.42 | 1.82 | | 1.82 | 0.42 | | | | 0.43 | | | | | | | | | 0.41 | 0.54 |
| | | | | | | | CO2e [11] | | | | | | | | | | 39287.00 | 152825.29 | | 152825.29 | 39287.00 | | | | 64316.32 | | | | | | | | | 39049.41 | 75836.45 |

**Notes:**

**General References:**
[4] Tailings basin emission are calculated by the dispersion modeling program based on the actual meteorological data for each day modeled.
[6] Lead is both a criteria pollutant and a toxic air pollutant, as well as a HAP.
[7] Pollutants evaluated included HAPs as well as other toxic compounds that may be evaluated in the AERA.
[8] These speciated compounds are HAPs because they are POM. HAP emissions are calculated with the total POM emission factor. The speciated compound data were used as inputs to the AERA.
[10] CS2 is not a PSD pollutant, but the CS2 total, along with the H2S total are used to calculate TRS which is a PSD pollutant.

# NorthMet Mine Site Emission Summary

| | | Year 8 | | Year 13 | |
|---|---|---|---|---|---|
| | | **Controlled Potential to Emit (PTE), (ton/yr)** | **Controlled Emission Rate, (lb/hr)** | **Controlled Potential to Emit (PTE), (ton/yr)** | **Controlled Emission Rate, (lb/hr)** |
| Totals for PSD Applicability (i.e. PSD Point Sources) | | | | | |
| Criteria Pollutant Totals | PM10 | 4.27 | 2.19 | 4.27 | 2.19 |
| | PM2.5 | 1.53 | 0.74 | 1.53 | 0.74 |
| | SO2 | 0.81 | 2.68 | 0.81 | 2.68 |
| | H2SO4/SO3 | 0.02 | 0.07 | 0.02 | 0.07 |
| | Total PM | 9.23 | 5.13 | 9.23 | 5.13 |
| | NOx | 5.43 | 17.04 | 5.43 | 17.04 |
| | VOC | 0.20 | 0.45 | 0.20 | 0.45 |
| | Carbon Monoxide | 1.83 | 4.61 | 1.83 | 4.61 |
| | Pb | 0.00 | 0.00 | 0.00 | 0.00 |
| Toxic Air Pollutant Totals [7] | Hydrogen Sulfide | 0.00 | 0.00 | 0.00 | 0.00 |
| | CS2 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TRS | 0.00 | 0.00 | 0.00 | 0.00 |
| | Fluorides (as F) | 0.10 | 0.03 | 0.11 | 0.04 |
| Mine Site Totals (Point and Fugitive Sources) | | | | | |
| Criteria Pollutant Totals | PM10 | 424.78 | 143.97 | 458.23 | 157.04 |
| | PM2.5 | 69.09 | 21.16 | 70.83 | 22.10 |
| | SO2 | 1.93 | 7.13 | 1.93 | 7.13 |
| | H2SO4/SO3 | 0.04 | 0.17 | 0.04 | 0.17 |
| | Total PM | 1367.41 | 487.05 | 1507.98 | 539.66 |
| | NOx | 12.03 | 43.44 | 12.03 | 43.44 |
| | VOC | 0.38 | 1.16 | 0.38 | 1.16 |
| | Carbon Monoxide | 3.34 | 10.66 | 3.34 | 10.66 |
| | Pb | 0.01 | 0.00 | 0.01 | 0.00 |
| Toxic Air Pollutant Totals | Antimony | 7.0E-03 | 2.5E-03 | 7.6E-03 | 2.7E-03 |
| | Arsenic | 2.8E-02 | 1.0E-02 | 3.2E-02 | 1.1E-02 |
| | Beryllium | 8.5E-04 | 3.0E-04 | 9.3E-04 | 3.3E-04 |
| | Cadmium | 8.5E-04 | 3.0E-04 | 9.4E-04 | 3.3E-04 |
| | Chromium | 2.5E-01 | 8.8E-02 | 2.7E-01 | 9.8E-02 |
| | Cobalt | 8.5E-02 | 3.0E-02 | 9.3E-02 | 3.3E-02 |
| | Manganese | 1.4E+00 | 4.8E-01 | 1.5E+00 | 5.4E-01 |
| | Mercury | 4.4E-05 | 1.7E-05 | 5.0E-05 | 1.9E-05 |
| | Nickel | 6.3E-01 | 2.0E-01 | 6.7E-01 | 2.2E-01 |
| | Phosphorus | 1.5E-01 | 3.4E-02 | 1.4E-01 | 3.2E-02 |
| | Selenium | 1.1E-02 | 4.0E-03 | 1.2E-02 | 4.4E-03 |
| | Barium | 5.9E-01 | 2.2E-01 | 6.7E-01 | 2.5E-01 |
| | Boron | 1.5E-02 | 5.3E-03 | 1.7E-02 | 5.9E-03 |
| | Copper | 1.2E+00 | 3.5E-01 | 1.3E+00 | 3.8E-01 |
| | Molybdenum | 4.6E-03 | 1.7E-03 | 5.2E-03 | 1.9E-03 |
| | Vanadium | 1.9E-01 | 6.3E-02 | 2.1E-01 | 7.0E-02 |
| | Zinc | 1.5E-01 | 5.2E-02 | 1.6E-01 | 5.8E-02 |
| | Tellurium | 3.5E-02 | 1.2E-02 | 3.8E-02 | 1.3E-02 |
| | Hafnium | 2.0E-04 | 4.5E-05 | 2.0E-04 | 4.5E-05 |
| | POM | 6.8E-04 | 2.7E-03 | 6.8E-04 | 2.7E-03 |
| | 2-Methylnaphthalene | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | 3-Methylchloranthrene | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | 7,12-Dimethylbenz (a)anthracene | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Acenaphthene | 1.5E-05 | 6.1E-05 | 1.5E-05 | 6.1E-05 |
| | Acenaphthylene | 3.0E-05 | 1.2E-04 | 3.0E-05 | 1.2E-04 |
| | Anthracene | 4.0E-06 | 1.6E-05 | 4.0E-06 | 1.6E-05 |
| | Benzo(a)anthracene | 2.0E-06 | 8.0E-06 | 2.0E-06 | 8.0E-06 |
| | Benzo(a)pyrene | 8.3E-07 | 3.3E-06 | 8.3E-07 | 3.3E-06 |
| | Benzo(b)fluoranthene | 3.6E-06 | 1.4E-05 | 3.6E-06 | 1.4E-05 |
| | Benzo(g,h,i)perylene | 1.8E-06 | 7.2E-06 | 1.8E-06 | 7.2E-06 |
| | Benzo(k)fluoranthene | 7.1E-07 | 2.8E-06 | 7.1E-07 | 2.8E-06 |
| | Chrysene | 4.9E-06 | 2.0E-05 | 4.9E-06 | 2.0E-05 |
| | Dibenzo(a,h)anthracene | 1.1E-06 | 4.5E-06 | 1.1E-06 | 4.5E-06 |
| | Fluoranthene | 1.3E-05 | 5.2E-05 | 1.3E-05 | 5.2E-05 |
| | Fluorene | 4.1E-05 | 1.7E-04 | 4.1E-05 | 1.7E-04 |
| | Indeno(1,2,3-cd)pyrene | 1.3E-06 | 5.4E-06 | 1.3E-06 | 5.4E-06 |
| | Phenanthrene | 1.3E-04 | 5.3E-04 | 1.3E-04 | 5.3E-04 |
| | Pyrene | 1.2E-05 | 4.8E-05 | 1.2E-05 | 4.8E-05 |
| | Benzene | 2.5E-03 | 1.0E-02 | 2.5E-03 | 1.0E-02 |
| | Dichlorobenzene | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Formaldehyde | 2.6E-04 | 1.0E-03 | 2.6E-04 | 1.0E-03 |
| | Hexane | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Toluene | 9.1E-04 | 3.6E-03 | 9.1E-04 | 3.6E-03 |
| | Naphthalene | 4.2E-04 | 1.7E-03 | 4.2E-04 | 1.7E-03 |
| | Xylene | 6.2E-04 | 2.5E-03 | 6.2E-04 | 2.5E-03 |
| | MIBC | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | HF | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | HCl | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Hydrogen Sulfide | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | CS2 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | TRS | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Crystalline Silica | 13.63 | 4.85 | 15.01 | 5.37 |
| | Fluorides (as F) | 1.0E-01 | 3.5E-02 | 1.1E-01 | 3.8E-02 |
| | Acetaldehyde | 8.1E-05 | 3.3E-04 | 8.1E-05 | 3.3E-04 |
| | Acrolein | 2.5E-05 | 1.0E-04 | 2.5E-05 | 1.0E-04 |
| | Propylene | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Hexchrome | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | PGME | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | 1,3-Butadiene | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Total HAP | 2.53 | 0.88 | 2.74 | 0.96 |
| Greenhouse Gas Totals | CO2 | 1739.88 | 2364.66 | 1739.88 | 2364.66 |
| | N2O | 0.08 | 0.02 | 0.08 | 0.02 |
| | CH4 | 0.02 | 0.00 | 0.02 | 0.00 |
| | CO2e [11] | 1764.19 | 2370.21 | 1764.19 | 2370.21 |

**Attachment L**

**Summary of Plant Site Emission Inventory as Updated for FEIS**

## NorthMet Plant Site Emission Summary

| | | Draft FEIS Inventory | | | SDEIS Inventory | | |
|---|---|---|---|---|---|---|---|
| | | Controlled Potential to Emit (PTE), (ton/yr) | Controlled Emission Rate, (lb/hr) | Limited Controlled Potential to Emit (ton/yr) | Controlled Potential to Emit (PTE), (ton/yr) | Controlled Emission Rate, (lb/hr) | Limited Controlled Potential to Emit (ton/yr) |
| Totals for PSD Applicability (i.e. PSD Point Sources) | | | | | | | |
| Criteria Pollutant Totals | PM10 | 192.86 | 46.11 | 166.90 | 216.38 | 51.44 | 190.41 |
| | PM2.5 | 179.51 | 43.00 | 164.30 | 203.03 | 48.35 | 187.82 |
| | SO2 | 6.97 | 16.70 | 6.97 | 6.98 | 16.70 | 6.98 |
| | H2SO4/SO3 | 5.02 | 1.49 | 5.02 | 5.02 | 1.49 | 5.02 |
| | Total PM | 238.86 | 57.77 | 175.50 | 262.37 | 63.06 | 199.01 |
| | NOx | 88.63 | 107.80 | 88.63 | 89.36 | 107.96 | 89.36 |
| | VOC | 48.71 | 14.35 | 48.71 | 48.79 | 14.37 | 48.79 |
| | Carbon Monoxide | 104.66 | 47.16 | 104.66 | 105.89 | 47.44 | 105.89 |
| | Pb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Toxic Air Pollutant Totals [7] | Hydrogen Sulfide | 1.88 | 0.43 | 1.88 | 1.88 | 0.43 | 1.88 |
| | CS2 | 5.10 | 1.16 | 5.10 | 5.10 | 1.16 | 5.10 |
| | TRS | 6.98 | 1.59 | 6.98 | 6.98 | 1.59 | 6.98 |
| | Fluorides (as F) | 0.03 | 0.01 | 0.03 | 0.03 | 0.01 | 0.03 |
| Plant Site Totals (Point and Fugitive Sources) | | | | | | | |
| Criteria Pollutant Totals | PM10 | 513.04 | 644.46 | 402.92 | 536.56 | 649.80 | 426.44 |
| | PM2.5 | 222.17 | 105.51 | 194.22 | 245.69 | 110.86 | 217.74 |
| | SO2 | 6.97 | 16.70 | 6.97 | 6.98 | 16.70 | 6.98 |
| | H2SO4/SO3 | 5.02 | 1.49 | 5.02 | 5.02 | 1.49 | 5.02 |
| | Total PM | 1112.15 | 2359.01 | 870.88 | 1135.66 | 2364.30 | 894.39 |
| | NOx | 88.63 | 107.80 | 88.63 | 89.36 | 107.96 | 89.36 |
| | VOC | 48.71 | 14.35 | 48.71 | 48.79 | 14.37 | 48.79 |
| | Carbon Monoxide | 104.66 | 47.16 | 104.66 | 105.89 | 47.44 | 105.89 |
| | Pb | 0.08 | 0.01 | 0.08 | 0.08 | 0.01 | 0.08 |
| Toxic Air Pollutant Totals | Antimony | 1.2E-03 | 2.9E-03 | 1.2E-03 | 1.4E-03 | 2.9E-03 | 1.4E-03 |
| | Arsenic | 2.6E-02 | 2.8E-02 | 2.6E-02 | 2.6E-02 | 2.8E-02 | 2.6E-02 |
| | Beryllium | 4.3E-04 | 1.3E-03 | 4.3E-04 | 4.5E-04 | 1.3E-03 | 4.5E-04 |
| | Cadmium | 1.1E-03 | 5.0E-04 | 1.1E-03 | 1.1E-03 | 5.1E-04 | 1.1E-03 |
| | Chromium | 1.0E-01 | 7.8E-02 | 1.0E-01 | 1.1E-01 | 7.9E-02 | 1.1E-01 |
| | Cobalt | 1.9E-01 | 1.4E-01 | 1.9E-01 | 1.9E-01 | 1.4E-01 | 1.9E-01 |
| | Manganese | 1.96 | 5.44 | 1.96 | 2.00 | 5.45 | 2.00 |
| | Mercury | 2.3E-03 | 5.3E-04 | 2.3E-03 | 2.3E-03 | 5.3E-04 | 2.3E-03 |
| | Nickel | 4.69 | 1.05 | 4.69 | 4.72 | 1.06 | 4.72 |
| | Phosphorus | 6.5E-02 | 1.5E-02 | 6.5E-02 | 7.7E-02 | 1.8E-02 | 7.7E-02 |
| | Selenium | 1.12 | 0.26 | 1.12 | 1.12 | 0.26 | 1.12 |
| | Barium | 9.6E-02 | 3.3E-02 | 9.6E-02 | 1.1E-01 | 3.5E-02 | 1.1E-01 |
| | Boron | 5.8E-02 | 7.3E-02 | 5.8E-02 | 5.9E-02 | 7.3E-02 | 5.9E-02 |
| | Copper | 2.29 | 0.51 | 2.29 | 2.39 | 0.53 | 2.39 |
| | Molybdenum | 1.8E-03 | 9.0E-04 | 1.8E-03 | 1.9E-03 | 9.3E-04 | 1.9E-03 |
| | Vanadium | 1.3E-01 | 2.4E-01 | 1.3E-01 | 1.3E-01 | 2.4E-01 | 1.3E-01 |
| | Zinc | 1.9E-01 | 3.6E-02 | 1.9E-01 | 2.0E-01 | 3.6E-02 | 2.0E-01 |
| | Tellurium | 2.7E-02 | 4.8E-02 | 2.7E-02 | 2.8E-02 | 4.9E-02 | 2.8E-02 |
| | Hafnium | 1.2E-03 | 2.1E-03 | 1.2E-03 | 1.2E-03 | 2.1E-03 | 1.2E-03 |
| | POM | 2.0E-03 | 6.1E-03 | 2.0E-03 | 2.0E-03 | 6.1E-03 | 2.0E-03 |
| | 2-Methylnaphthalene | 1.8E-05 | 4.2E-06 | 1.8E-05 | 1.9E-05 | 4.2E-06 | 1.9E-05 |
| | 3-Methylchloranthrene | 1.4E-06 | 3.1E-07 | 1.4E-06 | 1.4E-06 | 3.2E-07 | 1.4E-06 |
| | 7,12-Dimethylbenz (a)anthracene | 1.2E-05 | 2.8E-06 | 1.2E-05 | 1.2E-05 | 2.8E-06 | 1.2E-05 |
| | Acenaphthene | 3.4E-05 | 1.3E-04 | 3.4E-05 | 3.4E-05 | 1.3E-04 | 3.4E-05 |
| | Acenaphthylene | 6.7E-05 | 2.6E-04 | 6.7E-05 | 6.7E-05 | 2.6E-04 | 6.7E-05 |
| | Anthracene | 1.1E-05 | 3.7E-05 | 1.1E-05 | 1.1E-05 | 3.7E-05 | 1.1E-05 |
| | Benzo(a)anthracene | 6.1E-06 | 1.9E-05 | 6.1E-06 | 6.2E-06 | 1.9E-05 | 6.2E-06 |
| | Benzo(a)pyrene | 2.7E-06 | 7.6E-06 | 2.7E-06 | 2.8E-06 | 7.6E-06 | 2.8E-06 |
| | Benzo(b)fluoranthene | 9.1E-06 | 3.1E-05 | 9.1E-06 | 9.1E-06 | 3.1E-05 | 9.1E-06 |
| | Benzo(g,h,i)perylene | 4.9E-06 | 1.6E-05 | 4.9E-06 | 4.9E-06 | 1.6E-05 | 4.9E-06 |
| | Benzo(k)fluoranthene | 2.9E-06 | 6.5E-06 | 2.9E-06 | 2.9E-06 | 6.6E-06 | 2.9E-06 |
| | Chrysene | 1.2E-05 | 4.3E-05 | 1.2E-05 | 1.2E-05 | 4.3E-05 | 1.2E-05 |
| | Dibenzo(a,h)anthracene | 3.5E-06 | 1.0E-05 | 3.5E-06 | 3.5E-06 | 1.0E-05 | 3.5E-06 |
| | Fluoranthene | 3.2E-05 | 1.2E-04 | 3.2E-05 | 3.2E-05 | 1.2E-04 | 3.2E-05 |
| | Fluorene | 9.9E-05 | 3.9E-04 | 9.9E-05 | 9.9E-05 | 3.9E-04 | 9.9E-05 |
| | Indeno(1,2,3-cd)pyrene | 4.3E-06 | 1.2E-05 | 4.3E-06 | 4.4E-06 | 1.2E-05 | 4.4E-06 |
| | Phenanthrene | 3.0E-04 | 1.2E-03 | 3.0E-04 | 3.0E-04 | 1.2E-03 | 3.0E-04 |
| | Pyrene | 3.1E-05 | 1.1E-04 | 3.1E-05 | 3.1E-05 | 1.1E-04 | 3.1E-05 |
| | Benzene | 7.2E-03 | 2.3E-02 | 7.2E-03 | 7.3E-03 | 2.3E-02 | 7.3E-03 |
| | Dichlorobenzene | 9.1E-04 | 2.1E-04 | 9.1E-04 | 9.3E-04 | 2.1E-04 | 9.3E-04 |
| | Formaldehyde | 5.8E-02 | 1.6E-02 | 5.8E-02 | 5.9E-02 | 1.7E-02 | 5.9E-02 |
| | Hexane | 1.36 | 0.31 | 1.36 | 1.39 | 0.32 | 1.39 |
| | Toluene | 4.6E-03 | 8.8E-03 | 4.6E-03 | 4.7E-03 | 8.9E-03 | 4.7E-03 |
| | Naphthalene | 1.4E-03 | 3.8E-03 | 1.4E-03 | 1.4E-03 | 3.8E-03 | 1.4E-03 |
| | Xylene | 1.4E-03 | 5.7E-03 | 1.4E-03 | 1.4E-03 | 5.7E-03 | 1.4E-03 |
| | MIBC | 12.70 | 3.62 | 12.70 | 12.70 | 3.62 | 12.70 |
| | HF | 6.8E-03 | 1.5E-03 | 6.8E-03 | 6.8E-03 | 1.5E-03 | 6.8E-03 |
| | HCl | 1.01 | 19.45 | 1.01 | 1.01 | 19.45 | 1.01 |
| | Hydrogen Sulfide | 1.88 | 0.43 | 1.88 | 1.88 | 0.43 | 1.88 |
| | CS2 | 5.10 | 1.16 | 5.10 | 5.10 | 1.16 | 5.10 |
| | TRS | 6.98 | 1.59 | 6.98 | 6.98 | 1.59 | 6.98 |
| | Crystalline Silica | 45.13 | 130.75 | 40.30 | 45.36 | 130.80 | 40.54 |
| | Fluorides (as F) | 1.2E-01 | 2.0E-01 | 0.12 | 1.2E-01 | 2.0E-01 | 0.12 |
| | Acetaldehyde | 3.8E-04 | 1.5E-03 | 3.8E-04 | 3.8E-04 | 1.5E-03 | 3.8E-04 |
| | Acrolein | 7.9E-05 | 3.2E-04 | 7.9E-05 | 7.9E-05 | 3.2E-04 | 7.9E-05 |
| | Propylene | 6.9E-04 | 2.7E-03 | 6.9E-04 | 6.9E-04 | 2.7E-03 | 6.9E-04 |
| | Hexchrome | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | PGME | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | 1,3-Butadiene | 1.0E-05 | 4.2E-05 | 1.0E-05 | 1.0E-05 | 4.2E-05 | 1.0E-05 |
| | Total HAP | 15.78 | 28.01 | 15.78 | 15.89 | 28.04 | 15.89 |
| Greenhouse Gas Totals | CO2 [1] | 150,219 | 38,692 | 95,000 | 151,994 | 39,097 | 95,000 |
| | N2O [1] | 2.53 | 0.58 | 319 | 2.56 | 0.58 | 319 |
| | CH4 [1] | 1.79 | 0.41 | 3800 | 1.82 | 0.42 | 3800 |
| | CO2e [1] [2] | 151,017 | 38,874 | 95,000 | 152,802 | 39,282 | 95,000 |

[1] Limited controlled PTE Based on a proposed facility-wide emission cap of 95,000 tons per year of CO2e. Maximum allowable emissions of individual greenhouse gases were caclulated based on this limit and the global warming potential for each gas.

[2] Global Warming Potentials

| | |
|---|---|
| CO2 | 1 |
| CH4 | 25 |
| N2O | 298 |

**Attachment M**

**Updated Nearby Source Inventory (November 2014)**

**Cliffs Erie LLC - Hoyt Lakes Plant - Emission Inventory**

| Stack ID | Emission Unit | | Throughput | | | | Units | Pollutant | Emission Factor | | Max. Uncontrolled Potential to Emit | | Max. Controlled Potenital to Emit | | Insignificant Activity? | Future Operator |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | Maximum | | | | | | (lbs/Unit) | Note | (lbs/hr) | (tons/yr) | (lbs/hr) | (tons/yr) | | |
| | | | (Units/hr) | Note | (Units/yr) | Note | | | | | | | | | | |
| Fugitive | FS 009 | Pellets Loading | 1,000 | [9] | 10,000 | [10] | tons | PM | 0.0079 | [1] | 7.94 | 0.04 | 7.94 | 0.04 | [6] | Cliffs Erie |
| | | | | | | | | PM10 | 0.0038 | [1] | 3.75 | 0.02 | 3.75 | 0.02 | | Cliffs Erie |
| | | | | | | | | PM2.5 | 0.00057 | [1] | 0.57 | 0.00 | 0.57 | 0.00 | | Cliffs Erie |
| | | | | | | | | Antimony | | [5] | 3.29E-06 | 1.64E-08 | 3.29E-06 | 1.64E-08 | | Cliffs Erie |
| | | | | | | | | Arsenic | | [5] | 3.87E-05 | 1.94E-07 | 3.87E-05 | 1.94E-07 | | Cliffs Erie |
| | | | | | | | | Beryllium | | [5] | 5.89E-06 | 2.94E-08 | 5.89E-06 | 2.94E-08 | | Cliffs Erie |
| | | | | | | | | Cadmium | | [5] | 2.22E-07 | 1.11E-09 | 2.22E-07 | 1.11E-09 | | Cliffs Erie |
| | | | | | | | | Chromium | | [5] | 1.87E-04 | 9.37E-07 | 1.87E-04 | 9.37E-07 | | Cliffs Erie |
| | | | | | | | | Cobalt | | [5] | 5.60E-05 | 2.80E-07 | 5.60E-05 | 2.80E-07 | | Cliffs Erie |
| | | | | | | | | Lead | | [5] | 4.60E-06 | 2.30E-08 | 4.60E-06 | 2.30E-08 | | Cliffs Erie |
| | | | | | | | | Manganese | | [5] | 7.68E-03 | 3.84E-05 | 7.68E-03 | 3.84E-05 | | Cliffs Erie |
| | | | | | | | | Mercury | | [5] | 1.59E-08 | 7.94E-11 | 1.59E-08 | 7.94E-11 | | Cliffs Erie |
| | | | | | | | | Nickel | | [5] | 4.48E-05 | 2.24E-07 | 4.48E-05 | 2.24E-07 | | Cliffs Erie |
| | | | | | | | | Selenium | | [5] | 2.22E-06 | 1.11E-08 | 2.22E-06 | 1.11E-08 | | Cliffs Erie |
| Fugitive | FS 010 | Tailings Loading | 150 | [9] | 10,000 | [10] | tons | PM | 0.0079 | [1] | 1.19 | 0.04 | 1.19 | 0.04 | [6] | PolyMet |
| | | | | | | | | PM10 | 0.0038 | [1] | 0.56 | 0.02 | 0.56 | 0.02 | | PolyMet |
| | | | | | | | | PM2.5 | 0.00057 | [1] | 0.09 | 0.00 | 0.09 | 0.00 | | PolyMet |
| | | | | | | | | Antimony | | [5] | 9.61E-06 | 3.20E-07 | 9.61E-06 | 3.20E-07 | | PolyMet |
| | | | | | | | | Arsenic | | [5] | 1.75E-05 | 5.83E-07 | 1.75E-05 | 5.83E-07 | | PolyMet |
| | | | | | | | | Beryllium | | [5] | 2.52E-06 | 8.41E-08 | 2.52E-06 | 8.41E-08 | | PolyMet |
| | | | | | | | | Cadmium | | [5] | 1.25E-06 | 4.17E-08 | 1.25E-06 | 4.17E-08 | | PolyMet |
| | | | | | | | | Chromium | | [5] | 2.80E-05 | 9.33E-07 | 2.80E-05 | 9.33E-07 | | PolyMet |
| | | | | | | | | Cobalt | | [5] | 1.19E-05 | 3.97E-07 | 1.19E-05 | 3.97E-07 | | PolyMet |
| | | | | | | | | Lead | | [5] | 1.56E-05 | 5.20E-07 | 1.56E-05 | 5.20E-07 | | PolyMet |
| | | | | | | | | Manganese | | [5] | 6.08E-03 | 2.03E-04 | 6.08E-03 | 2.03E-04 | | PolyMet |
| | | | | | | | | Mercury | | [5] | 6.02E-06 | 2.01E-07 | 6.02E-06 | 2.01E-07 | | PolyMet |
| | | | | | | | | Nickel | | [5] | 8.38E-06 | 2.79E-07 | 8.38E-06 | 2.79E-07 | | PolyMet |
| | | | | | | | | Selenium | | [5] | 1.29E-05 | 4.29E-07 | 1.29E-05 | 4.29E-07 | | PolyMet |
| Fugitive | FS 011 | Tailings Unloading | 150 | [9] | 10,000 | [10] | tons | PM | 0.0079 | [1] | 1.19 | 0.04 | 1.19 | 0.04 | [6] | PolyMet |
| | | | | | | | | PM10 | 0.0038 | [1] | 0.56 | 0.02 | 0.56 | 0.02 | | PolyMet |
| | | | | | | | | PM2.5 | 0.00057 | [1] | 0.09 | 0.00 | 0.09 | 0.00 | | PolyMet |
| | | | | | | | | Antimony | | [5] | 9.61E-06 | 3.20E-07 | 9.61E-06 | 3.20E-07 | | PolyMet |
| | | | | | | | | Arsenic | | [5] | 1.75E-05 | 5.83E-07 | 1.75E-05 | 5.83E-07 | | PolyMet |
| | | | | | | | | Beryllium | | [5] | 2.52E-06 | 8.41E-08 | 2.52E-06 | 8.41E-08 | | PolyMet |
| | | | | | | | | Cadmium | | [5] | 1.25E-06 | 4.17E-08 | 1.25E-06 | 4.17E-08 | | PolyMet |
| | | | | | | | | Chromium | | [5] | 2.80E-05 | 9.33E-07 | 2.80E-05 | 9.33E-07 | | PolyMet |
| | | | | | | | | Cobalt | | [5] | 1.19E-05 | 3.97E-07 | 1.19E-05 | 3.97E-07 | | PolyMet |
| | | | | | | | | Lead | | [5] | 1.56E-05 | 5.20E-07 | 1.56E-05 | 5.20E-07 | | PolyMet |
| | | | | | | | | Manganese | | [5] | 6.08E-03 | 2.03E-04 | 6.08E-03 | 2.03E-04 | | PolyMet |
| | | | | | | | | Mercury | | [5] | 6.02E-06 | 2.01E-07 | 6.02E-06 | 2.01E-07 | | PolyMet |
| | | | | | | | | Nickel | | [5] | 8.38E-06 | 2.79E-07 | 8.38E-06 | 2.79E-07 | | PolyMet |
| | | | | | | | | Selenium | | [5] | 1.29E-05 | 4.29E-07 | 1.29E-05 | 4.29E-07 | | PolyMet |
| Fugitive | FS 014 | Waste Rock Truck Loading | 400 | [9] | 1,000,000 | [10] | tons | PM | 0.0079 | [1] | 3.17 | 3.97 | 3.17 | 3.97 | | Cliffs Erie |
| | | | | | | | | PM10 | 0.0038 | [1] | 1.50 | 1.88 | 1.50 | 1.88 | | Cliffs Erie |
| | | | | | | | | PM2.5 | 0.00057 | [1] | 0.23 | 0.28 | 0.23 | 0.28 | | Cliffs Erie |
| | | | | | | | | Antimony | | [5] | 2.56E-05 | 3.20E-05 | 2.56E-05 | 3.20E-05 | | Cliffs Erie |
| | | | | | | | | Arsenic | | [5] | 4.67E-05 | 5.83E-05 | 4.67E-05 | 5.83E-05 | | Cliffs Erie |
| | | | | | | | | Beryllium | | [5] | 6.73E-06 | 8.41E-06 | 6.73E-06 | 8.41E-06 | | Cliffs Erie |
| | | | | | | | | Cadmium | | [5] | 3.33E-06 | 4.17E-06 | 3.33E-06 | 4.17E-06 | | Cliffs Erie |

**Cliffs Erie LLC - Hoyt Lakes Plant - Emission Inventory**

| Stack ID | Emission Unit | | Throughput | | | | | Pollutant | Emission Factor | | Max. Uncontrolled Potential to Emit | | Max. Controlled Potenital to Emit | | Insignificant Activity? | Future Operator |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | Maximum | | | | Units | | (lbs/Unit) | Note | (lbs/hr) | (tons/yr) | (lbs/hr) | (tons/yr) | | |
| | | | (Units/hr) | Note | (Units/yr) | Note | | | | | | | | | | |
| | | | | | | | | Chromium | | [5] | 7.46E-05 | 9.33E-05 | 7.46E-05 | 9.33E-05 | | Cliffs Erie |
| | | | | | | | | Cobalt | | [5] | 3.17E-05 | 3.97E-05 | 3.17E-05 | 3.97E-05 | | Cliffs Erie |
| | | | | | | | | Lead | | [5] | 4.16E-05 | 5.20E-05 | 4.16E-05 | 5.20E-05 | | Cliffs Erie |
| | | | | | | | | Manganese | | [5] | 1.62E-02 | 2.03E-02 | 1.62E-02 | 2.03E-02 | | Cliffs Erie |
| | | | | | | | | Mercury | | [5] | 1.61E-05 | 2.01E-05 | 1.61E-05 | 2.01E-05 | | Cliffs Erie |
| | | | | | | | | Nickel | | [5] | 2.24E-05 | 2.79E-05 | 2.24E-05 | 2.79E-05 | | Cliffs Erie |
| | | | | | | | | Selenium | | [5] | 3.43E-05 | 4.29E-05 | 3.43E-05 | 4.29E-05 | | Cliffs Erie |
| Fugitive | FS 015 | Waste Rock Truck Unloading | 400 | [9] | 1,000,000 | [10] | tons | PM | 0.0079 | [1] | 3.17 | 3.97 | 3.17 | 3.97 | | Cliffs Erie |
| | | | | | | | | PM10 | 0.0038 | [1] | 1.50 | 1.88 | 1.50 | 1.88 | | Cliffs Erie |
| | | | | | | | | PM2.5 | 0.00057 | [1] | 0.23 | 0.28 | 0.23 | 0.28 | | Cliffs Erie |
| | | | | | | | | Antimony | | [5] | 2.56E-05 | 3.20E-05 | 2.56E-05 | 3.20E-05 | | Cliffs Erie |
| | | | | | | | | Arsenic | | [5] | 4.67E-05 | 5.83E-05 | 4.67E-05 | 5.83E-05 | | Cliffs Erie |
| | | | | | | | | Beryllium | | [5] | 6.73E-06 | 8.41E-06 | 6.73E-06 | 8.41E-06 | | Cliffs Erie |
| | | | | | | | | Cadmium | | [5] | 3.33E-06 | 4.17E-06 | 3.33E-06 | 4.17E-06 | | Cliffs Erie |
| | | | | | | | | Chromium | | [5] | 7.46E-05 | 9.33E-05 | 7.46E-05 | 9.33E-05 | | Cliffs Erie |
| | | | | | | | | Cobalt | | [5] | 3.17E-05 | 3.97E-05 | 3.17E-05 | 3.97E-05 | | Cliffs Erie |
| | | | | | | | | Lead | | [5] | 4.16E-05 | 5.20E-05 | 4.16E-05 | 5.20E-05 | | Cliffs Erie |
| | | | | | | | | Manganese | | [5] | 1.62E-02 | 2.03E-02 | 1.62E-02 | 2.03E-02 | | Cliffs Erie |
| | | | | | | | | Mercury | | [5] | 1.61E-05 | 2.01E-05 | 1.61E-05 | 2.01E-05 | | Cliffs Erie |
| | | | | | | | | Nickel | | [5] | 2.24E-05 | 2.79E-05 | 2.24E-05 | 2.79E-05 | | Cliffs Erie |
| | | | | | | | | Selenium | | [5] | 3.43E-05 | 4.29E-05 | 3.43E-05 | 4.29E-05 | | Cliffs Erie |
| Fugitive | FS 016 | Unpaved Roads, Tailings Basin | 900 | [12] | 25,000 | [10] | VMT | PM | 3.35 | [2] | 3,012.95 | 41.85 | 3,012.95 | 41.85 | | PolyMet |
| | | | | | | | | PM10 | 0.83 | [2] | 751.18 | 10.43 | 751.18 | 10.43 | | PolyMet |
| | | | | | | | | PM2.5 | 0.08 | [2] | 75.12 | 1.04 | 75.12 | 1.04 | | PolyMet |
| Fugitive | FS 017 | Unpaved Roads, Mine Area | 900 | [12] | 200,000 | [10] | VMT | PM | 4.13 | [2] | 3,715.05 | 412.78 | 3,715.05 | 412.78 | | Cliffs Erie |
| | | | | | | | | PM10 | 1.09 | [2] | 983.35 | 109.26 | 983.35 | 109.26 | | Cliffs Erie |
| | | | | | | | | PM2.5 | 0.11 | [2] | 98.34 | 10.93 | 98.34 | 10.93 | | Cliffs Erie |
| Fugitive | FS 020 | Wind Erosion, Pellets Storage Pile | 0.00057 | [14] | 5 | [13] | acres | PM | 3,001 | [3] | 1.71 | 7.50 | 1.71 | 7.50 | | Cliffs Erie |
| | | | | | | | | PM10 | 1,501 | [3] | 0.86 | 3.75 | 0.86 | 3.75 | | Cliffs Erie |
| | | | | | | | | PM2.5 | 1,501 | [3] | 0.86 | 3.75 | 0.86 | 3.75 | | Cliffs Erie |
| | | | | | | | | Antimony | | [5] | 7.09E-07 | 3.11E-06 | 7.09E-07 | 3.11E-06 | | Cliffs Erie |
| | | | | | | | | Arsenic | | [5] | 8.36E-06 | 3.66E-05 | 8.36E-06 | 3.66E-05 | | Cliffs Erie |
| | | | | | | | | Beryllium | | [5] | 1.27E-06 | 5.57E-06 | 1.27E-06 | 5.57E-06 | | Cliffs Erie |
| | | | | | | | | Cadmium | | [5] | 4.80E-08 | 2.10E-07 | 4.80E-08 | 2.10E-07 | | Cliffs Erie |
| | | | | | | | | Chromium | | [5] | 4.04E-05 | 1.77E-04 | 4.04E-05 | 1.77E-04 | | Cliffs Erie |
| | | | | | | | | Cobalt | | [5] | 1.21E-05 | 5.30E-05 | 1.21E-05 | 5.30E-05 | | Cliffs Erie |
| | | | | | | | | Lead | | [5] | 9.94E-07 | 4.35E-06 | 9.94E-07 | 4.35E-06 | | Cliffs Erie |
| | | | | | | | | Manganese | | [5] | 1.66E-03 | 7.26E-03 | 1.66E-03 | 7.26E-03 | | Cliffs Erie |
| | | | | | | | | Mercury | | [5] | 3.43E-09 | 1.50E-08 | 3.43E-09 | 1.50E-08 | | Cliffs Erie |
| | | | | | | | | Nickel | | [5] | 9.66E-06 | 4.23E-05 | 9.66E-06 | 4.23E-05 | | Cliffs Erie |
| | | | | | | | | Selenium | | [5] | 4.80E-07 | 2.10E-06 | 4.80E-07 | 2.10E-06 | | Cliffs Erie |
| Fugitive | FS 021 | Wind Erosion, Tailings Storage Pile | 0.00057 | [14] | 5 | [13] | acres | PM | 9,709 | [3] | 5.54 | 24.27 | 5.54 | 24.27 | | PolyMet |
| | | | | | | | | PM10 | 4,855 | [3] | 2.77 | 12.14 | 2.77 | 12.14 | | PolyMet |
| | | | | | | | | PM2.5 | 4,855 | [3] | 2.77 | 12.14 | 2.77 | 12.14 | | PolyMet |
| | | | | | | | | Antimony | | [5] | 4.47E-05 | 1.96E-04 | 4.47E-05 | 1.96E-04 | | PolyMet |
| | | | | | | | | Arsenic | | [5] | 8.15E-05 | 3.57E-04 | 8.15E-05 | 3.57E-04 | | PolyMet |
| | | | | | | | | Beryllium | | [5] | 1.17E-05 | 5.15E-05 | 1.17E-05 | 5.15E-05 | | PolyMet |
| | | | | | | | | Cadmium | | [5] | 5.82E-06 | 2.55E-05 | 5.82E-06 | 2.55E-05 | | PolyMet |

**Cliffs Erie LLC - Hoyt Lakes Plant - Emission Inventory**

| Stack ID | Emission Unit | | Throughput | | | | | Pollutant | Emission Factor | | Max. Uncontrolled Potential to Emit | | Max. Controlled Potenital to Emit | | Insignificant Activity? | Future Operator |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | Maximum | | | | Units | | | | | | | | | |
| | | | (Units/hr) | Note | (Units/yr) | Note | | | (lbs/Unit) | Note | (lbs/hr) | (tons/yr) | (lbs/hr) | (tons/yr) | | |
| | | | | | | | | Chromium | | [5] | 1.30E-04 | 5.70E-04 | 1.30E-04 | 5.70E-04 | | PolyMet |
| | | | | | | | | Cobalt | | [5] | 5.54E-05 | 2.43E-04 | 5.54E-05 | 2.43E-04 | | PolyMet |
| | | | | | | | | Lead | | [5] | 7.26E-05 | 3.18E-04 | 7.26E-05 | 3.18E-04 | | PolyMet |
| | | | | | | | | Manganese | | [5] | 2.83E-02 | 1.24E-01 | 2.83E-02 | 1.24E-01 | | PolyMet |
| | | | | | | | | Mercury | | [5] | 2.80E-05 | 1.23E-04 | 2.80E-05 | 1.23E-04 | | PolyMet |
| | | | | | | | | Nickel | | [5] | 3.90E-05 | 1.71E-04 | 3.90E-05 | 1.71E-04 | | PolyMet |
| | | | | | | | | Selenium | | [5] | 5.99E-05 | 2.62E-04 | 5.99E-05 | 2.62E-04 | | PolyMet |
| Fugitive | FS 022 | Wind Erosion, Waste Rock Storage Pile | 0.00114 | [14] | 10 | [13] | acres | PM | 883 | [3] | 1.01 | 4.41 | 1.01 | 4.41 | | PolyMet |
| | | | | | | | | PM10 | 441 | [3] | 0.50 | 2.21 | 0.50 | 2.21 | | PolyMet |
| | | | | | | | | PM2.5 | 441 | [3] | 0.50 | 2.21 | 0.50 | 2.21 | | PolyMet |
| | | | | | | | | Antimony | | [5] | 8.13E-06 | 3.56E-05 | 8.13E-06 | 3.56E-05 | | PolyMet |
| | | | | | | | | Arsenic | | [5] | 1.48E-05 | 6.49E-05 | 1.48E-05 | 6.49E-05 | | PolyMet |
| | | | | | | | | Beryllium | | [5] | 2.14E-06 | 9.36E-06 | 2.14E-06 | 9.36E-06 | | PolyMet |
| | | | | | | | | Cadmium | | [5] | 1.06E-06 | 4.63E-06 | 1.06E-06 | 4.63E-06 | | PolyMet |
| | | | | | | | | Chromium | | [5] | 2.37E-05 | 1.04E-04 | 2.37E-05 | 1.04E-04 | | PolyMet |
| | | | | | | | | Cobalt | | [5] | 1.01E-05 | 4.41E-05 | 1.01E-05 | 4.41E-05 | | PolyMet |
| | | | | | | | | Lead | | [5] | 1.32E-05 | 5.78E-05 | 1.32E-05 | 5.78E-05 | | PolyMet |
| | | | | | | | | Manganese | | [5] | 5.15E-03 | 2.25E-02 | 5.15E-03 | 2.25E-02 | | PolyMet |
| | | | | | | | | Mercury | | [5] | 5.10E-06 | 2.23E-05 | 5.10E-06 | 2.23E-05 | | PolyMet |
| | | | | | | | | Nickel | | [5] | 7.09E-06 | 3.11E-05 | 7.09E-06 | 3.11E-05 | | PolyMet |
| | | | | | | | | Selenium | | [5] | 1.09E-05 | 4.77E-05 | 1.09E-05 | 4.77E-05 | | PolyMet |
| Fugitive | FS 032 | Wind Erosion, Tailings Basin | 0.00057 | [14] | 5 | [13] | acres | PM | 9,709 | [3] | 5.54 | 24.27 | 5.54 | 24.27 | | PolyMet |
| | | | | | | | | PM10 | 4,855 | [3] | 2.77 | 12.14 | 2.77 | 12.14 | | PolyMet |
| | | | | | | | | PM2.5 | 4,855 | [3] | 2.77 | 12.14 | 2.77 | 12.14 | | PolyMet |
| | | | | | | | | Antimony | | [5] | 4.47E-05 | 1.96E-04 | 4.47E-05 | 1.96E-04 | | PolyMet |
| | | | | | | | | Arsenic | | [5] | 8.15E-05 | 3.57E-04 | 8.15E-05 | 3.57E-04 | | PolyMet |
| | | | | | | | | Beryllium | | [5] | 1.17E-05 | 5.15E-05 | 1.17E-05 | 5.15E-05 | | PolyMet |
| | | | | | | | | Cadmium | | [5] | 5.82E-06 | 2.55E-05 | 5.82E-06 | 2.55E-05 | | PolyMet |
| | | | | | | | | Chromium | | [5] | 1.30E-04 | 5.70E-04 | 1.30E-04 | 5.70E-04 | | PolyMet |
| | | | | | | | | Cobalt | | [5] | 5.54E-05 | 2.43E-04 | 5.54E-05 | 2.43E-04 | | PolyMet |
| | | | | | | | | Lead | | [5] | 7.26E-05 | 3.18E-04 | 7.26E-05 | 3.18E-04 | | PolyMet |
| | | | | | | | | Manganese | | [5] | 2.83E-02 | 1.24E-01 | 2.83E-02 | 1.24E-01 | | PolyMet |
| | | | | | | | | Mercury | | [5] | 2.80E-05 | 1.23E-04 | 2.80E-05 | 1.23E-04 | | PolyMet |
| | | | | | | | | Nickel | | [5] | 3.90E-05 | 1.71E-04 | 3.90E-05 | 1.71E-04 | | PolyMet |
| | | | | | | | | Selenium | | [5] | 5.99E-05 | 2.62E-04 | 5.99E-05 | 2.62E-04 | | PolyMet |
| SV 0128 | EU 148 | Administration Building Boiler 2 | 0.018 | [15] | 160.4 | [16] | Mgal | PM | 0.7 | [4] | 0.01 | 0.056 | 0.01 | 0.056 | [7] | PolyMet |
| | | Cleaver-Brooks, Model CB135-50 | | | | | | PM10 | 0.7 | [4] | 0.01 | 0.056 | 0.01 | 0.056 | | PolyMet |
| | | Installed: August 1957 | | | | | | PM2.5 | 0.7 | [4] | 0.01 | 0.056 | 0.01 | 0.056 | | PolyMet |
| | | 1.675 MM Btu/hr | | | | | | CO | 7.5 | [4] | 0.14 | 0.601 | 0.14 | 0.601 | | PolyMet |
| | | Relegated to Back-up: June 2009 | | | | | | NOx | 13.0 | [4] | 0.24 | 1.042 | 0.24 | 1.042 | | PolyMet |
| | | | | | | | | SO2 | 1.16 | [4] | 0.02 | 0.093 | 0.02 | 0.093 | | PolyMet |
| | | | | | | | | VOC | 0.8 | [4] | 0.01 | 0.064 | 0.01 | 0.064 | | PolyMet |
| | | | | | | | | CO2 | 12500.0 | [4] | 228.83 | 1,002.254 | 228.83 | 1,002.254 | | PolyMet |
| | | | | | | | | CH4 | 0.2 | [4] | 0.00 | 0.016 | 0.00 | 0.016 | | PolyMet |
| | | | | | | | | N2O | 0.9 | [4] | 0.02 | 0.072 | 0.02 | 0.072 | | PolyMet |
| SV 0128 | EU 149 | Administration Building Boiler 3 | 0.023 | [15] | 201.0 | [16] | Mgal | PM | 0.7 | [4] | 0.02 | 0.070 | 0.02 | 0.070 | [7] | PolyMet |
| | | 2.1 MM Btu/hr | | | | | | PM10 | 0.7 | [4] | 0.02 | 0.070 | 0.02 | 0.070 | | PolyMet |
| | | Installed: June 2009 (Insignificant | | | | | | PM2.5 | 0.7 | [4] | 0.02 | 0.070 | 0.02 | 0.070 | | PolyMet |

**Cliffs Erie LLC - Hoyt Lakes Plant - Emission Inventory**

| Stack ID | Emission Unit | | Throughput | | | | | Pollutant | Emission Factor | | Max. Uncontrolled Potential to Emit | | Max. Controlled Potenital to Emit | | Insignificant Activity? | Future Operator |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | Maximum | | | | Units | | | | | | | | | |
| | | | (Units/hr) | Note | (Units/yr) | Note | | | (lbs/Unit) | Note | (lbs/hr) | (tons/yr) | (lbs/hr) | (tons/yr) | | |
| | | Modification, per Minn. R. 7007.1250, subpart 1, B) | | | | | | CO | 7.5 | [4] | 0.17 | 0.754 | 0.17 | 0.754 | | PolyMet |
| | | | | | | | | NOx | 13.0 | [4] | 0.30 | 1.307 | 0.30 | 1.307 | | PolyMet |
| | | | | | | | | SO2 | 1.16 | [4] | 0.03 | 0.117 | 0.03 | 0.117 | | PolyMet |
| | | | | | | | | VOC | 0.8 | [4] | 0.02 | 0.080 | 0.02 | 0.080 | | PolyMet |
| | | | | | | | | CO2 | 12500.0 | [4] | 286.89 | 1,256.557 | 286.89 | 1,256.557 | | PolyMet |
| | | | | | | | | CH4 | 0.2 | [4] | 0.00 | 0.020 | 0.00 | 0.020 | | PolyMet |
| | | | | | | | | N2O | 0.9 | [4] | 0.02 | 0.090 | 0.02 | 0.090 | | PolyMet |

| | | | | | |
|---|---|---|---|---|---|
| **Total Facility:** | PM | 6,758.50 | 523.27 | 6,758.50 | 523.27 |
| | PM10 | 1,749.35 | 153.86 | 1,749.35 | 153.86 |
| | PM2.5 | 181.58 | 42.90 | 181.58 | 42.90 |
| | Antimony | 1.72E-04 | 4.95E-04 | 1.72E-04 | 4.95E-04 |
| | Arsenic | 3.53E-04 | 9.33E-04 | 3.53E-04 | 9.33E-04 |
| | Beryllium | 5.13E-05 | 1.35E-04 | 5.13E-05 | 1.35E-04 |
| | Cadmium | 2.21E-05 | 6.42E-05 | 2.21E-05 | 6.42E-05 |
| | Chromium | 7.17E-04 | 1.61E-03 | 7.17E-04 | 1.61E-03 |
| | Cobalt | 2.76E-04 | 6.63E-04 | 2.76E-04 | 6.63E-04 |
| | Lead | 2.78E-04 | 8.03E-04 | 2.78E-04 | 8.03E-04 |
| | Manganese | 1.16E-01 | 3.19E-01 | 1.16E-01 | 3.19E-01 |
| | Mercury | 1.05E-04 | 3.09E-04 | 1.05E-04 | 3.09E-04 |
| | Nickel | 2.01E-04 | 4.72E-04 | 2.01E-04 | 4.72E-04 |
| | Selenium | 2.28E-04 | 6.61E-04 | 2.28E-04 | 6.61E-04 |
| | Single HAP (Mn) | 1.16E-01 | 3.19E-01 | 1.16E-01 | 3.19E-01 |
| | Total HAPs | 1.18E-01 | 3.25E-01 | 1.18E-01 | 3.25E-01 |
| | CO | 0.31 | 1.36 | 0.31 | 1.36 |
| | NOx | 0.54 | 2.35 | 0.54 | 2.35 |
| | SO2 | 0.05 | 0.21 | 0.05 | 0.21 |
| | VOC | 0.03 | 0.14 | 0.03 | 0.14 |
| | CO2 | 515.71 | 2,258.81 | 515.71 | 2,258.81 |
| | CH4 | 0.01 | 0.04 | 0.01 | 0.04 |
| | N2O | 0.04 | 0.16 | 0.04 | 0.16 |
| | GHG [8] | 527.39 | 2,309.99 | 527.39 | 2,309.99 |

**Cliffs Erie LLC - Hoyt Lakes Plant - Proposed Model Inputs for NorthMet Cumulative Modeling**

| | | | | | | | | | | | | | | Emission Rates | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | NOx | | | PM10 | | | PM2.5 | | | SO2 | | |
| | | | | Volume Dimensions | | | Area/Open Pit Source Dimensions | | | | | | | Annual | Hourly | Annual | Annual | Hourly | Annual | Annual | Hourly | Annual | Annual | Hourly | Annual |
| Emiss. Inv. ID | Model ID | Operators Description | Release Height From Ground (m) | Side Length (m) | Syinit (m) | Szinit (m) | Sxinit (m) | Syinit (m) | Szinit (m) | Angle | Depth (m) | NAD83 Easting (m) | NAD83 Northing (m) | Elevation (m) [3] | (tpy) | (g/s) | (g/s) | (tpy) | (g/s) | (g/s) | (tpy) | (g/s) | (g/s) | (tpy) | (g/s) | (g/s) |
| Cliffs Erie | CCBV | Cliffs Erie Fugitive Sources | 6.00 | 350.00 | 350.00 | 3.66 | | | | | | | | | | | | 1.17E+02 | 3.36E+00 | 3.36E+00 | 1.52E+01 | 4.39E-01 | 4.39E-01 | | | |

**Northshore Mining Company - Peter Mitchell Mine - Model Inputs for NorthMet Cumulative NAAQS Modeling**

| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISSpm10 (lb/hr) | EMISSpm2.5 (lb/hr) | EMISSpm10 (g/s) | EMISSpm2.5 (g/s) | EMISSNox (lb/hr) | EMISSSO2 (lb/hr) | EMISSnox(g/s) | EMISSso2(g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | RELHGT | SYINIT | SZINIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shop Boiler 1 | SV001 | POINT | 583745 | 5279839 | 492.3 | 2.051 | 2.051 | 0.258 | 0.258 | 1.00 | 3.82 | 1.260E-01 | 4.813E-01 | 40 | 12.192 | 500 | 533.15 | 10000 | 38.27 | 1.3 | 0.39624 | | | |
| Shop Boiler 2 | SV002 | POINT | 583742.3 | 5279836 | 492.33 | 1.758 | 1.758 | 0.222 | 0.222 | 2.24 | 16.40 | 2.822E-01 | 2.066E+00 | 40 | 12.192 | 500 | 533.15 | 10000 | 38.27 | 1.3 | 0.39624 | | | |
| Shop Boiler 3 | SV003 | POINT | 583739.4 | 5279832 | 492.36 | 3.809 | 3.809 | 0.480 | 0.480 | 4.85 | 35.83 | 6.111E-01 | 4.514E+00 | 40 | 12.192 | 300 | 422.04 | 20000 | 44.76 | 1.7 | 0.51816 | | | |
| Shop Boiler 4 | SV004 | POINT | 583737.1 | 5279828 | 492.39 | 3.809 | 3.809 | 0.480 | 0.480 | 4.85 | 35.83 | 6.111E-01 | 4.514E+00 | 40 | 12.192 | 300 | 422.04 | 10000 | 38.27 | 1.3 | 0.39624 | | | |
| Crusher 1, Primary and Secondary [1] | SV005 | POINT | 583681.7 | 5280191 | 495.63 | 12.1 | 12.1 | 1.525 | 1.525 | | | | | 63.75 | 19.431 | 77 | 298.15 | 60000 | 20.99 | 4.3 | 1.31064 | | | |
| Portable Aggregate Crusher | SV009 | POINT | 581493.8 | 5279903 | 505.85 | 0.22 | 0.06 | 0.028 | 0.008 | | | | | 12 | 3.6576 | 77 | 298.15 | NA | 0.01 | 8.5 | 2.5908 | | | |
| Ore Loadout at Crusher 1 | SV010 | VOLUME | 583938.8 | 5280058 | 491.23 | 17.02 | 2.55 | 2.359 | 0.321 | | | | | 12 | 3.6576 | 77 | 298.15 | NA | 0.01 | 8.5 | 2.5908 | 3.658 | 0.603 | 1.701 |
| Fugitive Sources | FS001 | VOLUME | 581677.6 | 5279541 | 506.179 | 34.06 | 4.24 | 4.751 | 0.542 | | | | | | | | | | | | | 4.572 | 162.791 | 4.253 |

**Northshore Peter Mitchell Mine Parameters and Emissions comes from:**

June 2005 Title V Air Permit and associated permit application, 2009 permit reissuance application and Stack Test Data

[1] Based on 8/16/2010 and 12/2/2005 stack test results as analyzed by MPCA (per 7/9/2012 e-mail) - proposed initial value for modeling is maximum lb/hr total PM, filterable plus organic and inorganic condensables, over six runs.

| | |
|---|---|
| Conversion of lb/hr to g/s | 0.1260 |
| Conversion of ft to m | 0.3048 |
| Truck Height (ft) | 30 |

Data Source Key:
2005 Northshore Permit or Permit Application
2009 Permit Reissuance Application
Emission Rates identical in 2005 and 2009 Applications
Stack Test Data

## Data from Northshore Peter Mitchell Mine (Facility ID 13700032) Permit Reissuance Application

**Point Sources**

| | | | Uncontrolled Potential Emission Rate (lbs/hr) [5] | | | | | Controlled lbs/hr Emission Rate | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stack/Vent ID | Emission Unit ID | PM [5] | PM10 [5] | PM2.5 [5] | NOx [4] | SO2 [4] | PM [1] | PM10 [1] | PM2.5 [1] | NOx [4] | SO2 [4] |
| Shop Boiler #1 | 001 | 001 | 2.574 | 2.051 | 2.051 | 1.000 | 3.817 | 2.57 | 2.05 | 2.05 | 1.00 | 3.82 |
| Shop Boiler #2 | 002 | 002 | 2.206 | 1.758 | 1.758 | 2.237 | 16.400 | 2.21 | 1.76 | 1.76 | 2.24 | 16.40 |
| Shop Boiler #3 | 003 | 003 | 4.780 | 3.809 | 3.809 | 4.847 | 35.828 | 4.78 | 3.81 | 3.81 | 4.85 | 35.83 |
| Shop Boiler #4 | 004 | 004 | 4.780 | 3.809 | 3.809 | 4.767 | 35.828 | 4.78 | 3.81 | 3.81 | 4.85 | 35.83 |
| Crusher 1, Primary and Secondary Crushers | 005 | 005 | 808.64 | 808.64 | 237.84 | | | 8.09 | 8.09 | 2.38 | | |
| Portable Aggregate Crusher [3] | 009 | 009 | 0.27 | 0.22 | 0.06 | | | 0.27 | 0.22 | 0.06 | | |
| Ore Loadout at Crusher #1 | 010 | 010 | 42.56 | 17.02 | 2.55 | | | 20.41 | 8.16 | 1.22 | | |

| Controlled tpy Emission Rate [2] | | | | | Emission factor source from application (PM) | Emission factor source from application (PM10) | Emission factor source from application (PM2.5) |
|---|---|---|---|---|---|---|---|
| PM | PM10 | PM2.5 | NOx | SO2 | | | |
| 11.26 | 8.98 | 8.98 | 4.38 | 16.73 | AP-42 Section 1.11; Waste Oil Combustion for small boilers; % ash = 0.79 (10/96) | | Assume PM2.5 = PM10 |
| 9.68 | 7.71 | 7.71 | 9.81 | 71.83 | AP-42 Section 1.11; Waste Oil Combustion for small boilers; % ash = 0.79 (10/96) | | Assume PM2.5 = PM10 |
| 20.94 | 16.69 | 16.69 | 21.24 | 156.94 | AP-42 Section 1.11; Waste Oil Combustion for small boilers; % ash = 0.79 (10/96) | | Assume PM2.5 = PM10 |
| 20.94 | 16.69 | 16.69 | 21.24 | 156.94 | AP-42 Section 1.11; Waste Oil Combustion for small boilers; % ash = 0.79 (10/96) | | Assume PM2.5 = PM10 |
| 35.43 | 35.43 | 10.42 | | | AP-42 Table 11.23-3 (2/97) Taconite ore processing; Primary crusher with fabric filter - uncontrolled back calculated based on 99% control | Assumed equal to PM; | PM2.5 based on size distribution for mechanically generated emissions from unprocessed ores (category 3) from AP-42 Appendix B, Table B.2.2: 15%/51% = 29.4% of PM10 is PM2.5 (9/90; reformatted 1/95). |
| 1.18 | 0.96 | 0.26 | | | PM - AP-42 Table 11.19.2-2 - Primary crushing (January, 1995) | PM10 assumed 80% of PM | Based on size distribution for mechanically generated emissions from unprocessed ores (category 3) from AP-42 Appendix B, Table B.2.2: 15%/51% = 29.4% of PM10 is PM2.5 (9/90; reformatted 1/95). |
| 89.40 | 35.74 | 5.34 | | | AP-42 Section 11.24 Metallic Mineral Processing (8/82 reformatted 1/95); Primary crushing High moisture ore | AP-42 Section 11.24 Metallic Mineral Processing (8/82 reformatted 1/95); Primary crushing High moisture ore | Estimated based on the particle size factors in AP-42 Section 13.2-4 equation 1: 0.053/0.35 = 15% of PM10 is PM2.5 (11/06). |

[1] From GI-07 form (Page 1) submitted with facility permit reissuance application (December 2009).
[2] Calculated for comparison to EC-01 forms submitted with application and prior NorthMet modeling submittals.
[3] Permit application assumes maximum of 600,000 tpy material processed or about 1530 hours per year at full capacity.
[4] Maximum value for all permitted fuels from GI-02 forms submitted with facility permit reissuance application (December 2009)
[5] From EC-01 (column 9e) or EC-02 (max for all fuels from column 8e) from reissuance application (December 2009) for each emissions unit.

**Fugitive Sources**

| | Fugitive Source ID Number | Maximum Controlled PM Emissions (tpy) [8] | Maximum Controlled PM10 Emissions (tpy) [6] | Maximum Controlled PM2.5 Emissions (tpy) [7] | Maximum Controlled PM10 Emissions (lb/hr) | Maximum Controlled PM2.5 Emissions (lb/hr) |
|---|---|---|---|---|---|---|
| C1 Stockpile Handling | FS001 | 2.54 | 0.88 | 0.13 | 0.20 | 0.03 |
| C1 Stockpile wind erosion | FS001 | 2.35 | 1.18 | 0.18 | 0.27 | 0.04 |
| C2 Stockpile Handling | FS002 | 2.54 | 0.88 | 0.13 | 0.20 | 0.03 |
| C2 Stockpile wind erosion | FS002 | 2.35 | 1.18 | 0.18 | 0.27 | 0.04 |
| Taconite handling at pit | FS003 | 107.25 | 37.24 | 5.59 | 8.50 | 1.28 |
| Waste rock handling | FS003 | 75.08 | 26.07 | 3.91 | 5.95 | 0.89 |
| Haul roads | FS004 | 116.25 | 65.00 | 6.50 | 14.84 | 1.48 |
| Light vehicle travel | FS005 | 19.30 | 10.80 | 1.08 | 2.47 | 0.25 |
| Aggregate handling | FS007 | 2.02 | 0.70 | 0.11 | 0.16 | 0.03 |
| Aggregate stockpile wind erosion | FS007 | 5.37 | 2.69 | 0.40 | 0.61 | 0.09 |
| C1 surge pile handling | FS008 | 2.54 | 0.88 | 0.13 | 0.20 | 0.03 |
| C1 surge pile wind erosion | FS008 | 3.36 | 1.68 | 0.25 | 0.38 | 0.06 |
| **Totals** | **All** | **340.95** | **149.18** | **18.59** | **34.06** | **4.24** |

[6] From EC-15 form (Page 2) submitted with facility permit reissuance application (December 2009)
[7] From EC-15 form (Page 3) submitted with facility permit reissuance application (December 2009)
[8] From EC-15 form (Page 1) submitted with facility permit reissuance application (December 2009)

Proposed for use as NorthMet Modeling Input

Rows highlighted in yellow are Mesabi Nugget Phase II mining sources that are not at present permitted or under review by regulatory agencies so it is proposed that they be exluded from any additional cumulative modeling.

**Mesabi Nugget Phase I & II- Model Inputs for NorthMet Cumulative NAAQS/Increment Modeling**

| | | | | | | INCREMENT | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | NAAQS | | | | | | | | | | | | | | | | | | | | |
| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS PM10 (g/s) | EMISS PM10 (g/s) | EMISS PM2.5 (g/s) | EMISS NOX (g/s) | EMISS SO2 (g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | RELHGT | SXINIT | SYINIT | SZINIT | VOLUME | ANGLE | Emission Rate Source | |
| RHF | SV001 | POINT | 560874.82 | 5270798.87 | 512.65 | 10.302 | 10.302 | 10.302 | 2.696E+01 | 1.198E+01 | 196.85 | 60 | 179.2 | 354.9 | 638,711 | 21.45 | 13.8779528 | 4.23 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | SV001 POINT 560874.82 5270798.87 512.65 11.980 60.00 354.9 21.45 4.23 |
| Pulverizer | SV002 | POINT | 560995.96 | 5270767.53 | 509.29 | 2.040 | 2.040 | 2.04 | 3.127E-01 | 3.752E-03 | 131.234 | 40 | 159.5 | 343.97 | 34,643 | 5.31 | 6.49606299 | 1.98 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | SV002 POINT 560995.96 5270767.53 509.29 0.004 40.00 344.0 5.31 1.98 |
| Coal Flux Unload | SV003 | POINT | 561325.50 | 5270585.91 | 481.52 | 0.358 | 0.358 | 0.358 | | | 98.4252 | 30 | 76.73 | 298 | 149,988 | 56.77 | 4.13385827 | 1.26 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Rail Loadout | SV004 | POINT | 561336.54 | 5270621.73 | 490.80 | 0.358 | 0.358 | 0.358 | | | 98.4252 | 30 | 76.73 | 298 | 49,987 | 18.92 | 4.13385827 | 1.26 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| RHF Bldg Baghouse | SV007 | POINT | 560764.66 | 5270590.83 | 499.37 | 0.540 | 0.540 | 0.54 | 5.74E-02 | 6.88E-04 | 131.234 | 40 | 121.4 | 322.8 | 106,751 | 26.70 | 5.08530184 | 1.55 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | SV007 POINT 560764.66 5270590.83 499.37 0.001 40.00 322.8 26.70 1.55 |
| Cooling Tower | SV09A | POINT | 560871.37 | 5270545.61 | 496.22 | 0.023 | 0.023 | 0.023 | | | 61.3517 | 18.7 | 124.1 | 324.3 | 670,644 | 55.28 | 8.85826772 | 2.7 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Cooling Tower | SV09B | POINT | 560880.57 | 5270547.43 | 496.24 | 0.023 | 0.023 | 0.023 | | | 61.3517 | 18.7 | 124.1 | 324.3 | 670,644 | 55.28 | 8.85826772 | 2.7 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Cooling Tower | SV10A | POINT | 560897.89 | 5270550.22 | 496.23 | 0.023 | 0.023 | 0.023 | | | 61.3517 | 18.7 | 101.8 | 311.9 | 545,565 | 44.97 | 8.85826772 | 2.7 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Cooling Tower | SV10B | POINT | 560906.80 | 5270551.61 | 496.21 | 0.023 | 0.023 | 0.023 | | | 61.3517 | 18.7 | 101.8 | 311.9 | 545,565 | 44.97 | 8.85826772 | 2.7 | | | | | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Coal mat'l handling | FS034 | VOLUME | 561164.26 | 5270675.99 | 496.25 | 0.041 | 0.041 | 0.041 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Coal Wind Erosion | FS038 | VOLUME | 561164.26 | 5270675.99 | 496.25 | 1 | 1.000 | 1 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Flux mat'l handling | FS035 | VOLUME | 561261.65 | 5270725.22 | 496.53 | 0.093 | 0.093 | 0.093 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Flux Wind Erosion | FS039 | VOLUME | 561261.65 | 5270725.22 | 496.53 | 1 | 1.000 | 1 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Slag mat'l handling | FS037 | VOLUME | 560773.35 | 5270533.81 | 495.64 | 0.09 | 0.090 | 0.09 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Slag Wind Erosion | FS041 | VOLUME | 560773.35 | 5270533.81 | 495.64 | 1 | 1.000 | 1 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Concentrate mat'l handling | FS010 | VOLUME | 561498.23 | 5270799.51 | 497.11 | 0.227 | 0.227 | 0.0326 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Concentrate Wind Erosion | FS011 | VOLUME | 561498.23 | 5270799.51 | 497.11 | 1 | 1.000 | 1 | | | | | | | | | | | 5 | | 3.544 | 4.65 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| RHF Roof Monitor | SV005 | VOLUME | 560759.00 | 5270711.09 | 512.36 | 0.223 | 0.223 | 0.223 | | | | | | | | | | | 30.48 | | 5.581 | 14.17674 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Pulverizer Roof Monitor | SV012 | VOLUME | 560957.41 | 5270763.13 | 511.70 | 0.117 | 0.117 | 0.117 | | | | | | | | | | | 24.079 | | 5.581 | 11.19953 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD001i | VOLUME | 562081 | 5271136.3 | 512.08 | -5.12E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD002i | VOLUME | 562054.1 | 5271123.1 | 512 | -4.98E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD003i | VOLUME | 562027.2 | 5271109.8 | 512.42 | -4.78E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD004i | VOLUME | 562003 | 5271092.1 | 513.03 | -4.63E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD005i | VOLUME | 561978.7 | 5271074.5 | 513.41 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD006i | VOLUME | 561954.4 | 5271056.8 | 513.41 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD007i | VOLUME | 561930.5 | 5271038.8 | 511.76 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD008i | VOLUME | 561906.4 | 5271021 | 509.65 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD009i | VOLUME | 561880.3 | 5271006.1 | 510.78 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD010i | VOLUME | 561853.2 | 5270993.4 | 510.21 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD011i | VOLUME | 561825.1 | 5270983 | 509.07 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD012i | VOLUME | 561797.9 | 5270971.1 | 506.29 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD013i | VOLUME | 561772.2 | 5270955.5 | 501.75 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD014i | VOLUME | 561760.1 | 5270928.5 | 499.2 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD015i | VOLUME | 561750.5 | 5270900.2 | 498.29 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD016i | VOLUME | 561747 | 5270870.4 | 497.35 | -4.28E-02 | 0.00E+00 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD017i | VOLUME | 561739.9 | 5270841.8 | 496.43 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD018i | VOLUME | 561725.1 | 5270815.7 | 495.65 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD019i | VOLUME | 561705.2 | 5270796.4 | 495.13 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD020i | VOLUME | 561676 | 5270789.4 | 495.12 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD021i | VOLUME | 561646.4 | 5270785.1 | 495.26 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD022i | VOLUME | 561616.5 | 5270782.8 | 495.45 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD023i | VOLUME | 561586.7 | 5270783.3 | 495.74 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD024i | VOLUME | 561557 | 5270787.4 | 496.33 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD025i | VOLUME | 561527.5 | 5270792.9 | 496.85 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (Increment Source) | UPVD026i | VOLUME | 561498.2 | 5270799.5 | 497.11 | 1.19E-02 | 0.012 | | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD001 | VOLUME | 562081 | 5271136.3 | 512.08 | 3.42E-03 | 0.003 | 0.000342 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD002 | VOLUME | 562054.1 | 5271123.1 | 512.1 | 4.84E-03 | 0.005 | 0.000484 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD003 | VOLUME | 562027.2 | 5271109.8 | 512.42 | 6.84E-03 | 0.007 | 0.000684 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD004 | VOLUME | 562003 | 5271092.1 | 513.03 | 8.38E-03 | 0.008 | 0.000838 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD005 | VOLUME | 561978.7 | 5271074.5 | 513.41 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD006 | VOLUME | 561954.4 | 5271056.8 | 513.41 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD007 | VOLUME | 561930.5 | 5271038.8 | 511.76 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD008 | VOLUME | 561906.4 | 5271021 | 509.65 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD009 | VOLUME | 561880.3 | 5271006.1 | 510.78 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD010 | VOLUME | 561853.2 | 5270993.4 | 510.21 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD011 | VOLUME | 561825.1 | 5270983 | 509.07 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD012 | VOLUME | 561797.9 | 5270971.1 | 506.29 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD013 | VOLUME | 561772.2 | 5270955.5 | 501.75 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD014 | VOLUME | 561760.1 | 5270928.5 | 499.2 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD015 | VOLUME | 561750.5 | 5270900.2 | 498.29 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD016 | VOLUME | 561747 | 5270870.4 | 497.35 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD017 | VOLUME | 561739.9 | 5270841.8 | 496.43 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD018 | VOLUME | 561725.1 | 5270815.7 | 495.65 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD019 | VOLUME | 561705.2 | 5270796.4 | 495.13 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD020 | VOLUME | 561676 | 5270789.4 | 495.12 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD021 | VOLUME | 561646.4 | 5270785.1 | 495.26 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD022 | VOLUME | 561616.5 | 5270782.8 | 495.45 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD023 | VOLUME | 561586.7 | 5270783.3 | 495.74 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD024 | VOLUME | 561557 | 5270787.4 | 496.33 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD025 | VOLUME | 561527.5 | 5270792.9 | 496.85 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Unpaved Road Segment Concentrate Haul (NAAQS Source) | UPVD026 | VOLUME | 561498.2 | 5270799.5 | 497.11 | 1.19E-02 | 0.012 | 0.00119 | | | | | | | | | | | 3.11 | | 13.95 | 2.89 | | | Mesabi Nugget Delaware LLC Major Amendment 2009 | |
| Coarse Crusher #1 | SV501 | POINT | 563986.4 | 5269192.9 | 453 | 0.053 | 0.053 | 0.053 | | | 100 | 30.48 | 77.09 | 298.2 | 24,988 | 3.83 | 6.49606299 | 1.98 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Coarse Crusher #2 | SV502 | POINT | 564078.8 | 5269248.6 | 453 | 0.053 | 0.053 | 0.053 | | | 100 | 30.48 | 77.09 | 298.2 | 24,988 | 3.83 | 6.49606299 | 1.98 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Coarse Crusher #3 | SV503 | POINT | 564170.6 | 5269303.2 | 453 | 0.053 | 0.053 | 0.053 | | | 100 | 30.48 | 77.09 | 298.2 | 24,988 | 3.83 | 6.49606299 | 1.98 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Crushed Ore Conveyor Transfer | SV504 | POINT | 563971.2 | 5269183.5 | 453 | 0.011 | 0.011 | 0.011 | | | 100 | 30.48 | 77.09 | 298.2 | 5,002 | 4.47 | 2.69028871 | 0.82 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Fine Crusher #1 | SV505 | POINT | 563817.2 | 5269065 | 453 | 0.053 | 0.053 | 0.053 | | | 120.013 | 36.58 | 77.09 | 298.2 | 24,988 | 5.32 | 5.51181102 | 1.68 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Fine Crusher #2 | SV506 | POINT | 563818.5 | 5269028.6 | 453 | 0.053 | 0.053 | 0.053 | | | 120.013 | 36.58 | 77.09 | 298.2 | 24,988 | 5.32 | 5.51181102 | 1.68 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Fine Crusher #3 | SV507 | POINT | 563821.6 | 5269067.4 | 453 | 0.053 | 0.053 | 0.053 | | | 120.013 | 36.58 | 77.09 | 298.2 | 24,988 | 5.32 | 5.51181102 | 1.68 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Overland Conveyor Transfer Center | SV508 | POINT | 562798.1 | 5270726.7 | 489.88 | 0.011 | 0.011 | 0.011 | | | 29.9869 | 9.14 | 77.09 | 298.2 | 4,999 | 11.11 | 1.70603675 | 0.52 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Ore Barn Feed | SV509 | POINT | 562216.7 | 5270836.9 | 495.66 | 0.011 | 0.011 | 0.011 | | | 110.007 | 33.53 | 77.09 | 298.2 | 4,999 | 6.13 | 2.29658793 | 0.7 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Ore Barn | SV510 | POINT | 562210 | 5270814 | 493.74 | 0.053 | 0.053 | 0.053 | | | 110.007 | 33.53 | 77.09 | 298.2 | 25,001 | 30.66 | 2.29658793 | 0.7 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| OreBarn Reclaim Tunnel #1 | SV511 | POINT | 562034.1 | 5270859.7 | 499.61 | 0.021 | 0.021 | 0.021 | | | 110.007 | 33.53 | 77.09 | 298.2 | 10,002 | 6.01 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| OreBarn Reclaim Tunnel #2 | SV512 | POINT | 562033.3 | 5270853.6 | 499.17 | 0.021 | 0.021 | 0.021 | | | 110.007 | 33.53 | 77.09 | 298.2 | 10,002 | 6.01 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Conveyor Transfer and Surge Bin | SV513 | POINT | 561900 | 5270877 | 496.23 | 0.011 | 0.011 | 0.011 | | | 50 | 15.24 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Distribution Bin Discharge #1 | SV514 | POINT | 561896.9 | 5270882.4 | 496.92 | 0.011 | 0.011 | 0.011 | | | 50 | 15.24 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Distribution Bin Discharge #2 | SV515 | POINT | 561894 | 5270879.5 | 496.24 | 0.011 | 0.011 | 0.011 | | | 50 | 15.24 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Distribution Bin Discharge #3 | SV516 | POINT | 561892.2 | 5270876.3 | 495.94 | 0.011 | 0.011 | 0.011 | | | 50 | 15.24 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Roll Press #1 | SV517 | POINT | 561815.8 | 5270934 | 499.99 | 0.053 | 0.053 | 0.053 | | | 110.007 | 33.53 | 77.09 | 298.2 | 24,996 | 15.02 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Roll Press #2 | SV518 | POINT | 561807.4 | 5270919.8 | 498.5 | 0.053 | 0.053 | 0.053 | | | 110.007 | 33.53 | 77.09 | 298.2 | 24,996 | 15.02 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Roll Press #3 | SV519 | POINT | 561799.4 | 5270905.8 | 497.72 | 0.053 | 0.053 | 0.053 | | | 110.007 | 33.53 | 77.09 | 298.2 | 24,996 | 15.02 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Concentrator Feed System #1 | SV520 | POINT | 561710.4 | 5270982.2 | 508.41 | 0.011 | 0.011 | 0.011 | | | 139.993 | 42.67 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Concentrator Feed System #2 | SV521 | POINT | 561702.1 | 5270966.1 | 505.24 | 0.011 | 0.011 | 0.011 | | | 139.993 | 42.67 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Concentrator Feed System #3 | SV522 | POINT | 561692.5 | 5270950.8 | 502.62 | 0.011 | 0.011 | 0.011 | | | 139.993 | 42.67 | 77.09 | 298.2 | 4,992 | 3 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Concentrate Rail Loadout | SV523 | POINT | 560580.1 | 5270480.8 | 493.31 | 0.11 | 0.110 | 0.11 | | | 29.9869 | 9.14 | 77.09 | 298.2 | 50,008 | 30.05 | 3.2808399 | 1 | | | | | | | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Tailings Wind Erosion | FS516A | AREA | 556096.7 | 5269359.9 | 475.488 | 1 | 1.000 | 1 | | | | | | | | | | | 22.86 | 1450 | 150 | 0 | | -15 | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Tailings Wind Erosion | FS516B | AREA | 556126 | 5269324.3 | 475.488 | 1 | 1.000 | 1 | | | | | | | | | | | 22.86 | 550 | 150 | 0 | | 55 | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Tailings Wind Erosion | FS516C | AREA | 556580.4 | 5268953.4 | 475.488 | 1 | 1.000 | 1 | | | | | | | | | | | 22.86 | 1120 | 150 | 0 | | 0 | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Tailings Wind Erosion | FS516D | AREA | 557506.1 | 5269734.4 | 475.488 | 1 | 1.000 | 1 | | | | | | | | | | | 22.86 | 1120 | 150 | 0 | | -15 | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Tailings Wind Erosion | FS516E | AREA | 557719.7 | 5269103.9 | 475.488 | 1 | 1.000 | 1 | | | | | | | | | | | 22.86 | 540 | 150 | 0 | | -65 | Mesabi Nugget Phase II EIS Modeling (2009) | |
| Tailings Wind Erosion | FS516F | AREA | 557960.1 | 5269575.8 | 475.488 | 1 | 1.000 | 1 | | | | | | | | | | | 22.86 | 686 | 150 | 0 | | -15 | Mesabi Nugget Phase II EIS Modeling (2009) | |

Rows highlighted in yellow are Mesabi Nugget Phase II mining sources that are not at present permitted or under review by regulatory agencies so it is proposed that they be exluded from any additional cumulative modeling.

**Mesabi Nugget Phase I & II- Model Inputs for NorthMet Cumulative NAAQS/Increment Modeling**

| | | | | | | INCREMENT | NAAQS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS PM10 (g/s) | EMISS PM10 (g/s) | EMISS PM2.5 (g/s) | EMISS NOX (g/s) | EMISS SO2 (g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | RELHGT | SXINIT | SYINIT | SZINIT | VOLUME | ANGLE | Emission Rate Source |
| Tailings Activity | TBBDOZE | VOLUME | 556108.1 | 5269490.3 | 490.28 | 1.261 | 1.261 | 0.48 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Grizzley Rejects Load/Unload Pile | FS51245 | VOLUME | 563962.4 | 5269189.9 | 453 | 0.048 | 0.048 | 0.007 | | | | | | | | | | | 7.5 | | 7 | 3.49 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Grizzley Rejects Wine Erosion Pile | FS513 | VOLUME | 563962.4 | 5269189.9 | 453 | 1.1 | 1.100 | 1 | | | | | | | | | | | 7.5 | | 7 | 3.49 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Concentrate Stockpile: Loading | FS51820 | VOLUME | 560734.2 | 5270594 | 498.85 | 0.212 | 0.212 | 0.029 | | | | | | | | | | | 17.37 | | 16.3 | 8.08 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Concentrate Stockpile: Wind Erosion | FS519 | VOLUME | 560734.2 | 5270594 | 498.85 | 1.1 | 1.100 | 1 | | | | | | | | | | | 17.37 | | 16.3 | 8.08 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 2WX Open Pit Source | 2WXPIT | OPENPIT | 562187.1 | 5267299.9 | 390.144 | 0.00000188 | 0.00000188 | 0.000000192 | | | | | | | | | | | 10 | 2275 | 1453 | | 221,658,637 | 0 | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 NW Open Pit Source | 6NWPIT | OPENPIT | 557425.2 | 5267470.9 | 428.244 | 0.00000143 | 0.00000143 | 0.000000156 | | | | | | | | | | | 10 | 1646 | 694 | | 33,077,134 | 0 | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Open Pit Source | A6PIT | OPENPIT | 558200.3 | 5266212.1 | 394.716 | 0.0000002 | 0.00000020 | 3.31E-08 | | | | | | | | | | | 10 | 530 | 1832 | | 60,669,465 | 34 | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 2WX SW Stockpile WR Handling | 2SWXWR | VOLUME | 563355.3 | 5265682.2 | 447.47 | 4.45E-02 | 0.045 | 2.20E-02 | | | | | | | | | | | 9.14 | | 1.4 | 4.25 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 2WX SW Stockpile WR Wind Erosion | 2SWXWRWE | VOLUME | 563355.3 | 5265682.2 | 447.47 | 1.1 | 1.100 | 1 | | | | | | | | | | | 9.14 | | 1.4 | 4.25 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 2WX SW Stockpile OB Handling | 2SWXOB | VOLUME | 563022.5 | 5266257.3 | 439.92 | 3.57E-02 | 0.036 | 0.0173 | | | | | | | | | | | 9.14 | | 1.4 | 4.25 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 2WX SW Stockpile OB Wind Erosion | 2SWXOBWE | VOLUME | 563022.5 | 5266257.3 | 439.92 | 1.1 | 1.100 | 1 | | | | | | | | | | | 9.14 | | 1.4 | 4.25 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 9 Underwater Dumping | A9DUMP | VOLUME | 556850.5 | 5267825.6 | 503.61 | 5.24E-02 | 0.052 | 0.0257 | | | | | | | | | | | 9.14 | | 1.4 | 4.25 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT1 | VOLUME | 563239.2 | 5266352.9 | 444.31 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT2 | VOLUME | 563276.7 | 5266306.2 | 449.84 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT3 | VOLUME | 563312.3 | 5266257.9 | 453.18 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT4 | VOLUME | 563339.3 | 5266205.7 | 454.47 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT5 | VOLUME | 563355 | 5266147.8 | 454 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT6 | VOLUME | 563370 | 5266089.7 | 453.32 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT7 | VOLUME | 563380.5 | 5266031 | 452.9 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT8 | VOLUME | 563381.7 | 5265971.1 | 452.89 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT9 | VOLUME | 563385.5 | 5265911.2 | 452 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT10 | VOLUME | 563385.3 | 5265851.3 | 452 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT11 | VOLUME | 563382.8 | 5265791.4 | 451.42 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Waste Rock from 2WX to SW Stockpile | AT12 | VOLUME | 563378.2 | 5265731.7 | 450.39 | 0.0157 | 0.0157 | 0.00143 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O1 | VOLUME | 564529.8 | 5269356.8 | 462.81 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O2 | VOLUME | 564472.2 | 5269369.5 | 460.02 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O3 | VOLUME | 564414.6 | 5269378.7 | 457.11 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O4 | VOLUME | 564355 | 5269386 | 458.87 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O5 | VOLUME | 564295.1 | 5269389 | 457.46 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O6 | VOLUME | 564235.2 | 5269390.6 | 457.07 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O7 | VOLUME | 564175.2 | 5269392.2 | 459.55 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O8 | VOLUME | 564116 | 5269399.8 | 462.42 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O9 | VOLUME | 564066.4 | 5269431.9 | 460.13 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O10 | VOLUME | 564008.7 | 5269445.4 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O11 | VOLUME | 563949 | 5269450.8 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O12 | VOLUME | 563889 | 5269450.8 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O13 | VOLUME | 563829 | 5269450.8 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O14 | VOLUME | 563769 | 5269450.7 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O15 | VOLUME | 563709 | 5269450.7 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O16 | VOLUME | 563649 | 5269451.6 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Mine East Crusher Entrance Road -- (Service Vehicles only) | O17 | VOLUME | 563593.1 | 5269470.9 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P1 | VOLUME | 563571.2 | 5269483.2 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P2 | VOLUME | 563539.8 | 5269534.3 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P3 | VOLUME | 563508.3 | 5269585.4 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P4 | VOLUME | 563476.9 | 5269636.5 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P5 | VOLUME | 563446.1 | 5269688 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P6 | VOLUME | 563416.5 | 5269740.2 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P7 | VOLUME | 563386.9 | 5269792.4 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P8 | VOLUME | 563357.3 | 5269844.6 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P9 | VOLUME | 563327.7 | 5269896.8 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P10 | VOLUME | 563298.1 | 5269949 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P11 | VOLUME | 563268.5 | 5270001.2 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P12 | VOLUME | 563237.5 | 5270052.5 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P13 | VOLUME | 563206.1 | 5270103.6 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P14 | VOLUME | 563174.6 | 5270154.7 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P15 | VOLUME | 563143.2 | 5270205.8 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P16 | VOLUME | 563113.8 | 5270256.9 | 453 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P17 | VOLUME | 563084.3 | 5270307.8 | 453.93 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P18 | VOLUME | 563048.9 | 5270359.2 | 454 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P19 | VOLUME | 563017.5 | 5270410.3 | 455 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P20 | VOLUME | 562985.6 | 5270461 | 455 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P21 | VOLUME | 562935.2 | 5270492.4 | 455.15 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P22 | VOLUME | 562877.6 | 5270509.2 | 456.27 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P23 | VOLUME | 562820 | 5270526 | 456.85 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P24 | VOLUME | 562761.6 | 5270539.5 | 459.89 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P25 | VOLUME | 562703 | 5270552.6 | 465.83 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P26 | VOLUME | 562644.1 | 5270557.1 | 469.67 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P27 | VOLUME | 562584.6 | 5270571.5 | 470.49 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P28 | VOLUME | 562525 | 5270578.2 | 471.57 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P29 | VOLUME | 562465.3 | 5270584 | 472.26 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P30 | VOLUME | 562405.4 | 5270587.4 | 473.15 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P31 | VOLUME | 562345.5 | 5270584.9 | 475.53 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Nugget Plant -- (Service Vehicles only) | P32 | VOLUME | 562285.7 | 5270579.9 | 476.99 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Concentratordump -- (Service Vehicles only) | Q1 | VOLUME | 562261.2 | 5270577.9 | 477.39 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Concentratordump -- (Service Vehicles only) | Q2 | VOLUME | 562207.8 | 5270605.3 | 480.84 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Concentratordump -- (Service Vehicles only) | Q3 | VOLUME | 562152.6 | 5270627.1 | 481.58 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Concentratordump -- (Service Vehicles only) | Q4 | VOLUME | 562093.9 | 5270640.1 | 482.95 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Road to Concentratordump -- (Service Vehicles only) | Q5 | VOLUME | 562035.3 | 5270652.7 | 483.68 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI1 | VOLUME | 558313.1 | 5267458.7 | 484.95 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI2 | VOLUME | 558323.5 | 5267399.6 | 484.28 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI3 | VOLUME | 558334 | 5267340.5 | 484.63 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI4 | VOLUME | 558344.4 | 5267281.4 | 484.98 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI5 | VOLUME | 558354.9 | 5267222.3 | 485.02 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI6 | VOLUME | 558365.3 | 5267163.2 | 484.67 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AI7 | VOLUME | 558375.8 | 5267104.2 | 484.15 | 0.0304 | 0.0304 | 0.00277 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AJ1 | VOLUME | 558379 | 5267085.9 | 483.71 | 0.0182 | 0.0182 | 0.00167 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AJ2 | VOLUME | 558377.6 | 5267025.9 | 482.12 | 0.0182 | 0.0182 | 0.00167 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AJ3 | VOLUME | 558376.1 | 5266965.9 | 482.51 | 0.0182 | 0.0182 | 0.00167 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AN1 | VOLUME | 558366.5 | 5266898.8 | 483.51 | 0.0243 | 0.0243 | 0.0022 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AN2 | VOLUME | 558357.1 | 5266839.5 | 483 | 0.0243 | 0.0243 | 0.0022 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AN3 | VOLUME | 558347.7 | 5266780.3 | 482.33 | 0.0243 | 0.0243 | 0.0022 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AN4 | VOLUME | 558338.3 | 5266721 | 481 | 0.0243 | 0.0243 | 0.0022 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AN5 | VOLUME | 558328.9 | 5266677.8 | 480.38 | 0.0243 | 0.0243 | 0.0022 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AQ1 | VOLUME | 558328 | 5266630.4 | 478.48 | 0.0307 | 0.0307 | 0.00279 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AQ2 | VOLUME | 558324.3 | 5266570.5 | 476.8 | 0.0307 | 0.0307 | 0.00279 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AQ3 | VOLUME | 558319.4 | 5266510.7 | 474.65 | 0.0307 | 0.0307 | 0.00279 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 South OB Stockpile Road | AQ4 | VOLUME | 558324.5 | 5266453.3 | 472.26 | 0.0307 | 0.0307 | 0.00279 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S1 | VOLUME | 563853.3 | 5269031.6 | 453 | -0.106 | 0.0125 | 0.00114 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S2 | VOLUME | 563797.7 | 5269009.1 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |

Rows highlighted in yellow are Mesabi Nugget Phase II mining sources that are not at present permitted or under review by regulatory agencies so it is proposed that they be exluded from any additional cumulative modeling.

**Mesabi Nugget Phase I & II- Model Inputs for NorthMet Cumulative NAAQS/Increment Modeling**

| | | | | | | INCREMENT | NAAQS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS PM10 (g/s) | EMISS PM10 (g/s) | EMISS PM2.5 (g/s) | EMISS NOX (g/s) | EMISS SO2 (g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | RELHGT | SXINIT | SYINIT | SZINIT | VOLUME | ANGLE | Emission Rate Source |
| AREA 6 to Crusher Road | S3 | VOLUME | 563742 | 5268986.6 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S4 | VOLUME | 563686.4 | 5268964.2 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S5 | VOLUME | 563630.8 | 5268941.7 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S6 | VOLUME | 563575.1 | 5268919.2 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S7 | VOLUME | 563519.5 | 5268896.8 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S8 | VOLUME | 563463 | 5268877.1 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S9 | VOLUME | 563404.3 | 5268864.5 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S10 | VOLUME | 563345.5 | 5268852.8 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S11 | VOLUME | 563285.8 | 5268847.4 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S12 | VOLUME | 563226 | 5268842 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S13 | VOLUME | 563166.3 | 5268836.6 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S14 | VOLUME | 563106.5 | 5268831 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S15 | VOLUME | 563046.8 | 5268824.9 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S16 | VOLUME | 562987.2 | 5268818.9 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S17 | VOLUME | 562927.7 | 5268810.8 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S18 | VOLUME | 562868.3 | 5268802.2 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S19 | VOLUME | 562808.9 | 5268793.6 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S20 | VOLUME | 562749.6 | 5268784.9 | 453 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S21 | VOLUME | 562690.1 | 5268776.8 | 453.58 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S22 | VOLUME | 562631.3 | 5268765.5 | 456.64 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S23 | VOLUME | 562573.6 | 5268749.3 | 456.87 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S24 | VOLUME | 562516.6 | 5268730.5 | 454.69 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S25 | VOLUME | 562460.4 | 5268709.6 | 456.89 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | S26 | VOLUME | 562404.3 | 5268688.3 | 459.29 | -0.0748 | 0.0433 | 0.00394 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U1 | VOLUME | 560111.5 | 5267894.5 | 452.48 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U2 | VOLUME | 560051.5 | 5267895.6 | 453.7 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U3 | VOLUME | 559991.5 | 5267896.7 | 456.43 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U4 | VOLUME | 559931.5 | 5267897.8 | 454.52 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U5 | VOLUME | 559871.5 | 5267898.4 | 454.47 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U6 | VOLUME | 559813.5 | 5267899 | 455.74 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U7 | VOLUME | 559752.3 | 5267906.6 | 456.98 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U8 | VOLUME | 559693.4 | 5267918.3 | 458.85 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U9 | VOLUME | 559634.6 | 5267930.1 | 460.66 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U10 | VOLUME | 559583.1 | 5267960.6 | 462.36 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U11 | VOLUME | 559532 | 5267992 | 465.04 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U12 | VOLUME | 559481.2 | 5268023.9 | 466.71 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U13 | VOLUME | 559433.6 | 5268060.4 | 467.73 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U14 | VOLUME | 559386 | 5268096.9 | 469.68 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U15 | VOLUME | 559338.9 | 5268134 | 471.93 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U16 | VOLUME | 559295 | 5268174.9 | 476.92 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U17 | VOLUME | 559249.8 | 5268214.4 | 474.84 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U18 | VOLUME | 559204.7 | 5268253.9 | 480.55 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U19 | VOLUME | 559159.7 | 5268293.6 | 480.85 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U20 | VOLUME | 559116.1 | 5268334.9 | 486.12 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U21 | VOLUME | 559072.6 | 5268376.2 | 488 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U22 | VOLUME | 559029.1 | 5268417.5 | 488.22 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U23 | VOLUME | 558985.6 | 5268458.8 | 488 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U24 | VOLUME | 558936.9 | 5268490.1 | 484.73 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U25 | VOLUME | 558878 | 5268501.3 | 483 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U26 | VOLUME | 558819.1 | 5268512.6 | 483 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U27 | VOLUME | 558760.1 | 5268523.8 | 483.54 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| NORTH AREA 6 TO CRUSHER ROAD -- (Only in Period 1-5) | U28 | VOLUME | 558701.2 | 5268535.1 | 484 | -0.0961 | 0.0220 | 0.002 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO2 | VOLUME | 560054.9 | 5267874.5 | 452.25 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO3 | VOLUME | 559998.3 | 5267854.8 | 451.64 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO4 | VOLUME | 559941 | 5267837 | 452.28 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO5 | VOLUME | 559887.2 | 5267810.5 | 452.27 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO6 | VOLUME | 559833.8 | 5267783.1 | 452.38 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO7 | VOLUME | 559775.7 | 5267768.8 | 454.31 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO8 | VOLUME | 559716.9 | 5267756.8 | 456.52 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO9 | VOLUME | 559658 | 5267745.8 | 456.52 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO10 | VOLUME | 559599 | 5267734.6 | 456.38 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO11 | VOLUME | 559540.1 | 5267723.2 | 457.13 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO12 | VOLUME | 559481.7 | 5267710.1 | 457.44 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO13 | VOLUME | 559426.7 | 5267686.1 | 458.92 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| SOUTH AREA 6 TO CRUSHER ROAD | AO14 | VOLUME | 559371.7 | 5267662 | 463.13 | 0.0226 | 0.0226 | 0.00205 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | I1 | VOLUME | 564223.3 | 5269254.2 | 453 | -0.107 | 0.0112 | 0.00102 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | I2 | VOLUME | 564171.9 | 5269223.3 | 453 | -0.107 | 0.0112 | 0.00102 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | I3 | VOLUME | 564120.5 | 5269192.3 | 453 | -0.107 | 0.0112 | 0.00102 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | I4 | VOLUME | 564069.1 | 5269161.4 | 453 | -0.107 | 0.0112 | 0.00102 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | I5 | VOLUME | 564017.7 | 5269130.5 | 453 | -0.107 | 0.0112 | 0.00102 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | I6 | VOLUME | 563966.3 | 5269099.5 | 453 | -0.107 | 0.0112 | 0.00102 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | H1 | VOLUME | 563853.3 | 5269031.6 | 453 | -0.0815 | 0.0366 | 0.00333 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Crusher Grizzly Dump Road | H2 | VOLUME | 563904.7 | 5269062.5 | 453 | -0.102 | 0.0164 | 0.00149 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| PIT 2WX to Crusher | G1 | VOLUME | 563853.3 | 5269031.6 | 453 | 0.0237 | 0.0237 | 0.00216 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| PIT 2WX to Crusher | G2 | VOLUME | 563884.6 | 5268980.4 | 453 | 0.0335 | 0.0335 | 0.00305 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| PIT 2WX to Crusher | G3 | VOLUME | 563915.9 | 5268929.1 | 453.71 | 0.0335 | 0.0335 | 0.00305 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T1 | VOLUME | 562367.8 | 5268743.8 | 452.88 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T2 | VOLUME | 562307.8 | 5268684.8 | 462.34 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T3 | VOLUME | 562248.8 | 5268695.4 | 460.95 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T4 | VOLUME | 562190 | 5268707.1 | 456.82 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T5 | VOLUME | 562131.4 | 5268720 | 454.21 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T6 | VOLUME | 562072.9 | 5268733.3 | 453.15 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T7 | VOLUME | 562014.1 | 5268744.9 | 452.32 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T8 | VOLUME | 561954.3 | 5268749.5 | 451.98 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T9 | VOLUME | 561894.8 | 5268742.2 | 451.73 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T10 | VOLUME | 561835.2 | 5268734.9 | 451.34 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T11 | VOLUME | 561776.2 | 5268725.5 | 450.89 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T12 | VOLUME | 561722.1 | 5268700 | 450.86 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T13 | VOLUME | 561672.7 | 5268666.1 | 450.74 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T14 | VOLUME | 561626 | 5268628.5 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T15 | VOLUME | 561579.2 | 5268590.9 | 450.86 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T16 | VOLUME | 561532.5 | 5268553.2 | 450.67 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T17 | VOLUME | 561485.7 | 5268515.6 | 450.82 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T18 | VOLUME | 561439 | 5268478 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T19 | VOLUME | 561392.3 | 5268440.4 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T20 | VOLUME | 561345.5 | 5268402.8 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T21 | VOLUME | 561298.8 | 5268365.2 | 450.91 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T22 | VOLUME | 561252 | 5268327.5 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T23 | VOLUME | 561205.3 | 5268289.9 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T24 | VOLUME | 561158.5 | 5268252.3 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |

Rows highlighted in yellow are Mesabi Nugget Phase II mining sources that are not at present permitted or under review by regulatory agencies so it is proposed that they be exluded from any additional cumulative modeling.

**Mesabi Nugget Phase I & II- Model Inputs for NorthMet Cumulative NAAQS/Increment Modeling**

| | | | | | | INCREMENT | NAAQS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS PM10 (g/s) | EMISS PM10 (g/s) | EMISS PM2.5 (g/s) | EMISS NOX (g/s) | EMISS SO2 (g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | RELHGT | SXINIT | SYINIT | SZINIT | VOLUME | ANGLE | Emission Rate Source |
| AREA 6 to Crusher Road | T25 | VOLUME | 561111.8 | 5268214.7 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T26 | VOLUME | 561065.7 | 5268176.3 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T27 | VOLUME | 561020.3 | 5268137.1 | 451.07 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T28 | VOLUME | 560977.5 | 5268095 | 452.84 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T29 | VOLUME | 560934.8 | 5268053 | 453.24 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T30 | VOLUME | 560892 | 5268010.9 | 454.04 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T31 | VOLUME | 560843.3 | 5267976.3 | 452.54 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T32 | VOLUME | 560792.4 | 5267944.5 | 451.49 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T33 | VOLUME | 560738.1 | 5267919.9 | 451 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T34 | VOLUME | 560680.7 | 5267902.8 | 451.11 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T35 | VOLUME | 560622.4 | 5267900.4 | 452.06 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T36 | VOLUME | 560562.7 | 5267899.2 | 453 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T37 | VOLUME | 560502.7 | 5267900.2 | 453 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T38 | VOLUME | 560442.7 | 5267901.2 | 453 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T39 | VOLUME | 560382.7 | 5267902.2 | 453.08 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T40 | VOLUME | 560322.7 | 5267903.2 | 454 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T41 | VOLUME | 560262.7 | 5267904.1 | 454.8 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T42 | VOLUME | 560202.7 | 5267910 | 454.91 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 to Crusher Road | T43 | VOLUME | 560142.7 | 5267910.9 | 453.9 | -0.0744 | 0.0436 | 0.00397 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9001 | VOLUME | 557411.7 | 5267755.2 | 476.13 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9002 | VOLUME | 557352.7 | 5267744.6 | 479.12 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9003 | VOLUME | 557294.2 | 5267731.4 | 482.92 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9004 | VOLUME | 557236 | 5267716.7 | 483.9 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9005 | VOLUME | 557178.4 | 5267700.1 | 485.9 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9006 | VOLUME | 557120.7 | 5267683.5 | 489.27 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9007 | VOLUME | 557062.5 | 5267682.6 | 494.26 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9008 | VOLUME | 557003.8 | 5267695.1 | 498.36 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9009 | VOLUME | 556948.6 | 5267718.4 | 501.43 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9010 | VOLUME | 556893.5 | 5267742.3 | 503.4 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9011 | VOLUME | 556844.6 | 5267772.7 | 505.02 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| HAUL ROAD TO AREA 9 INPIT DISPOSAL | A9012 | VOLUME | 556817.1 | 5267826 | 505.68 | 0.0271 | 0.0271 | 0.00246 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A1 | VOLUME | 562721.9 | 5267294.1 | 451 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A2 | VOLUME | 562757 | 5267245.5 | 450.99 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A3 | VOLUME | 562792.2 | 5267196.9 | 449.76 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A4 | VOLUME | 562827.4 | 5267148.3 | 448.36 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A5 | VOLUME | 562862.5 | 5267099.6 | 446.99 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A6 | VOLUME | 562897.7 | 5267051 | 444.61 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A7 | VOLUME | 562932.8 | 5267002.4 | 442.13 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A8 | VOLUME | 562965.9 | 5266952.3 | 441.03 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A9 | VOLUME | 562998.2 | 5266901.8 | 442 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A10 | VOLUME | 563036.6 | 5266851.3 | 441.63 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A11 | VOLUME | 563056.8 | 5266797.5 | 442.06 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A12 | VOLUME | 563081.5 | 5266742.8 | 442.08 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A13 | VOLUME | 563106.2 | 5266688.1 | 441.78 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A14 | VOLUME | 563123.9 | 5266630.9 | 441.29 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A15 | VOLUME | 563139.6 | 5266573 | 441.82 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A16 | VOLUME | 563155 | 5266515 | 441.82 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A17 | VOLUME | 563169.8 | 5266456.8 | 440.92 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB and WR Haul to 2WX SW Stockpile | A18 | VOLUME | 563184.5 | 5266398.7 | 440.31 | 0.0175 | 0.0175 | 0.00159 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB Haul to 2WX SW Stockpile | AS1 | VOLUME | 563189 | 5266323.4 | 442.36 | 0.0033 | 0.0033 | 0.0003 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB Haul to 2WX SW Stockpile | AS2 | VOLUME | 563187.4 | 5266263.5 | 442.41 | 0.0033 | 0.0033 | 0.0003 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB Haul to 2WX SW Stockpile | AS3 | VOLUME | 563176.1 | 5266208.7 | 442.81 | 0.0033 | 0.0033 | 0.0003 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| OB Haul to 2WX SW Stockpile | AS4 | VOLUME | 563118.8 | 5266206.6 | 440.12 | 0.0033 | 0.0033 | 0.0003 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W1 | VOLUME | 558648.5 | 5268545.1 | 484.89 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W2 | VOLUME | 558617.3 | 5268523.5 | 485.93 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W3 | VOLUME | 558618.3 | 5268463.5 | 484.94 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W4 | VOLUME | 558619.3 | 5268403.5 | 484.86 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W5 | VOLUME | 558620.2 | 5268343.5 | 484 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W6 | VOLUME | 558611.6 | 5268284.4 | 484 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W7 | VOLUME | 558600.4 | 5268225.4 | 484 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| AREA 6 NORTH CRUSHER HAUL ROAD | W8 | VOLUME | 558568.3 | 5268176.3 | 484 | 0.0285 | 0.0285 | 0.0026 | | | | | | | | | | | 7.77 | | 14 | 7.23 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V1 | VOLUME | 561567.1 | 5270172.3 | 477.42 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V2 | VOLUME | 561510.2 | 5270153.3 | 479.04 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V3 | VOLUME | 561453.3 | 5270134.3 | 480.67 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V4 | VOLUME | 561396.5 | 5270115 | 481.28 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V5 | VOLUME | 561339.9 | 5270095 | 482.83 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V6 | VOLUME | 561283.1 | 5270075.6 | 483.38 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V7 | VOLUME | 561226.2 | 5270056.2 | 483.53 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V8 | VOLUME | 561169.2 | 5270038 | 484.72 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V9 | VOLUME | 561112.6 | 5270018.2 | 485.02 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V10 | VOLUME | 561056 | 5269998.2 | 486.24 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V11 | VOLUME | 560999.4 | 5269978.2 | 485.87 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V12 | VOLUME | 560942.3 | 5269959.8 | 486.36 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V13 | VOLUME | 560884.9 | 5269942.5 | 486.83 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V14 | VOLUME | 562261.2 | 5270577.9 | 477.39 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V15 | VOLUME | 562167.1 | 5270428.9 | 472.09 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V16 | VOLUME | 562258.1 | 5270472 | 474.79 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V17 | VOLUME | 562241.1 | 5270522.1 | 476.08 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V18 | VOLUME | 562122 | 5270389.3 | 470.45 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V19 | VOLUME | 562074.6 | 5270352.6 | 469.92 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V20 | VOLUME | 562022.6 | 5270323.7 | 470.56 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V21 | VOLUME | 561965.9 | 5270304.2 | 472.47 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V22 | VOLUME | 561908.9 | 5270285.4 | 472.56 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V23 | VOLUME | 561680.7 | 5270211 | 474.51 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V24 | VOLUME | 561737.4 | 5270230.6 | 473.62 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V25 | VOLUME | 561794.5 | 5270249.2 | 472.99 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V26 | VOLUME | 561851.7 | 5270267.3 | 472.64 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V27 | VOLUME | 561624 | 5270191.4 | 475.78 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V28 | VOLUME | 560827.5 | 5269925.1 | 487.21 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V29 | VOLUME | 560770 | 5269907.8 | 487.59 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V30 | VOLUME | 560712.4 | 5269891 | 488.03 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V31 | VOLUME | 560654.7 | 5269874.5 | 488.48 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V32 | VOLUME | 560597 | 5269858 | 488.87 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V33 | VOLUME | 560539.4 | 5269841.4 | 488.38 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V34 | VOLUME | 560481.7 | 5269824.9 | 487.82 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V35 | VOLUME | 560424 | 5269808.4 | 488.27 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V36 | VOLUME | 560366.1 | 5269792.5 | 488.74 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V37 | VOLUME | 560308.2 | 5269777.1 | 488.23 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V38 | VOLUME | 560248.7 | 5269770.6 | 488.01 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V39 | VOLUME | 560188.9 | 5269771.7 | 487.05 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |

Rows highlighted in yellow are Mesabi Nugget Phase II mining sources that are not at present permitted or under review by regulatory agencies so it is proposed that they be exluded from any additional cumulative modeling.

**Mesabi Nugget Phase I & II- Model Inputs for NorthMet Cumulative NAAQS/Increment Modeling**

| | | | | | | INCREMENT | NAAQS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | **EMISS PM10 (g/s)** | **EMISS PM10 (g/s)** | **EMISS PM2.5 (g/s)** | **EMISS NOX (g/s)** | **EMISS SO2 (g/s)** | **HEIGHT (ft)** | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | RELHGT | SXINIT | SYINIT | SZINIT | VOLUME | ANGLE | Emission Rate Source |
| Area 6 Service Road (Service Vehicles only) | V40 | VOLUME | 560129.1 | 5269776.8 | 487.1 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V41 | VOLUME | 560069.4 | 5269782.1 | 487 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V42 | VOLUME | 560009.6 | 5269787.7 | 487 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V43 | VOLUME | 559949.9 | 5269793.4 | 486.89 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V44 | VOLUME | 559890.2 | 5269799 | 486.04 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V45 | VOLUME | 559770.7 | 5269810.1 | 486 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V46 | VOLUME | 559830.4 | 5269804.6 | 486 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V47 | VOLUME | 559710.9 | 5269815.6 | 486 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V48 | VOLUME | 559651.2 | 5269821.1 | 485 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V49 | VOLUME | 559591.4 | 5269826.6 | 483.54 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V50 | VOLUME | 559531.6 | 5269830.4 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V51 | VOLUME | 559472 | 5269826 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V52 | VOLUME | 559413.5 | 5269813.1 | 482.35 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V53 | VOLUME | 559355.5 | 5269797.4 | 482 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V54 | VOLUME | 559297.6 | 5269781.8 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V55 | VOLUME | 559239.7 | 5269766.1 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V56 | VOLUME | 559181.7 | 5269750.7 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V57 | VOLUME | 559123.7 | 5269735.5 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V58 | VOLUME | 559066.1 | 5269718.5 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V59 | VOLUME | 558956.4 | 5269671.3 | 483 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V60 | VOLUME | 559009.3 | 5269699.3 | 483.05 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V61 | VOLUME | 558909.4 | 5269634 | 483.09 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V62 | VOLUME | 558865.7 | 5269593.2 | 483.06 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V63 | VOLUME | 558826 | 5269548.2 | 483.59 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V64 | VOLUME | 558796.4 | 5269496.1 | 483.83 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V65 | VOLUME | 558771.3 | 5269441.6 | 483.8 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V66 | VOLUME | 558754.2 | 5269384.6 | 483.51 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V67 | VOLUME | 558745.3 | 5269325.3 | 483.66 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V68 | VOLUME | 558738.2 | 5269265.7 | 483.9 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V69 | VOLUME | 558731.1 | 5269206.1 | 484.14 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V70 | VOLUME | 558723.7 | 5269146.6 | 485.17 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V71 | VOLUME | 558716.1 | 5269087.1 | 486.13 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V72 | VOLUME | 558701.7 | 5268967.9 | 487.89 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V73 | VOLUME | 558708.4 | 5269027.6 | 486.78 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V74 | VOLUME | 558695 | 5268908.3 | 488.2 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V75 | VOLUME | 558688.3 | 5268848.7 | 488.69 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V76 | VOLUME | 558681.7 | 5268789.1 | 488.41 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V77 | VOLUME | 558675.1 | 5268729.4 | 486.62 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V78 | VOLUME | 558668.5 | 5268669.8 | 485.47 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V79 | VOLUME | 558660.9 | 5268610.3 | 485.16 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |
| Area 6 Service Road (Service Vehicles only) | V80 | VOLUME | 558649.7 | 5268551.4 | 484.85 | 0.0135 | 0.0135 | 0.00123 | | | | | | | | | | | 2.07 | | 14 | 1.93 | | | Mesabi Nugget Phase II EIS Modeling (2009) |

# Air Permit 13700013-007 - 100% Natural Gas

**Minnesota Power - Laskin Energy - Model Inputs from MPCA SO2 Request and NOX Permitted lb/hr**

| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS NOX (lb/hr) | EMISS NOX(g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Boiler Stack | LSK001 | POINT | 563085 | 5264402 | 442.16 | 264.00 | 3.326E+01 | 300 | 91.44 | 136 | 330.93 | 246685 | 14.47 | 10.5 | 3.20 |

**Minnesota Power Laskin Energy Parameters and Emissions comes from:**

Air Permit 13700013-006 Appendix F (NOx Modeling Parameters)

Note: modeling was NOT conducted for Air Permit 13700013-007

| | |
|---|---|
| Conversion of lb/hr to g/s | 0.1260 |
| Conversion of ft to m | 0.3048 |

**Arcelor Mittal - Minorca Mine Inc - Model Inputs from MPCA SO2 Request and NOX Permitted lb/hr**

| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS NOX (lb/hr) | MPCA NOX (lb/hr) | EMISS SO2 (lb/hr) | MPCA SO2 (lb/hr) | EMISS NOX(g/s) | EMISS NOX(g/s) | EMISS SO2(g/s) | EMISS SO2(g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indurating Machine | AMM014 | POINT | 535972.6 | 5267628 | 494.51 | 163.2 | 189.3 | 16.5 | 94.8 | 2.056E+01 | 2.385E+01 | 2.079E+00 | 1.194E+01 | 118.6 | 36.15 | 125 | 324.82 | 206035 | 17.37 | 8.76 | 2.67 |
| Indurating Machine | AMM015 | POINT | 535966.6 | 5267628 | 494.59 | 202.4 | 210.4 | 16.5 | 60.2 | 2.550E+01 | 2.651E+01 | 2.079E+00 | 7.582E+00 | 118.3 | 36.06 | 125 | 324.82 | 201951 | 17.02 | 8.76 | 2.67 |
| Indurating Machine | AMM016 | POINT | 535960.6 | 5267628 | 494.61 | 330.8 | 304.2 | 16.5 | 126.4 | 4.167E+01 | 3.833E+01 | 2.079E+00 | 1.593E+01 | 118.3 | 36.06 | 133 | 329.26 | 200406 | 16.89 | 8.76 | 2.67 |
| Indurating Machine | AMM017 | POINT | 535954.6 | 5267628 | 494.61 | 390.6 | 384.1 | 16.5 | 59.3 | 4.921E+01 | 4.840E+01 | 2.079E+00 | 7.466E+00 | 118.3 | 36.06 | 131 | 328.15 | 195216 | 16.45 | 8.76 | 2.67 |

**Arcelor Mittal Parameters and Emissions comes from:**

Original values (unhighlighted columns): MPCA SO2 Modeling Information Request (66 lb/hr limit for all 4 indurators) and 1 hour NO2 Modeling Information Request (1088 lb/hr limit for all 4 indurators)

MPCA recommended values from review of version 1 of the modeling results in yellow highlighted columns - these values used for version 2 of the modeling where applicable

Conversion of lb/hr to g/s 0.1260
Conversion of ft to m 0.3048

MPCA VALUES

**Arcelor Mittal Parameters and Emissions comes from:**

For NOx:

From Permit: 13700062-003 Indurating Furnace NOx Permit Limit (1,088 lb/hr) distributed between the 4 stacks based on stack test data

| | | | | |
|---|---|---|---|---|
| Stack A | 17% | 189.3 | lb/hr | (SV 14) |
| Stack B | 19% | 210.4 | lb/hr | (SV 15) |
| Stack C | 28% | 304.2 | lb/hr | (SV 16) |
| Stack D | 35% | 384.1 | lb/hr | (SV 17) |
| **TOTAL** | **100%** | **1,088.0** | **lb/hr** | |

For SO2:

From Permit: 13700062-003; 2 lb SO2/million Btu by state rule and production information

339.4 lb SO2/hr at EU 26

| | Fraction | SO2 lb/hr |
|---|---|---|
| Stack A | 0.2792 | 94.8 |
| Stack B | 0.1773 | 60.2 |
| Stack C | 0.3725 | 126.4 |
| Stack D | 0.1746 | 59.3 |

**Virginia Public Utilities - Model Inputs from MPCA Air Permit 13700028-009**

| DESCRIPTION | ID | TYPE | X (m) | Y | ELEV | EMISS NOX (lb/hr) | EMISS SO2 (lb/hr) | EMISS NOX(g/s) | EMISS SO2(g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiler #7 | VPU002 | POINT | 534554 | 5263319 | 436.33 | 90.6 | 339.6 | 1.141E+01 | 4.279E+01 | 150 | 45.72 | 335 | 441.5 | 97863 | 12.92 | 7 | 2.13 |
| Boiler #9 | VPU003 | POINT | 534544 | 5263308 | 436.25 | 129.2 | 339.6 | 1.627E+01 | 4.279E+01 | 150 | 45.72 | 390 | 472.0 | 106860 | 27.65 | 5 | 1.52 |
| Nat Gas Boiler 10 | VPU004 | POINT | 534536 | 5263339 | 436.15 | 27.5 | 0.16421 | 3.462E+00 | 2.069E-02 | 150 | 45.72 | 314 | 429.8 | 88060 | 15.82 | 6 | 1.83 |
| Wood Fired Boiler 11 | VPU005 | POINT | 534552 | 5263264 | 436.41 | 34.5 | 5.75 | 4.347E+00 | 7.245E-01 | 150 | 45.72 | 315 | 430.4 | 99066 | 15.17 | 6.5 | 1.98 |

**Virginia Public Utilities Parameters and Emissions comes from:**

MPCA Air Permit 13700028-009 Technical Support Document (Attachment 1; Calculations and PTE Summary and Attachment 2 Facility Description and CD-01 Forms (stack/vent table))

| | |
|---|---|
| Conversion of lb/hr to g/s | 0.1260 |
| Conversion of ft to m | 0.3048 |

**US Steel - Minntac - Model Inputs from MPCA 1 hour SO2/NOX Modeling Protocol Request**

| DESCRIPTION | SV ID | ID | TYPE | X (m) | Y | ELEV | EMISS NOX (lb/hr) | MPCA NOX (lb/hr) | EMISS SO2 (lb/hr) | MPCA SO2 (lb/hr) | EMISS NOX(g/s) | EMISS NOX(g/s) | EMISS SO2(g/s) | EMISS SO2(g/s) | HEIGHT (ft) | HEIGHT (m) | TEMP (F) | MPCA TEMP (F) | TEMP (K) | MPCA TEMP (K) | FLOW (acfm) | VELOCITY (m/s) | Diameter (ft) | DIAMETER (m) | SYINIT (m) | SZINIT (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI 104 MMBtu Boiler | SV001M | USX001M | POINT | 527605.4 | 5268166 | 512.68 | 54.4 | | 5.3 | | 6.854 | | 0.665 | | 67.25 | 20.50 | 380 | | 466.5 | | | 5.43 | 4.50 | 1.37 | NA | NA |
| SI 104 MMBtu Boiler | SV002M | USX002M | POINT | 527612.1 | 5268167 | 512.68 | 54.4 | | 5.3 | | 6.854 | | 0.665 | | 67.25 | 20.50 | 380 | | 466.5 | | | 5.43 | 4.50 | 1.37 | NA | NA |
| SII 125 MMBtu Boiler | SV003M | USX003M | POINT | 527619.1 | 5268168 | 512.68 | 65.5 | | 6.3 | | 8.253 | | 0.7987 | | 67.25 | 20.50 | 380 | | 466.5 | | | 6.64 | 4.50 | 1.37 | NA | NA |
| SIII 153 MMBtu Boiler | SV004M | USX004M | POINT | 527627 | 5268169 | 512.68 | 80.3 | | 7.8 | | 10.120 | | 0.978 | | 68.59 | 20.91 | 380 | | 466.5 | | | 8.15 | 4.50 | 1.37 | NA | NA |
| SIII 153 MMBtu Boiler | SV005M | USX005M | POINT | 527633.9 | 5268170 | 512.68 | 80.3 | | 7.8 | | 10.120 | | 0.978 | | 68.59 | 20.91 | 380 | | 466.5 | | | 8.15 | 4.50 | 1.37 | NA | NA |
| Diesel Generator | SV006M | USX006M | POINT | 527648.6 | 5268167 | 512.68 | 36.7 | | 2.4 | | 4.624 | | 0.302 | | 20.01 | 6.10 | 700 | | 644.3 | | | 0.01 | 0.66 | 0.20 | NA | NA |
| Diesel Generator | SV008M | USX008M | POINT | 527597.4 | 5268207 | 512.68 | 23.8 | | 1.6 | | 2.999 | | 0.202 | | 20.01 | 6.10 | 700 | | 644.3 | | | 0.01 | 0.49 | 0.15 | NA | NA |
| Diesel Fire Pump | SV009M | USX009M | POINT | 527592.2 | 5268163 | 512.68 | 5.0 | | 0.3 | | 0.630 | | 0.038 | | 20.01 | 6.10 | 700 | | 644.3 | | | 4.04 | 4.00 | 1.22 | NA | NA |
| 24.6 MMBtu Boiler | SV010M | USX010M | POINT | 527646.2 | 5266984 | 493.48 | 3.4 | | 1.2 | | 0.431 | | 0.157 | | 58.84 | 17.93 | 380 | | 466.5 | | | 4.24 | 2.50 | 0.76 | NA | NA |
| 24.6 MMBtu Boiler | SV011M | USX011M | POINT | 527650.7 | 5266985 | 493.48 | 3.4 | | 1.2 | | 0.431 | | 0.157 | | 58.84 | 17.93 | 380 | | 466.5 | | | 4.24 | 2.50 | 0.76 | NA | NA |
| Diesel Generator | SV012M | USX012M | POINT | 527658.9 | 5266936 | 493.48 | 19.0 | | 1.3 | | 2.394 | | 0.164 | | 16.01 | 4.88 | 700 | | 644.3 | | | 0.01 | 0.82 | 0.25 | NA | NA |
| Zinc Melt Furnace | SV019M | USX019M | POINT | 527252.5 | 5267524 | 527.92 | 0.2 | | 0.0 | | 0.024 | | 0.000 | | 32.00 | 9.75 | 700 | | 644.3 | | | 85.12 | 1.67 | 0.51 | NA | NA |
| Zinc Melt Furnace | SV020M | USX020M | POINT | 527164.4 | 5267450 | 527.92 | 0.4 | | 1.4 | | 0.048 | | 0.176 | | 32.00 | 9.75 | 700 | | 644.3 | | | 85.12 | 1.67 | 0.51 | NA | NA |
| Diesel Generator | SV029M | USX029M | POINT | 527279.1 | 5267727 | 534.02 | 16.5 | | 1.1 | | 2.079 | | 0.139 | | 14.01 | 4.27 | 700 | | 644.3 | | | 0.01 | 0.66 | 0.20 | NA | NA |
| Zinc Melt Furnace | SV086M | USX086M | POINT | 527183.8 | 5267920 | 527.62 | 0.4 | | 1.4 | | 0.048 | | 0.176 | | 29.00 | 8.84 | 700 | | 644.3 | | | 85.12 | 1.67 | 0.51 | NA | NA |
| Diesel Generator | SV098M | USX098M | POINT | 527152.1 | 5268039 | 513.9 | 19.3 | | 3.0 | | 2.432 | | 0.383 | | 119.00 | 36.27 | 700 | | 644.3 | | | 0.01 | 0.66 | 0.20 | NA | NA |
| Diesel Generator | SV099M | USX099M | POINT | 528189.5 | 5268256 | 519.54 | 19.3 | | 3.0 | | 2.432 | | 0.383 | | 25.00 | 7.62 | 700 | | 644.3 | | | 37.46 | 0.66 | 0.20 | NA | NA |
| L3 Waste Gas Stack | SV103M | USX103M | POINT | 528069.9 | 5268291 | 519.54 | 400.3 | 806.0 | 146.3 | 191.7 | 50.440 | 1.016E+02 | 18.430 | 2.415E+01 | 116.00 | 35.36 | 235 | 220 | 385.9 | 377.6 | | 20.83 | 10.00 | 3.05 | NA | NA |
| L4 Waste Gas Stack | SV118M | USX118M | POINT | 528116.6 | 5268295 | 519.54 | 739.2 | 1004.0 | 144.8 | 263.6 | 93.140 | 1.265E+02 | 18.250 | 3.321E+01 | 139.60 | 42.55 | 115 | 117 | 319.3 | 320.4 | | 21.45 | 14.00 | 4.27 | NA | NA |
| L5 Waste Gas Stack | SV127M | USX127M | POINT | 528130.9 | 5268296 | 519.54 | 711.3 | 1289.0 | 151.4 | 232.1 | 89.620 | 1.624E+02 | 19.080 | 2.924E+01 | 139.60 | 42.55 | 115 | 119 | 319.3 | 321.5 | | 21.45 | 14.00 | 4.27 | NA | NA |
| L6 Waste Gas Stack | SV144M | USX144M | POINT | 528434.4 | 5268236 | 520.3 | 726.5 | 1140.0 | 133.3 | 559.8 | 91.540 | 1.436E+02 | 16.800 | 7.053E+01 | 140.00 | 42.67 | 109 | 119 | 315.9 | 321.5 | | 14.04 | 16.00 | 4.88 | NA | NA |
| L7 Waste Gas Stack | SV151M | USX151M | POINT | 528377.7 | 5268246 | 520.3 | 354.1 | 1177.0 | 143.8 | 561.8 | 44.610 | 1.483E+02 | 18.120 | 7.079E+01 | 140.00 | 42.67 | 109 | 123 | 315.9 | 323.7 | | 15.16 | 16.00 | 4.88 | NA | NA |
| Diesel Generator | SV183M | USX183M | POINT | 527964.7 | 5268284 | 517.25 | 25.3 | | 1.6 | | 3.188 | | 0.202 | | 37.99 | 11.58 | 700 | | 644.3 | | | 0.01 | 0.66 | 0.20 | NA | NA |
| Diesel Generator | SV184M | USX184M | POINT | 527960.5 | 5268295 | 517.25 | 27.8 | | 1.8 | | 3.503 | | 0.227 | | 25.00 | 7.62 | 700 | | 644.3 | | | 0.01 | 0.82 | 0.25 | NA | NA |
| Diesel Generator | SV185M | USX185M | POINT | 528363.9 | 5268343 | 511.16 | 23.0 | | 1.5 | | 2.893 | | 0.189 | | 35.99 | 10.97 | 700 | | 644.3 | | | 0.01 | 0.66 | 0.20 | NA | NA |
| Diesel Generator | SV186M | USX186M | POINT | 528363.4 | 5268346 | 511.16 | 23.0 | | 1.5 | | 2.893 | | 0.189 | | 35.99 | 10.97 | 700 | | 644.3 | | | 0.01 | 0.66 | 0.20 | NA | NA |
| Diesel Air Compressor | SV187M | USX187M | POINT | 528033 | 5268212 | 519.54 | 9.4 | | 0.7 | | 1.184 | | 0.088 | | 39.99 | 12.19 | 80.01 | | 299.8 | | | 0.01 | 0.98 | 0.30 | NA | NA |
| Electric Shop Curing Oven | SV189M | USX189M | POINT | 528094.3 | 5267762 | 530.97 | 0.6 | | 0.0 | | 0.069 | | 0.000 | | 46.00 | 14.02 | 300 | | 422.0 | | | 0.01 | 2.00 | 0.61 | NA | NA |
| Burnout Oven | SV190M | USX190M | POINT | 528141.1 | 5267787 | 530.97 | 0.6 | | 0.0 | | 0.069 | | 0.000 | | 46.00 | 14.02 | 800 | | 699.8 | | | 0.01 | 1.67 | 0.51 | NA | NA |
| Concentrator Bldg Space Heaters (25 units, Ltr 8/10/01) | SV198M | USX198M | VOLUME | 527224.2 | 5268066 | 526.39 | 8.4 | | 0.0 | | 1.058 | | 0.006 | | 37.50 | 11.43 | NA | | NA | | NA | NA | #VALUE! | NA | 13.95 | 10.633 |

**USS Minntac Parameters and Emissions comes from:**

Orignal Values (unhighlighted columns): MPCA Requested 1 hour SO2/NO2 Modeling Protocol October 2011

MPCA recommended values from review of version 1 of the modeling results in yellow highlighted columns - these values used for version 2 of the modeling where applicable

Conversion of lb/hr to g/s 0.1260

Conversion of ft to m 0.3048

| NOx input supporting information | Performance Test Date |
|---|---|
| L3 Waste Gas Stack | 6/10/1997 |
| L4 Waste Gas Stack | 2/16/1997 |
| L5 Waste Gas Stack | 4/9/1997 |
| L6 Waste Gas Stack | 6/13/1997 |
| L7 Waste Gas Stack | 6/20/2002 |

SO2 Input information

Please refer to spreadsheet titled: 1-hr SO2 Calculations for Minntac

**Attachment N**

**Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota**

# *Cumulative Impacts Analysis*

## *Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining Inc.***

***January 2012***
***Version 3***

# *Cumulative Impacts Analysis*

## *Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining Inc.***

***January 2012***
***Version 3***

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# Cumulative Impacts Analysis
# Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota

## January 2012

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# Technical Summary

PolyMet plans to construct and operate a mine area near the town of Babbit, MN, to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailing Basin near Hoyt Lakes, MN and to build an ore processing facility at the former LTVSMC site. The proposed project is referred to as the NorthMet Project. The project description is provided in the March, 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement (reference(1)) and the NorthMet Project Description Version 3 Submitted September 13, 2011. The impact statement co-lead agencies, Minnesota Department of Natural Resources (MDNR), US Army Corps of Engineers, and US Forrest Service have concluded the proposed project requires a Supplemental Draft Environmental Impact Statement (SDEIS).

The Final Air Impact Assessment Planning Summary Memo for the Supplemental DEIS requires an updated assessment of the cumulative potential effects on visibility in Northeastern Minnesota (reference(2)). This assessment is to address not only the impacts of the proposed project, but also that of other past and "reasonably foreseeable" proposed projects on the Iron Range (see Table 1 and Figure 1). In addition, the project's potential cumulative air quality impacts are to be evaluated within the context of increasingly strict state and federal regulations to be implemented over the next decade. In this report, the project's potential cumulative impacts on visibility in the Boundary Waters Canoe Area Wilderness (BWCAW) and Voyageurs National Park (VNP) were evaluated.

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

### Causes of Haze and Visibility Impairment

Persistent, widespread visibility problems in areas like national parks are primarily caused by fine particles less than 2.5 microns in diameter ($PM_{2.5}$). Most of the visibility impairment in the BWCAW and VNP is due to secondary sulfate, nitrate, and organic aerosols. These aerosols are not typically emitted directly, but are formed in the atmosphere through chemical reactions. Sulfur dioxide and nitrogen oxides react with ammonia to form sulfates and nitrates respectively. Volatile organic compounds (VOCs) react to form larger low-volatility compounds, which condense into fine particulate matter known as secondary organic aerosols (SOA). In Minnesota's Class I areas, the organic compounds leading to SOA were shown through modeling to be of mostly of biogenic origin (reference(3)).

Regional haze, a term used to describe visibility degradation over a broad area, is caused by both local as well as long-range transport emissions, and does not depend on stagnant meteorological conditions. In the absence of precipitation, fine aerosol particles (and their gaseous precursors) can exist in the atmosphere for many days and can be carried great distances by winds. Sources in Minnesota contribute approximately 30 percent of visibility degradation in the Class I areas, but the majority of regional haze is often caused by conversion and transport of gaseous precursor emissions from sources outside of Minnesota (reference(3)). In addition, organic particles are produced as primary emissions from natural sources such as wildfire smoke, plant waxes, and pollen and as a result of conversion of volatile organic compound emissions such as terpenes and other hydrocarbons from trees and other natural sources.

### Regulatory Background

In July 1999, the U.S. Environmental Protection Agency (EPA) published regulations intended to improve visibility in our nation's largest national parks and wilderness ("Class I") areas. On June 15, 2005, EPA issued final amendments to its July 1999 rule. This rule and amendments are referred to as the Regional Haze Rule. Minnesota has two Class I areas – the BWCAW and VNP. The rule sets the goal of no man-made degradation of visibility by 2064 in Class I areas and also requires emission controls known as Best Available Retrofit Technology, or BART, for certain industrial facilities emitting air pollutants that reduce visibility. The Minnesota Pollution Control Agency (MPCA) submitted to EPA a State Implementation Plan (SIP) in December 2009 that sets forth a visibility goal for 2018 that shows reasonable progress towards the ultimate 2064 goal. Progress reports on the reasonable progress goals are to be submitted every five years and revisions to SIPs every ten years.

### Pollutant Air Concentrations

$SO_2$, $NO_x$ and particulate air concentrations, coarse and fine, are monitored by the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring network. An IMPROVE site is located in the BWCAW (BOWA1) just north and east of Ely and in VNP (VOYA2) just east of International Falls. See Figure 2 and Figure 3. The particulate air concentrations are estimated from filter samples collected by standard equipment and are reported as $PM_{10}$, coarse particle ($PM_{2.5}$ – $PM_{10}$) or fine particle ($PM_{2.5}$ or less) air concentrations.

### Visibility Metric

In this report, visibility is usually described by the haze index measured in "deciviews" which is calculated from the "light extinction coefficient". Deciviews are a logarithmic conversion of light extinction coefficient that more accurately reflects how humans perceive visibility impairment. Visibility

is not generally measured directly, but is usually indirectly estimated from monitored ambient particulate concentrations. The light extinction coefficient is calculated by multiplying the six major particulate components by component-specific light extinction efficiencies. Finally, visibility impairment often varies significantly from week to week and season to season. Therefore, visibility data is routinely reported not as an annual average but as that measured on "20% worst," "median," and "20% best" days.

### Summary Findings and Conclusions

1. **Class I Area Visibility Gradually Improving or Showing No Trend.** Between 1992 and 2009, visibility in the BWCAW on the 20% worst days improved from 21.4 deciviews to 19.8 deciviews, based on a rolling five-year average. This 1.6 deciview reduction is equivalent to about an 8% improvement in visibility. Most of this visibility improvement took place in the first half of the time period. For VNP, the National Park Service (NPS) has concluded that through 2007 there was not a trend of either improving visibility or declining visibility for this park (reference(4)). Monitoring data at VNP from 2000-2008 confirm the NPS finding.

2. **Sulfate and Nitrate Particles Are Largest Contributor to Visibility Impairment**. Ammonium sulfate, ammonium nitrate and organic carbon matter particulates are the largest contributors to visibility impairment in both Class I areas. The ammonium sulfate and nitrate are due to emissions of $SO_2$ and $NO_x$, respectively. The organic carbon matter in Minnesota has been shown to be attributable to mostly biogenic sources. Elemental carbon, soil, coarse particulate matter and gaseous species are minor contributors.

3. **Overall Emissions of Pollutants that are Precursors to Sulfate and Nitrate Particulates will Decrease.** When the emissions from the proposed projects in northeast Minnesota are viewed together with the concurrent emission reductions of $SO_2$ and $NO_x$ from the power and mining facilities in northeast Minnesota, there is a net decrease in emissions of both pollutants in the six-county area of northeast Minnesota. Minnesota's Regional Haze SIP requires additional reductions in $SO_2$ and $NO_x$ emissions from existing facilities in the six-county project area. Additional reductions in emissions may be required in the future to meet longer-term regulatory goals (e.g., Regional Haze). The foreseeable regulatory requirements indicate that $SO_2$ and $NO_x$ emissions from Minnesota sources will likely decline in the future.

4. **Percentage Increase in Pollutants Small Compared to Statewide Emissions that Affect Visibility and Fine Particulate Air Concentrations.** The percentage increase in pollutants from the proposed projects, not including the concurrent reductions, in northeast Minnesota is small in comparison to

current total statewide emissions. Worst-case total potential emissions from the proposed Iron Range projects represent a comparatively small increase compared to the 2009 statewide emissions: less than 1% of $PM_{10}$, about 2% of $SO_2$, and about 2% of $NO_x$ emissions.

5. **Fine Particulate Concentrations and Visibility Impairment Mostly Due to Out of State Emissions.** Long-range transport modeling done in support of the Minnesota Regional Haze SIP shows that approximately 14 to 15% of the visibility impairment on the 20% worst days is due to emissions from northeast Minnesota. Three projects were included in this modeling; Mesabi Nugget, the NorthMet Project and Minnesota Steel (now Essar Steel). Based on the modeling results, the remainder of the visibility impairment is estimated to be due to sources in other parts of Minnesota (12 to 17%), other states and Canada (reference (3)). Overall, Minnesota sources are estimated to be responsible for about 30% of the current visibility impairment, with about 70% of the visibility impairment due to all other out-of-state sources, including global sources.

6. **National Emission Reductions Likely to Drive Further Improvement.** Over the next decade, voluntary and mandatory reductions in $SO_2$, $NO_x$ and direct particulate emissions from existing sources in Minnesota and nationwide (including transportation sources) are likely to more than offset emissions from the proposed projects. In addition, the proposed projects will be controlling emissions of these pollutants in accordance with applicable regulations and permits, including the 2010 $SO_2$ and $NO_x$ NAAQS. More importantly, continued nationwide emission reductions over the next decade in visibility impairing pollutants will likely allow for both industrial growth on the Iron Range and continued improvement in visibility in the nearby Class I areas.

# 1.0 Introduction

To support the analyses in the SDEIS, this cumulative visibility evaluation is provided. The scope of the SDEIS requires a series of cumulative impact assessments covering a range of environmental issues. These assessments are to address not only the impacts of the proposed project, but also those of other past and "reasonably foreseeable" proposed projects. In addition, the project's potential cumulative air quality impacts for visibility are to be evaluated within the context of increasingly strict state and federal regulations to be implemented over the next decade.

As required by the Final Air Impact Assessment Planning Summary Memo for the Supplemental DEIS (reference(2)), a semi-quantitative analysis was conducted to determine whether the project has the potential to contribute to visibility impairment in the Federal Class I areas in Minnesota (VNP and the BWCAW). Particulate emissions are included in this assessment, along with $SO_2$ and $NO_x$ emissions, because fine particles are an important contributor to visibility impairment and fine particles can be made up of sulfate and nitrate aerosols. In addition, particle emissions are typically evaluated for their potential impacts in Federal Class I Areas, individually and in conjunction with $SO_2$ and $NO_x$ emissions, for Prevention of Significant Deterioration (PSD) air permitting analyses. Because of the relationship of particle emissions with visibility impairment and the specific assessments of potential impacts related to particulate emissions that are required to be conducted for PSD air permitting, particulate emissions are evaluated along with $SO_2$ and $NO_x$ emissions in this cumulative impact analysis.

## 1.1 What Are "Cumulative Impacts"?

The Council on Environmental Quality's (CEQ) regulations, which implement the National Environmental Policy Act (NEPA), define "cumulative effects" as: "… The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. …" (40 CFR 1508.7). The Minnesota Environmental Quality Board environmental review rules use a similar definition for "cumulative impacts" instead of "cumulative effects" (see Minnesota Rules, part 4410.0200, Subp. 11).

Some regulatory programs, in effect, require a form of quantitative cumulative impact assessment as part of a permit review. For example, air quality modeling of all significant nearby emission sources is required for "New Source Review" air permits. Likewise, water discharge permits often require the applicant to account for the impact of other discharges that affect the same water body as the proposed

project. But for most cumulative impact issues, such as those to be addressed for the NorthMet Project, there are only general guidelines. Therefore, the specific approach used to assess cumulative impacts must be developed case by case (reference(5)).

## 1.2 Visibility Impairment "Cumulative Impact" Approach

In addition to national and statewide emissions, this analysis summarizes stationary source emission trends in the six-county area encompassed by Itasca, St. Louis, Lake, Carlton, Koochiching and Cook counties. This six-county area was chosen to be consistent with the MPCA's Regional Haze SIP analysis area for northeastern Minnesota.

The assessment of potential cumulative impacts on visibility from the proposed project is completed in four parts:

1. Assess the IMPROVE data for VNP and the BWCAW to provide the current haze index (an indicator for visibility) and concentrations of other pollutants that may degrade visibility, including a trends analysis where there is sufficient data (improvement, no change, or degradation).

2. Assess available information from the Regional Haze SIP (see Section 1.4) that identifies emission sources and/or emission source regions as significant contributors to ambient air concentrations in the Class I areas located in Minnesota.

3. Evaluate local, statewide and national $SO_2$, $NO_x$, and $PM_{10}$ emissions and trends using existing emission inventory data.

4. Evaluate the cumulative impacts from the proposed projects based on the potential increases in $SO_2$, $NO_x$, and $PM_{10}$ emissions and concurrent reductions from current and reasonably foreseeable projects and the expected decrease in state and national emissions in the future.

## 1.3 Proposed Projects and Summary of Potential Emissions

Table 1 shows the estimated potential emissions of $SO_2$, $NO_x$, and $PM_{10}$ from each of the proposed projects and reductions included in this analysis. Concurrent emission reductions are provided for comparison to the emissions estimated for the proposed projects. Additional details regarding each of the emission reduction projects and their status are provided in Section 4.0. Proposed projects were included only if they were not yet fully operating as of January 1, 2010 and reductions were only included if they were fully implemented after January 1, 2010. This cutoff date was chosen because the monitoring data used to assess the past or existing conditions includes information through December 31, 2009. Any projects that began operating after January 1, 2010 were not included in the analysis of the existing

conditions and therefore needs to be considered in the assessment of future cumulative impacts. Similarly, any reductions that occurred or will occur after January 1, 2010 are not reflected in the monitoring data and are considered in this assessment of cumulative impacts.

The two major contributors to visibility impairment for both Federal Class I areas in Minnesota are ammonium sulfate and ammonium nitrate, secondary aerosols formed from emissions of $SO_2$ and $NO_x$, respectively. Even though there is a net increase in $PM_{10}$ for all the proposed projects combined, direct $PM_{10}$ emissions are not considered to be a concern for visibility impairment in the BWCAW or VNP (reference(3)).

As can be seen from Table 1, emissions of both $NO_x$ and $SO_2$ will be reduced significantly in northeast Minnesota due to large reductions from Minnesota Power's facilities and BART reductions. The emission increases from the proposed projects (mainly mining) will be more than compensated for by the reductions from the power plants and other BART reductions. However, as noted later in this report, additional reductions may need to be made to meet the Regional Haze goals for visibility.

The $PM_{10}$ emissions for the proposed projects include both stack and fugitive emissions and show a net increase for all the proposed projects. Stack emissions are generally fine particulate while fugitive emissions are typically larger particles. Fugitive emissions are often ground-level emissions, especially in the case of mining sources, having the potential for local air quality impacts near the facility, but likely not associated with impacts at a distance from a facility (reference(6)). Table 1 includes both fugitive and stack emissions in order to show a complete picture of the emissions.

Figure 1 shows the general locations of the proposed projects in northeast Minnesota in relation to the federal Class I areas included in this analysis, the BWCAW and VNP.

**Table 1 Maximum potential sulfur dioxide, nitrogen oxide, and particulate emissions from proposed projects in the six-county project area in comparison to emission reductions.**

(Six-county project area is Carlton, Koochiching, Itasca, St. Louis, Lake, Cook counties)

| Project | Location In Minnesota | $SO_2$ (tpy) | $NO_x$ (tpy) | $PM_{10}$ [16] (tpy) | BACT/ MACT [18] |
|---|---|---|---|---|---|
| **Increases** | | | | | |
| Excelsior Energy, Mesaba Energy Project [1] | Taconite, Itasca County | 1,390 | 2,872 | 532 | Yes |
| Mesabi Nugget Phase I LSDP [2] | Hoyt Lakes, St. Louis County | 417 | 955 | 587 | Yes |
| Mesabi Nugget Phase II [3] | Hoyt Lakes, St. Louis County | 7 | 298 | 1260 | Yes |
| Essar Steel Minnesota LLC (formerly Minnesota Steel) [4] | Nashwauk, Itasca County | 421 | 1,505 | 1,354 | Yes |
| Essar Steel Minnesota LLC – Project modifications [5] | Nashwauk, Itasca County | 146 | -69 | -90 | Yes |
| Northshore Mining Company: Furnace 5 Reactivation [6] | Silver Bay, Lake County | 56 | 200 | 149 | Yes |
| PolyMet Mining, NorthMet Project [7] | Hoyt Lakes, St. Louis County | 40 | 473 | 1186 | No |
| SAPPI Cloquet [12] | Cloquet, Carlton County | 1 | 162 | 29 | Yes |
| UPM/Blandin Paper Mill Expansion: Project Thunderhawk [8] | Grand Rapids, Itasca County | 213 | 169 | -7 | Yes |
| US Steel Keewatin, Keetac Expansion [9] | Keewatin, Itasca and St. Louis Counties | 81 | 35 | 1284 | Yes |
| United Taconite Green Production Project [13] | Forbes, St. Louis County | 35 | 35 | -10 | No [13] |
| **Total Increases** | | 2,807 | 6,635 | 6,274 | |
| **Anticipated Reductions from 2009 Emissions** | | | | | |
| Minnesota Power – Taconite Harbor Energy Center Unit 2, emission control modifications for SO2, $NO_x$ and mercury [11] | Schroeder, Cook County | -1549 | -423 | | |
| Minnesota Power – Laskin Energy Center Unit 2 $NO_x$ reductions [10][11] | Hoyt Lakes, St. Louis County | 0 | 0 | | |
| Minnesota Power – Boswell Energy Center Unit 3 [11] | Cohasset, Itasca County | -4,224 | -6,372 | | |
| US Steel Minntac [15] | Mtn. Iron, St. Louis County | | -1,973 | | |
| Hill Wood Products [14] | Cook, St. Louis County | 0 | 0 | -14 | |
| Northshore Mining Company: BART Reductions [11][17] | Silver Bay, Lake County | -583 | -1,159 | | |
| United Taconite BART Reductions [11][17] | Forbes, St. Louis County | -1,954 | | | |
| **Total Reductions** | | -8,310 | -9,927 | -14 | |
| **Net Reduction/Increase** | | -5,503 | -3,292 | +6,260 | |

[1] Emission estimates (Phase I and Phase II) based on emissions used in the air quality analysis in the final EIS, website: http://energy.gov/nepa/downloads/eis-0382-final-environmental-impact-statement-0. Accessed on May 5, 2011.

[2] Mesabi Nugget's Proposed Large Scale Demonstration Plant (LSDP): No crushing/grinding at the site; receive concentrate from off-site. Technical Support Document for MPCA permit 13700318-003. Included in Northeast Minnesota Plan Project Tracking for MPCA SIP, version 1-20-2011.

[3] Preliminary emission estimates, Barr Engineering, as of 1/29/2011.

[4] Baseline emissions from Potential to emit from Technical Support Document for Minnesota Steel (MPCA permit #06100067-002).

[5] Project modifications preliminary emission estimates Barr Engineering, emission estimate from EI spreadsheet submitted to MPCA on 4/5/2011.

[6] Northshore Mining's Furnace 5 Project: reactivating 2 crushing lines, 9 concentrating lines, one pellet furnace (Furnace 5); new sources emissions only (MPCA permit #07500003-003). Although construction for the project was completed prior to the January 1, 2009 cutoff date for this analysis, due to plant turnaround and current demand, the furnace has not yet operated at a capacity reflecting the expected increase and is therefore included in this evaluation.

[7] PolyMet Mining's Proposed Facility: crushing/grinding of ore, reagent and materials handling, flotation, hydrometallurgical processing, mobile emissions. Emission estimates from Barr Engineering report dated November 2008 *Stationary and Mobile Source Emission Calculations for the NorthMet Project –Combined Report (RS57)*, submitted to MDNR and updated 4/1/2009. An updated emission inventory is being prepared to reflect the project as currently proposed. All portions of the inventory are expected to be submitted for review within a few weeks of submittal of this report. The expectation is that emission will tend to be lower than those reported previously.

[8] Net Emission Increase from Blandin Project Thunderhawk MPCA permit #06100001-009 No change in emissions for -010 or -011.

[9] U. S. Steel Keewatin, Keetac mine expansion and restart of taconite processing line – preliminary emission calculations, Barr Engineering. Submitted to MPCA in May 2011 permit application. $NO_x$ emission increase is from the baseline actual emissions used to determine PSD applicability. Although there will be a small increase in actual emissions, there will be a decrease in the allowable emissions.

[10] Minnesota Power completed installation of the Low NOx burner system project in Spring 2010. Although actual 2009 emissions already show reductions in excess of the anticipated reductions from 2002 levels, additional reductions are expected to result from the use of the low NOx burners in 2010 and future years. A reduction of zero is used in this analysis because the actual future reductions are unknown.

[11] Emission estimates provided by the MPCA from the "Northeast Minnesota Plan Emission Tracking Spreadsheet" 1-20-2011. Reductions are the estimated reduction from 2002 emissions minus any reduction in actual emissions that has occurred between 2002 and 2009.

[12] Net emission change estimates from final EAW dated 5/1/2009. Plant expansion, new paper machine, new boiler.

[13] United Taconite's Green Production Project involves fuel changes and improvements to the concentrator and the Line 1 pellet plant to increase pellet production and was a Prevention of Significant Deterioration (PSD) minor project. Because it was a PSD minor project, specific considerations for BACT/MACT were not required. However, the Line 1 pellet plant has an existing wet scrubber to control particulate and SO2 emissions. Emission estimates are taken from the Technical Support Document of Permit Number 13700113-005 authorizing the project on August 19, 2010.

[14] Net emissions increase from TSD of Air Emission Permit No. 13700030-003.

[15] Reductions calculated based on data in "US Steel Minntac Line 7 Low NOx Main Burner Final Testing Report", May 13, 2011of 3,990 ton per year goal for NOx emissions and the 2009 actual emissions provided in the MPCA "Northeast Minnesota Plan Emissions Tracking Spreadsheet" 1-20-2011.

[16] $PM_{10}$ emission estimates include stationary and fugitive emissions for all sources at a facility.

[17] The MPCA RH SIP is still being reviewed by the EPA for approval including the recommended BART determinations for affected facilities. Under a court imposed consent decree the EPA must approve the MN SIP by May 15, 2012. Actual BART requirements are pending discussions with the MPCA and have not yet been implemented.

[18] Abbreviations:
tpy = tons per year;
BACT = Best Available Control Technology
MACT = Maximum Achievable Control Technology
$SO_2$ = sulfur dioxide
$PM_{10}$ = particulate matter less than 10 micrometers in size
$NO_x$ = nitrogen oxides
N/A = not applicable

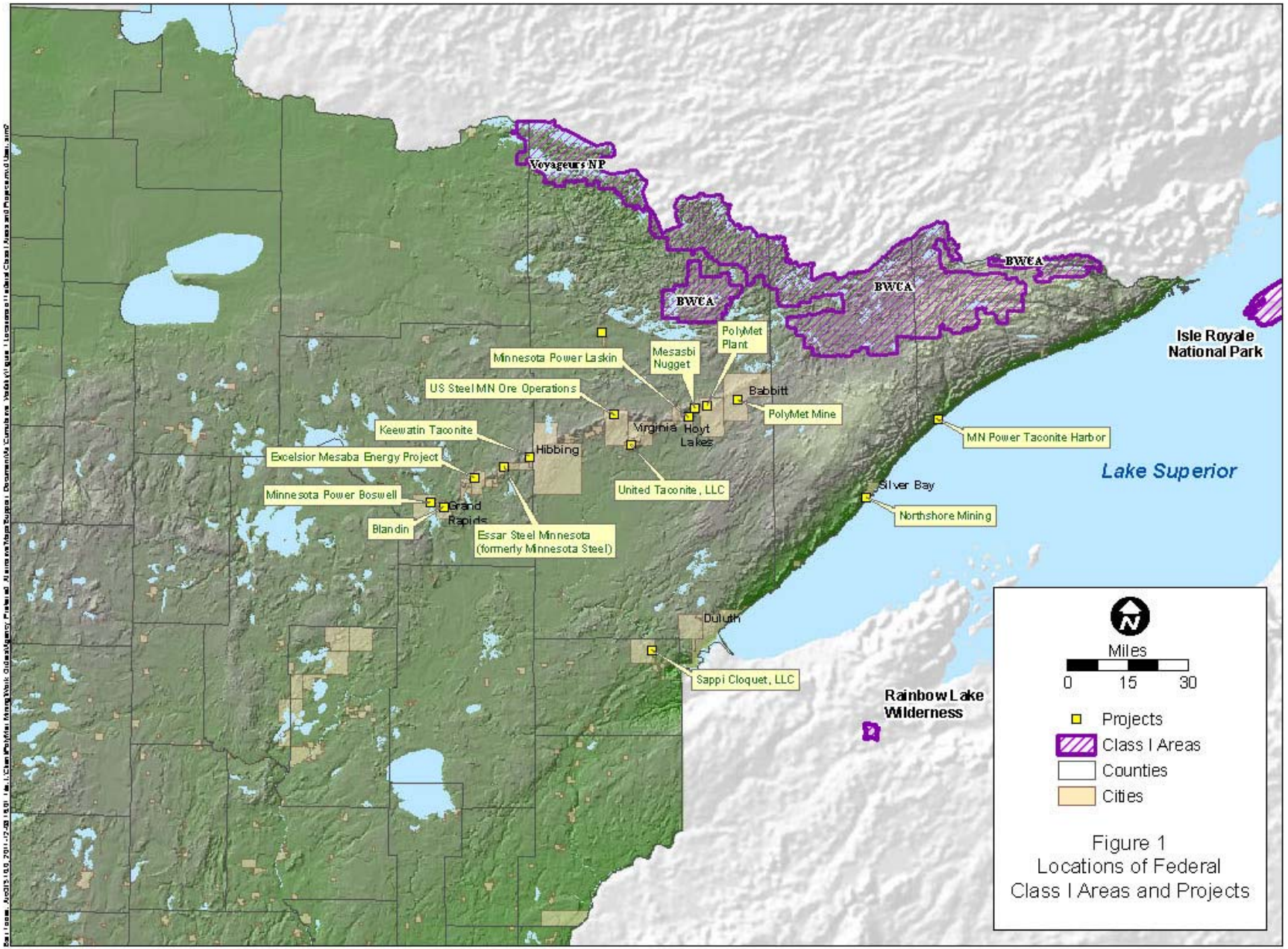



**Figure 1 Location of Federal Class I Areas and Projects**

## 1.4 Background on Regional Haze and Visibility Impairment

In order to better understand regional haze and visibility impairment and the methods used to describe it, this section summarizes the sources and types of visibility impairing particulate matter, visibility measurement methods and the applicable federal regional haze regulations.

### 1.4.1 What are Regional Haze and Visibility Impairment?

As defined by the U.S. EPA (reference (7)) "regional haze" is visibility impairment caused by the cumulative air pollutant emissions from numerous sources over a wide geographic area. Visibility impairment can be defined as the "introduction of particulate matter and certain gases into the atmosphere [that] interferes with the ability of an observer to see landscape features" and is primarily caused by very small particles, usually less than 2.5 microns in diameter ($PM_{2.5}$), including solid particles and liquid or aqueous aerosols (reference (8)).

$PM_{10}$ can be divided into coarse (between 2.5 and 10 microns) and fine (less than 2.5 microns, $PM_{2.5}$) particulate fractions. The primary cause of regional haze in Minnesota's class I areas is light scattering resulting from fine particles in the atmosphere, specifically ammonium sulfate, ammonium nitrate and organic carbon matter (references (3)(8)). Coarse particles between 2.5 and 10 microns in diameter do contribute to light extinction. However, these particles tend to settle out from the air more rapidly than fine particles and usually will be found relatively close to their emission sources (references (6)(9)).

Visibility impairing particulates can also be categorized based on whether the particulate matter is emitted directly into the atmosphere or is indirectly formed when gaseous air pollutants react in the atmosphere (reference (6)). These two major categories of particulate matter are called "primary particulate matter" and "secondary particulate matter."

- **Primary PM** consists of mainly carbon emitted from many sources including smokestacks, cars, trucks, heavy equipment, forest fires, burning waste, crustal material from unpaved roads, stone crushing, construction sites, and metallurgical operations.
- **Secondary PM** forms due to chemical reactions of gases in the atmosphere. Some of these reactions require sunlight and/or water vapor in order to occur. Secondary PM includes sulfates formed from sulfur dioxide emissions, nitrates formed from nitrogen oxide emissions, and carbon formed from reactive organic gas emissions. Sulfur dioxide and nitrogen oxides are emitted from power plants, industrial facilities, cars and trucks. Organic gas emissions are emitted from these sources as well as from forest fires and biogenic sources such as trees. In Minnesota, the organic carbon matter found to be contributing to visibility impairment was found through modeling to be biogenic (reference (3)).

The fine particulate fraction ($PM_{2.5}$), which usually consists of secondary particulates, can be transported long distances by wind and weather and can be found in the air thousands of miles from where they were formed and can contribute to visibility problems at remote locations, such as national parks (references(6)(10)). The coarse fraction (particles with a diameter between 2.5 and 10 microns) is usually made up of primary particulates (references (6)(7)).

### 1.4.2 Fine Particulate Emission Sources

The air emissions most often responsible for regional haze are sulfur dioxide ($SO_2$, precursors of sulfate particles), nitrogen oxides ($NO_x$, precursors of nitrate aerosols and $NO_2$), primary volatile organic particles, gaseous VOCs (precursor of secondary organic particles), elemental carbon, soil-material, and ammonia ($NH_3$) (a precursor of ammonium nitrate). Each of these components can be naturally occurring or the result of human activity. The natural levels of these species result in some level of visibility impairment in the absence of any human influences, and will vary with season, daily meteorology, and geography (reference (11)).

The major anthropogenic sources of atmospheric fine particles (less than 2.5 microns) and their major mission sources are summarized Table 2.

**Table 2 Atmospheric Fine Particles (PM2.5) and Their Major Emission Sources.**

| Atmospheric Pollutant | Primary Sources | | Secondary Sources | |
|---|---|---|---|---|
| | Natural | Man Made | Natural | Man Made |
| Sulfate ($SO_4$) | Sea spray | Fossil Fuel combustion | $SO_2$ from volcanoes, oceans, wetlands | $SO_2$ from fossil fuel combustion |
| Nitrate ($NO_3$) | N/A | Motor vehicle exhaust, fossil fuel combustion | $NO_x$ from soils, forest fires, lightning | $NO_x$ from fossil fuel combustion, vehicle exhaust, prescribed burning |
| Organic Carbon | Wildfires | Open burning, wood burning, prescribed burning, motor vehicles, incineration, tire wear | Oxidation of Hydrocarbons (terpenes and waxes) emitted by vegetation and wildfires | Oxidation of hydrocarbons by vehicles, open burning, wood burning, fuel storage, solvent use |
| Ammonia ($NH_3$) | N/A | Motor vehicle exhaust | | Animal agriculture, sewage, fertilizer |

Reference: USEPA, 1997

### 1.4.3 How is Visibility Impairment Measured?

For the purposes of this report, visibility is characterized by the light extinction coefficient and the haze index. The light extinction coefficient is calculated using air concentrations of various fine particulate species and other factors. Haze index is a way of measuring visibility that better reflects how humans perceive changes in visibility. A description of and the relationship between these two measures of visibility is described below.

#### Light Extinction Coefficient

Because of the complications involved in direct measurements of visibility, most scientists use an indirect method which involves calculating the light extinction coefficient. The extinction coefficient is the sum of the atmospheric concentration of each species of interest multiplied by a corresponding coefficient. The light extinction coefficient is referred to as $b_{ext}$ and has units of $10^{-6}$ $m^{-1}$ or $(10^6$ $m)^{-1}$, or as typically labeled, inverse megameters ($Mm^{-1}$).

The IMPROVE program monitors air concentrations of visibility impairing constituents throughout the United States and uses these measured concentrations to calculate light extinction coefficients. The detailed IMPROVE light extinction coefficient calculations and assumptions can be found in the MPCA Regional Haze SIP (reference (3)).

#### Haze Index (Deciview)

Light extinction coefficient measurements are not linear with respect to the human perception of visual scene changes caused by uniform haze. For example, a given change in light extinction coefficient can result in a scene change that is either unnoticeably small or very apparent depending on the baseline visibility conditions. Presentation of visibility measurement data or model results in terms of extinction coefficient can lead to misinterpretation by those who are not aware of the nonlinear relationship.

Therefore, using the relationship of a constant fractional change in extinction coefficient to perceived visual change, a new visibility index called deciview (dv) was developed. The deciview is a unit of measurement of haze, implemented in a haze index (HI), which is derived from calculated light extinction, and is designed such that uniform changes in HI correspond approximately to uniform incremental changes in perception, across the entire range of conditions, from pristine to highly impaired (reference (7)).

The scale of the visibility index, expressed in deciview (dv), is linear with respect to perceived visual changes over its entire range, analogous to the decibel scale for sound. A one deciview change represents

a change in scenic quality that would be noticed by most people regardless of the initial visibility conditions. A deciview of zero equals clear air, while deciviews greater than zero depict proportionally increased visibility impairment (reference (12)). For example, a value of 29 dv represents more visibility impairment than does a value of 11 dv.

The haze index (*HI)* is defined by the following equation:

$$HI = 10\ln\left(\frac{b_{TOTAL}}{10}\right)$$

where $b_{TOTAL}$ is the light extinction and is expressed in inverse megameters, or $Mm^{-1}$. One dv change is approximately a 10% change in extinction coefficient, which is a small, but perceptible scenic change under many circumstances. The deciview scale is near zero (0) for a pristine atmosphere (dv = 0 for a Rayleigh condition at about 1.5 km elevation) and increases as visibility is degraded. Like the decibel scale for sound, equal changes in deciview are equally perceptible. Because the deciview metric expresses visual scene changes that are linear with respect to human perception, EPA supports the use of the deciview metric in characterizing visibility changes for regulatory purposes.

### 1.4.4 Federal Regional Haze Rule

Section 169A of the 1977 Clean Air Act Amendments (CAAA) established a national visibility goal to remedy existing impairment and prevent future impairment in 156 National Parks and wilderness areas across the country designated as mandatory Federal Class I areas. The EPA issued initial visibility regulations in 1980 (reference(13)) that addressed visibility impairment in a mandatory Federal Class I area that is "reasonably attributable" to a single source or small group of sources (reference(7)).

Then, to address widespread regional haze problems, the EPA published regulations to address visibility impairment in federal Class I areas in July 1999. This rule is commonly known as the "Regional Haze Rule" (reference(14)) and is found in 40 CFR part 51, in §§ 51.300 through 51.309. On June 15, 2005, EPA issued final amendments to its July 1999 rule, including Appendix Y to 40 CFR part 51 "Guidelines for BART Determination Under the Regional Haze Rule." The MPCA subsequently prepared a BART strategy for Minnesota sources and is in the process of moving forward with that strategy (reference(15)).

As required under these rules, Minnesota submitted to EPA a Regional Haze State Implementation Plan (SIP) that identifies sources that cause or contribute to visibility impairment in these areas in December of 2009. EPA is currently reviewing the SIP to verify that the plan complies with all of the rule requirements. Under a court imposed consent decree, the EPA must approve of the MN SIP by May 15,

2012. The Regional Haze SIP includes a long term strategy that contains a 2018 visibility goal that demonstrates reasonable progress toward reaching the 2064 goal of no man-made visibility impairment for each of the federal Class I areas in Minnesota. The Federal Regional Haze Rule also requires states to submit progress reports every five years and SIP revisions every ten years. The first SIP revision for Minnesota is planned for 2018. The first progress report evaluating reasonable progress goals is due 2014.

In addition, the federal new source review (NSR) program generally requires air permit applicants to conduct a source impact analysis. For the NSR program, the impact analysis must demonstrate that the new or modified source will not cause or contribute to a violation of state or national ambient air quality standards (NAAQS) or cause an adverse impact to visibility in any federal class I area. Included in this impact analysis is the protection of federal lands (national parks, wilderness areas, etc.) which have been designated as federal Class I areas for PSD purposes. The EPA also administers several other programs designed to protect visibility including the secondary NAAQS for $PM_{10}$ and $PM_{2.5}$, and section 401 under the provisions for acid deposition control. EPA has also promulgated a series of related regulations likely to reduce regional haze. See http://www.epa.gov/oar/visibility/actions.html.

## Affected Federal Class I Areas

Minnesota has two federal Class I areas – the BWCAW and VNP. These Class I areas in Minnesota are the current focus of this analysis due to their proximity to the proposed projects.

There are also two federal Class I areas nearby, Rainbow Lakes Wilderness Area in Wisconsin and Isle Royale National Park in Lake Superior and part of the state of Michigan. Both Rainbow Lakes Wilderness and Isle Royale are out of scope for this analysis. Visibility is not an Air Quality Related Values for Rainbow Lakes Wilderness, so this area is not included in the visibility analysis. For both areas, PSD modeling results that have been reviewed by the Federal Land Managers (FLMs) for several of the proposed projects indicate that potential air quality impacts in the wilderness area and the park, including $PM_{10}$ increment, are below the respective "significant impact levels" (SILs). If each proposed project has modeled potential impacts below the respective SILs, there is a level of confidence that air quality is protected against potential cumulative impacts (reference(16)). In addition, modeling performed for the Minnesota Regional Haze SIP for the year 2018 estimates that stationary sources in northeastern Minnesota contribute approximately three percent to the visibility impairment at Isle Royale for the 20 percent worst days. The SIP identifies any contributions less than 5 percent as insignificant. Because the estimated contributions from northeast Minnesota sources to modeled visibility impairment at Isle Royale are considered to be insignificant, Isle Royale is not included in the visibility analysis.

## Rule Requirements

The federal Regional Haze Rule includes the following key requirements:

- Certain emission sources "that may reasonably be anticipated to cause or contribute" to visibility impairment in downwind Class I areas are required to install Best Available Retrofit Technology (BART).

- Control strategy State Implementation Plans (SIPs) must be submitted to EPA with individual states adopting progress goals for improving visibility from baseline conditions (represented by 2000 – 2004) to 2018 (represented by 2014 – 2018) for each Class I area in the state.
    - A state without any Class I areas will also need to adopt emission reduction strategies to address its contribution to visibility impairment problems in Class I areas located in other states.

- Specifically, a state is required to set reasonable progress goals for each Class I area in the state that:
    - Provide for an improvement in visibility for the most impaired (i.e., 20% worst) days over the period of the implementation plan; and
    - Ensure no degradation in visibility for the least impaired (i.e., 20% best) days over the same period.

- Reasonable progress goals are established by taking into account "reasonable progress factors", which include the costs of compliance, the time needed for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any existing source subject to such requirements

- States will determine whether they are meeting their goals by comparing visibility conditions from one five-year rolling average to another (e.g., 2000-2004 to 2014-2018).

## IMPROVE Monitoring Network and Regional Planning Organizations

The IMPROVE program was established in 1985 to assist states and the federal government with SIPs for improving visibility in Class I areas and visibility data is gathered throughout the United States. It has been operating in Minnesota since 1988. After publication of the regional haze rule in 1999, the first step in the implementation process was the upgrade and expansion of the IMPROVE visibility monitoring network to 110 sites nationally. These sites were selected to represent all mandatory federal Class I areas (reference(7)). Representative data from this network has been used to establish baseline conditions (for the 2000 – 2004 time period) for each Class I area and to track progress toward the goals to be established in each State's SIP.

Five regional planning organizations (RPOs) were formed to assist in implementing the regional haze rule. Minnesota belongs to the Central Regional Air Planning Association (CENRAP), but also worked

extensively with the Midwest RPO. These RPOs are intended to respond to the transport of visibility-reducing pollutants within and across state and international boundaries. Over the last few years, RPOs have assisted states with assessing current haze conditions, establishing baseline levels, and specifying and coordinating emissions reduction strategies. The goal is to achieve "natural" visibility conditions by 2064.

## 1.5 Pollutant Emissions in Class I Areas and Potential Cumulative Impacts

Air quality in Federal Class I areas is protected under PSD air quality regulations and permitting. A Class I area assessment for potential air quality impacts is conducted for those projects that exceed specific emission thresholds. The NPS and US Forest Service, FLMs for the respective Class I areas, have specific requirements for the Class I area assessments. For example, for routine air permitting purposes, particulate emissions are calculated as primary particulate emissions (total particulate, $PM_{10}$, and $PM_{2.5}$). However, when assessing and evaluating potential air quality impacts in Federal Class I areas, the FLMs require an assessment of primary particulate as well as speciated particulate matter. The following size and speciation fractions of particulate matter have potential implications on visibility:

- Coarse ($PM_{2.5}$ < particles < $PM_{10}$)
- Fine ($PM_{2.5}$ or smaller)
- Elemental Carbon (EC)
- Organic Carbon (OC)
- Sulfate aerosol
- Nitrate aerosol

This cumulative impact analysis evaluates the particulate fractions (coarse, fine) and species (primarily sulfate and nitrate aerosols) identified above. Sulfate and nitrate aerosols are formed from $SO_2$ and $NO_x$ in the atmosphere. Therefore an evaluation of $SO_2$ and $NO_x$ emissions is also included.

# 2.0 Analysis Boundaries

The analysis boundaries for the visibility cumulative impact analysis are:

- The timeframe for the analysis
- Other "reasonably foreseeable" actions to be assessed in addition to the proposed project
- The geographic area that may be affected (the "zone of impact")

## 2.1 Timeframe

The timeframe for this analysis extends to the expected duration of the NorthMet mine plan, 20 years. For emission rate data, this report describes historical emission rates back to 1990 for sources in northeastern Minnesota and uses information from the MPCA's Regional Haze SIP to show expected future emission rates based on likely emission caps or other regulatory emission limits. Emission inventory data is available through 2008. Monitoring data for key species affecting visibility and visibility information from the IMPROVE network are available for full calendar years from 1992 to 2009, depending on the (see section 3.0 and Table 3 for more information). Projections of future emission changes are compared to the 2008 baseline, the date of the most recent emissions data, for future emission projections and to a 2009 baseline when discussed in the context of future visibility.

## 2.2 Other Actions to be Assessed

Other "reasonably foreseeable" actions to be assessed include activities occurring in two different geographic areas:

- Other projects proceeding concurrently with the NorthMet Project, including projects that will both increase and decrease emissions, within the six-county area of northeastern Minnesota (Lake, Cook, St. Louis, Carlton, Itasca and Koochiching)
- Regulatory and other major actions to be undertaken in geographic areas that could potentially impact visibility in the BWCAW or VNP based on the Minnesota Regional Haze SIP

Figure 1 shows the general locations of the "reasonably foreseeable" projects to be assessed for cumulative impacts, as well as the locations of federally protected Class I areas. The projects selected as "reasonably foreseeable" are defined as those that are already underway and are actively moving through the environmental review process. It includes those that have completed their environmental review and received permits but were not yet constructed or operating in 2009, and therefore are not included in the IMPROVE monitoring data, or for which a completed data portion of an environmental review document

has been submitted to the MDNR or the MPCA. "Reasonably foreseeable actions" in regard to potential emission reductions include those regulatory actions that have been placed on public notice by a government agency (e.g., draft rules or regulations) or there has been a submittal to a regulatory agency that provides details on a planned action being considered.

The following projects and actions are considered to be underway or "reasonably foreseeable":

- Proposed projects:
    - Excelsior Energy, Mesaba Energy Project, Coal Gasification Power Plant
    - Mesabi Nugget Company, Phase I Large Scale Demonstration Plant
    - Mesabi Nugget Company, Phase II Project
    - Essar Steel Minnesota LLC, Mining/Taconite/DRI/Steel Plant
    - Essar Steel Minnesota LLC, Project modifications
    - Northshore Mining Company, Furnace 5 Reactivation Project
    - PolyMet Mining, NorthMet Project
    - SAPPI Cloquet Plant Expansion
    - UPM/Blandin Paper Mill Expansion, Project Thunderhawk
    - U. S. Steel Keetac, Expansion Project
    - United Taconite Green Production Project
- Emission Reductions
    - Minnesota Power Taconite Harbor Energy Center Unit 2, Emission Control Modifications
    - Minnesota Power Laskin Energy Center Unit 2, $NO_x$ Reductions
    - Minnesota Power Boswell Energy Center Unit 3,
    - U. S. Steel Minntac BACT Reductions
    - Hill Wood Products major modification amendment.
    - Northshore Mining Company: BART Reductions
    - United Taconite BART Reductions
- Regulatory and other actions:
    - Implementation of the Regional Haze Rule and Best Available Retrofit Technology (BART) Rule;
    - Implementation of the Cross State Air Pollution Rule (CAIR Replacement Rule)
    - Implementation of other MACT standards, especially for boilers and process heater
    - State acid rain rule and statewide $SO_2$ emissions cap
    - Title IV of the 1990 Clean Air Act Amendments.
    - On-road mobile source programs
        - Fuel blending standards
        - Tier II/Low sulfur gasoline
    - Non-road mobile source programs
        - Non-road diesel rule
        - Control of emissions from unregulated non-road engines

- Locomotive/Marine engine reductions
- RACT requirements under the Wisconsin and Michigan $PM_{2.5}$ and ozone SIPs
- Updates and additions to the NAAQS for $SO_2$, $NO_x$, $PM/PM_{2.5}$ and ozone, including 1-hr $NO_x$ and $SO_2$ standards
- Xcel Energy's Riverside plant re-powering project

## 2.3 Zone of Impact

The "zone of impact" is defined as the area of concern to be evaluated for potential cumulative impacts due to the above listed actions. The selected zone of impact is defined as VNP and the BWCAW, based on guidance from the Air Impact Assessment Planning Group (reference(2)). VNP is primarily located in St. Louis County, while the BWCAW encompasses parts of St. Louis, Lake, and Cook Counties.

The federal Class I areas in Minnesota are the current focus of this analysis due to their proximity to the proposed projects. Other Class I areas within 250 kilometers of the proposed Iron Range projects are Isle Royale National Park located to the northeast of the Iron Range off the northeast tip of Minnesota in Lake Superior (in the state of Michigan) and Rainbow Lake Wilderness located to the southeast of the proposed projects in northwest Wisconsin (Figure 1). Neither Rainbow Lakes Wilderness nor Isle Royale are included in this analysis. See Section 1.4.4 of this report for details.

# 3.0 Assessment of Existing Visibility Impairment in Minnesota Class I Areas

The assessment of visibility impairment due to past actions in Minnesota Class I areas is based on monitoring data from the IMPROVE program. The monitoring data provides measurements of pollutants that contribute to visibility impairment including: coarse particulate matter ($PM_{2.5}$ to $PM_{10}$), fine particulate matter ($PM_{2.5}$ and less), sulfate, nitrate, elemental carbon, organic carbon and soil.

The assessment of visibility impairment involves four primary tasks:

- accessing data from the IMPROVE program
- using the data available from the IMPROVE program combined with Barr calculations to derive 5-year rolling averages for the specific pollutants
- presenting the results of the 5-year rolling average calculations
- interpreting those results.

## 3.1 IMPROVE Monitoring Data Availability

The IMPROVE monitoring program has been ongoing in Minnesota since March 1988. The initial monitoring site was in VNP near the Rainy Lake Visitor Center at the western end of the Park and is referred to as VOYA1. Data were only collected at this site until 1993. A new, more centrally located site near the Ash River Visitor Center, referred to as VOYA2, began collecting data in late 1999. Monitoring was initiated for the BWCAW at the Fernberg Lookout Tower (north and east of Ely along the Fernberg Road) in 1991 at a site referred to as BOWA1. See Figure 2 and Figure 3 for the approximate locations of these monitors. See Table 3 for operating dates of each monitoring site.

For this analysis, data for full calendar years from BOWA1 and VOYA2 will be assessed. Due to the lack of adequate continuous measurements and the change in monitor location within Voyageurs to the VOYA2 location, data from VOYA1 are not assessed for trends, but comparisons are made between data from the VOYA2 site and the VOYA1 site.

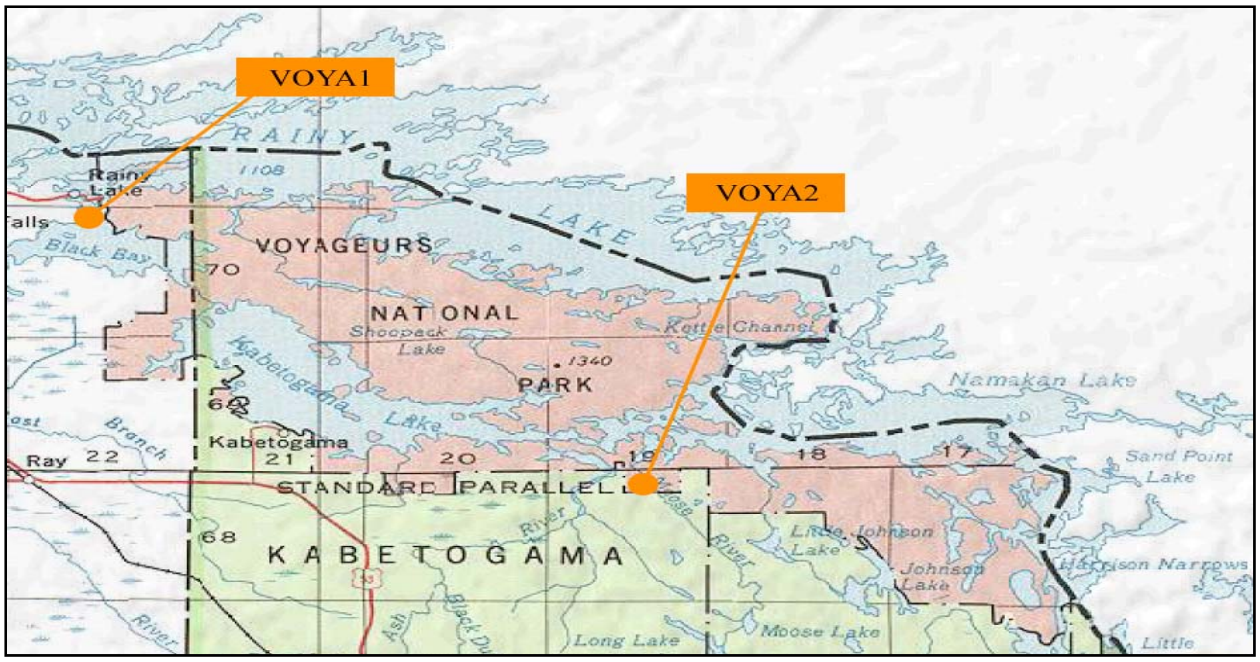



**Figure 2 Approximate locations of the VOYA1 and VOYA2 IMPROVE monitoring sites within Voyageurs National Park in northern Minnesota.**

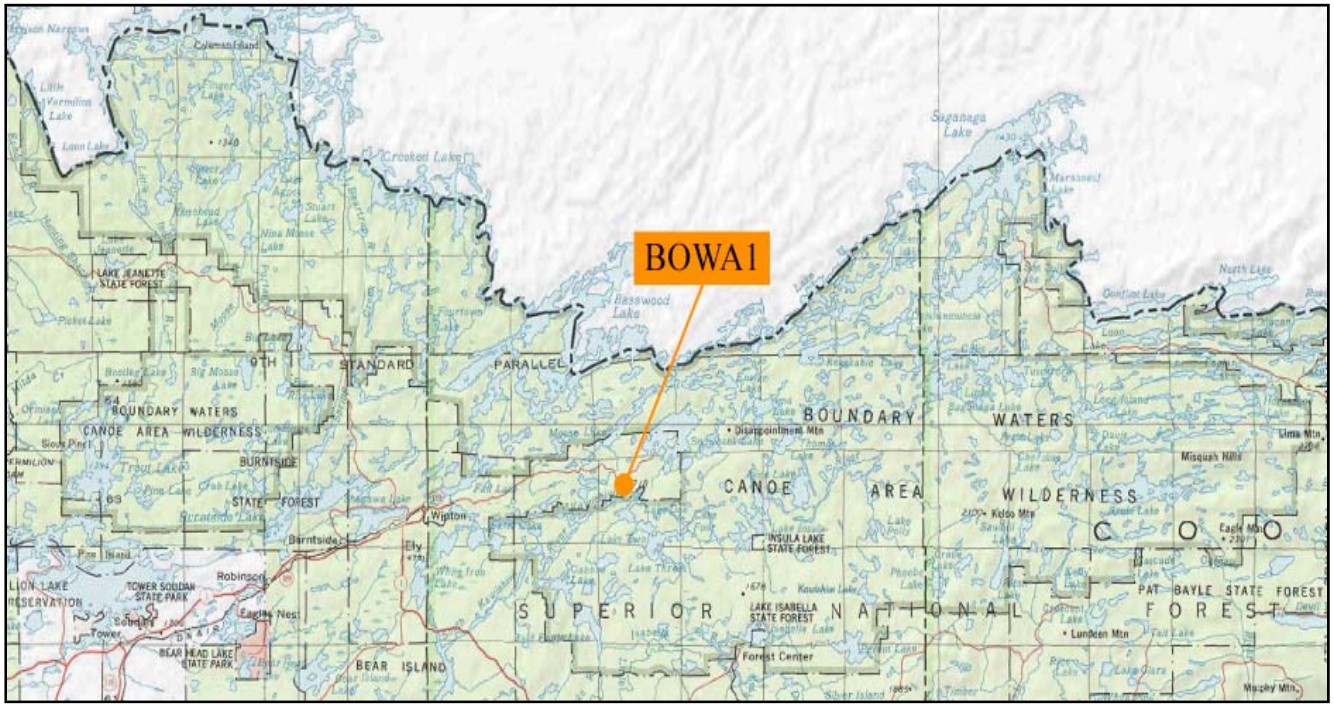



**Figure 3 Approximate location of the BOWA1 IMPROVE monitoring site for the Boundary Waters Canoe Area Wilderness in northern Minnesota.**

**Table 3 IMPROVE monitoring sites in Minnesota Class I areas and start and end dates for available quality assured data. [1]**

| Monitoring Location | IMPROVE Monitoring Site Name | Starting Date | Ending Date (quality assured data) |
|---|---|---|---|
| Boundary Waters Canoe Area | BOWA1 | AUG 1991 | DEC 2009 |
| Voyageurs National Park | VOYA1 | MAR 1988 | AUG 1993 |
| | VOYA2 | JAN 2000 | DEC 2009 |

[1] VIEWS. 2011. "VIEWS Query Wizard." http://vista.cira.colostate.edu/views/Web/Data/DataWizard.aspx (accessed April 2011)

Data from the IMPROVE program, which is housed on the Visibility Information Exchange Web System (VIEWS) (reference (17)) website, includes ambient air concentrations for constituents that may affect visibility and relative humidity data. The VIEWS website also provides the calculated total light-extinction coefficient from aerosol measurements and relative humidity data using the IMPROVE algorithm. In December 2005, the IMPROVE Steering Committee adopted a new light-extinction coefficient calculation method because the older method tended to underestimate the highest extinction values and over-estimate the lowest extinction values (reference (18)). The new IMPROVE algorithm is used to calculate light extinction for data from both BOWA1 and VOYA2 for this report.

Ambient concentration data, extinction coefficient and haze index calculations are available from the VIEWS website for all monitoring sites. In addition, as of December 2011, IMPROVE had not made available on its website the recalculated 5-year rolling averages using the revised calculation methods. Using the available annual data, 5-year rolling averages were calculated by Barr Engineering staff and are presented in this report.

Although most monitoring data is available from the IMPROVE network, some data for the BOWA1 site was not available due to malfunctions of the monitors. The first dataset that was not available are concentrations of fine soil, elemental carbon, organic matter and coarse mass for some days in 2002 through 2004. The VIEWS website posted a surrogate dataset for this time period based on a seasonal regression analysis using data from VOYA2 site as a surrogate.[1] MPCA used this surrogate data set for the Regional Haze SIP and it is used in this analysis to remain consistent with the Regional Haze analyses.

In addition, the MPCA identified certain days for both the BOWA1 and the VOYA2 sites in the analyses conducted for the Regional Haze SIP where data for certain particulate constituents was missing (typically fine soil mass and coarse mass). This missing data would ordinarily exclude these days from

[1] Visibility Information Exchange Web System (VIEWS) http://vista.cira.colostate.edu/views/web/documents/substitutedata.aspx (RHR dataset)

inclusion in the dataset used for the Regional Haze program based on quality assurance criteria. However, these days fell within the worst 20% days even without considering the light extinction due to these missing components. Because these days were likely dominated by anthropogenic sources, the MPCA has chosen to consider these days for the Regional Haze program (reference(3)). To ensure that this analysis correlates with the Regional Haze program, these days have been included here. All other data comes directly from the IMPROVE monitoring data.

## 3.2 Characteristics and Composition of Particulate Air Concentrations

A summary of the average of the median $PM_{10}$ and $PM_{2.5}$ concentrations and haze index observed in the BWCAW and VNP over the entire monitoring period is provided in Table 4. For comparison, the table includes the average values from the VOYA1 site.

**Table 4 Average PM10 and PM2.5 median concentrations and haze index observed at IMPROVE monitoring sites in Class I areas in Minnesota.**

| IMPROVE Monitoring site | Time frame [1] | Average $PM_{10}$ Median Concentration $\mu g/m^3$ | Average $PM_{2.5}$ Median Concentration $\mu g/m^3$ | Average Haze Index Median Concentration Deciviews |
|---|---|---|---|---|
| BOWA1 | 1/92 -12/ 09 | 5.7 | 3.6 | 11.5 |
| VOYA1 | 3/88-8/93 | 11.7 | 5.6 | 13.7 |
| VOYA2 | 1/00-12/ 09 | 5.2 | 3.2 | 11.3 |

[1] Concentration and Haze Index data available through 12/2009 for BOWA1 and VOYA2

(Source: VIEWS Data Wizard; http://vista.cira.colostate.edu/views/Web/Data/DataWizard.aspx)

The particulate matter that affects visibility is generally the fine fraction and is made up of mainly five constituents: sulfates, nitrates, organic matter, elemental (or light absorbing) carbon and fine soil. The sulfate and nitrate originate as $SO_2$ and $NO_x$ from fuel combustion (e.g. electrical generation and transportation) and transform over time and distance to ammonium sulfate and nitrate, respectively. The source of the organic matter is less well understood, but some sources are fossil fuel burning, wood burning, and natural sources. Elemental carbon is believed to come from diesel exhaust and biomass burning (reference (8)(19)).

## 3.3 Monitored Changes in Visibility with Time

Monitoring data is available from the IMPROVE network to examine the trends in visibility and pollutant air concentrations over time for the BWCAW at the BOWA1 and VOYA2 sites which can help assess the cumulative impacts of past actions. The BOWA1 and VOYA2 IMPROVE data can be evaluated for trends for the 20% worst days, the median concentration days, and 20% best days. As of July 2011, the

IMPROVE website provided full calendar years of data for pollutant air concentrations and haze index from 1992 to 2009 for the BOWA1 site and from 2000 to 2009 for the VOYA2 site. Calendar year annual averages for the best and worst 20 percent days and the median concentrations were used to calculate the 5-year rolling averages presented below in Table 5 for the BOWA1 and VOYA2 sites, respectively. The changes were calculated by comparing the 5-year rolling averages and median for 1992 or 2000 to the 5-yr rolling averages and median for 2009, depending on data availability, and determining the percent change.

**Table 5 Changes in 5 Five-year Rolling Average[6] and Median Particulate and Haze Index for BOWA1 and VOYA2.**

| Site | Change in 20% Best Days | | | Change in Median Days | | | Change in 20% Worst Days | | |
|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ | $PM_{2.5}$ | HI[2] | $PM_{10}$ | $PM_{2.5}$ | HI | $PM_{10}$ | $PM_{2.5}$ | HI |
| **BOWA1** [1] [3] **1992-2009** | -45% | -35% | -27% | -39% | -33% | -20% | -23% | -22% | -7% |
| **BOWA1** [1] [5] **2000-2009** | -21% | -30% | -23% | -25% | -27% | -17% | -20% | -14% | -3% |
| **VOYA2** [3][4] 2000-2009 | -13% | -12% | -14% | -23% | -10% | -9% | -9% | +3% | +1% |

[1] Data for the BOWA1 site are for 1992 to 2009
[2] HI = Haze Index;
[3] Negative numbers indicate improving concentrations or haze index.
[4] Data for the VOYA2 site are for 2000 to 2009
[5] Although data for the BOWA1 site are available for 1992 to 2009, a portion of the entire dataset is shown because the regulatory timeframe of the Regional Haze Rule evaluates progress using the year 2000 as a benchmark.
[6] Rolling averages require at least 3 years of data and average the specified year, two years prior and two years succeeding the specified year.

Figure 4 through Figure 8 show the annual haze index, concentration for $PM_{10}$, $PM_{2.5,}$ ammonium sulfate, and ammonium nitrate at BOWA1. For BOWA1, the 5-yr rolling average data indicates a downward trend for four parameters ($PM_{10}$, $PM_{2.5,}$ haze index and ammonium sulfate) while ammonium nitrate does not appear to show a trend from 1992 to 2009 for the 20% best days, and the median days and a slight increasing trend for the 20% worst days. Within the Regional Haze Rule regulatory timeframe (2000-present) the haze index trend is relatively flat for the 20% worst days and a downward trend for the median and 20% best days. The use of rolling averages to determine trends is used for many data types and allows the smoothing of the data to more clearly show underlying trends over time (references(20)(21)). The decline in $PM_{2.5}$ air concentrations primarily reflects a reduction in sulfate air concentration.

Figure 9 through Figure 13 show the 5-yr rolling average for the VOYA2 site for the ten years from 2000 to 2009. As shown in Table 5, the changes vary from a 23% decrease to a 3% increase. Overall, no trend is evident. The NPS reviews trends in visibility for all the National Parks, including VNP. The most recent report published by the NPS includes data from 1998 through 2007 and concludes based on a statistical analysis that visibility for the 20 percent haziest and the 20 percent clearest days at VNP is not showing a trend either improving or degrading (reference (4)).

Compared to national averages, the 39% decline in median $PM_{10}$ concentration for BWCAW since 1992 is in line with the national decline in average $PM_{10}$ air concentration of 38% from 1990 to 2009. The 33% decrease in median $PM_{2.5}$ concentrations for BWCAW is above the national average of 27% from 2000 to 2009 (reference (22)).

Nationally, the long term trend for concentrations of visibility impairing pollutants is decreasing in federal Class I areas in both the eastern US and western US from 1989-2008 with a few exceptions in the western US where concentrations of total carbon, soil and fine particulate are increasing in a few areas (reference(23)). National short term trends from 2000 to 2008 are less significant but show general decreasing trends for most visibility impairing pollutants, with a few exceptions in the western US. Soil and coarse particulate show a mix of short term increasing and decreasing trends across the US (reference(23)). The level of visibility impairment is much higher in the eastern US, where the visual range on the best visibility days is similar to that on the worst visibility days in the western US (reference(24)).

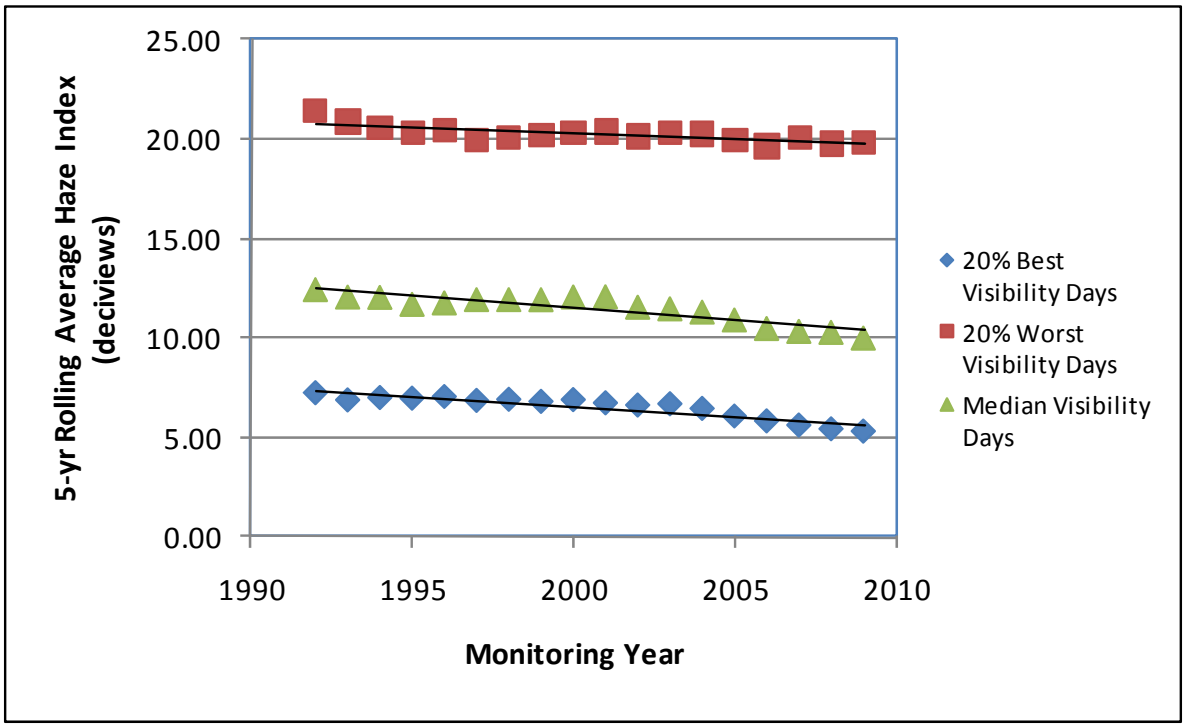



**Figure 4** **Five-year rolling averages of the haze index (deciviews) and linear trend lines for the BOWA1 IMPROVE monitoring site in northeast Minnesota, based on data for January 1992 through December 2009.**

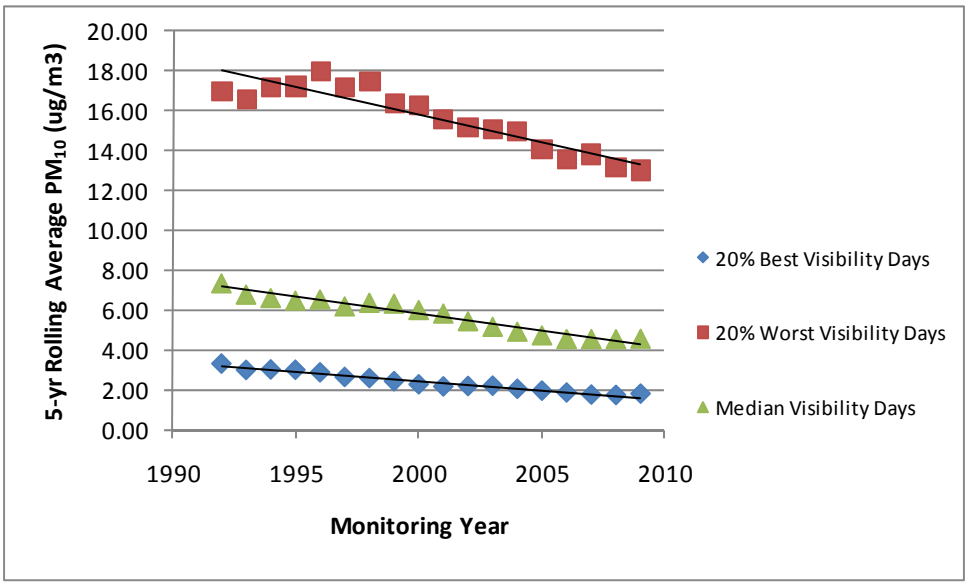



**Figure 5** **Five-year rolling average PM10 concentrations (µg/m3) and linear trend lines for the BOWA1 IMPROVE monitoring site in northeast Minnesota, based on data for January 1992 through December 2009.**

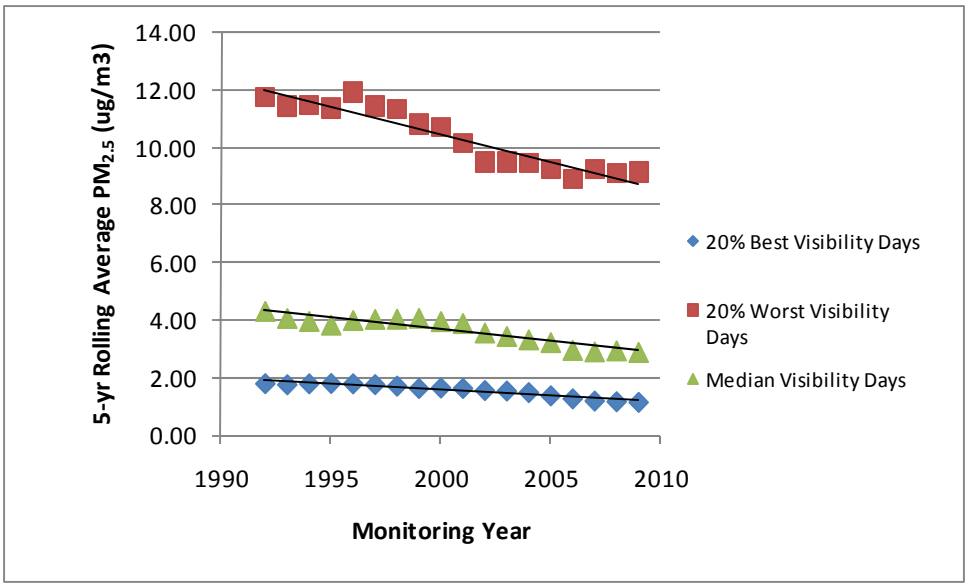



**Figure 6** **Five-year rolling average PM2.5 concentrations (µg/m3) and linear trend lines for the BOWA1 IMPROVE monitoring site in northeast Minnesota, based on data for January 1992 through December 2009.**

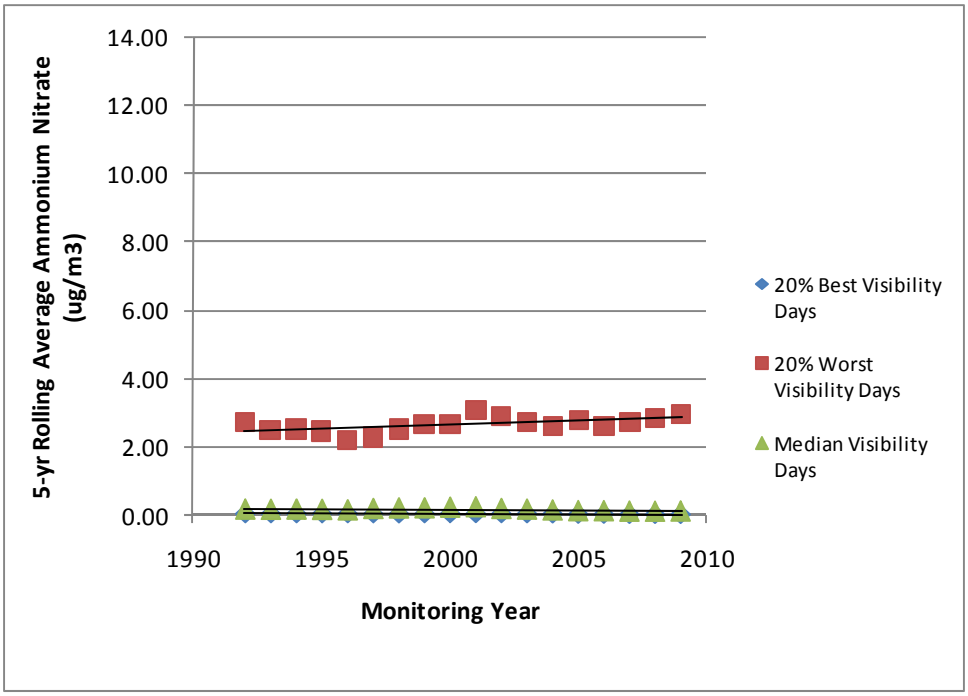



**Figure 7** **Five-year rolling average ammonium nitrate concentrations (µg/m3) and linear trend lines for the BOWA1 IMPROVE monitoring site in northeast Minnesota, based on data for January 1992 through December 2009.**

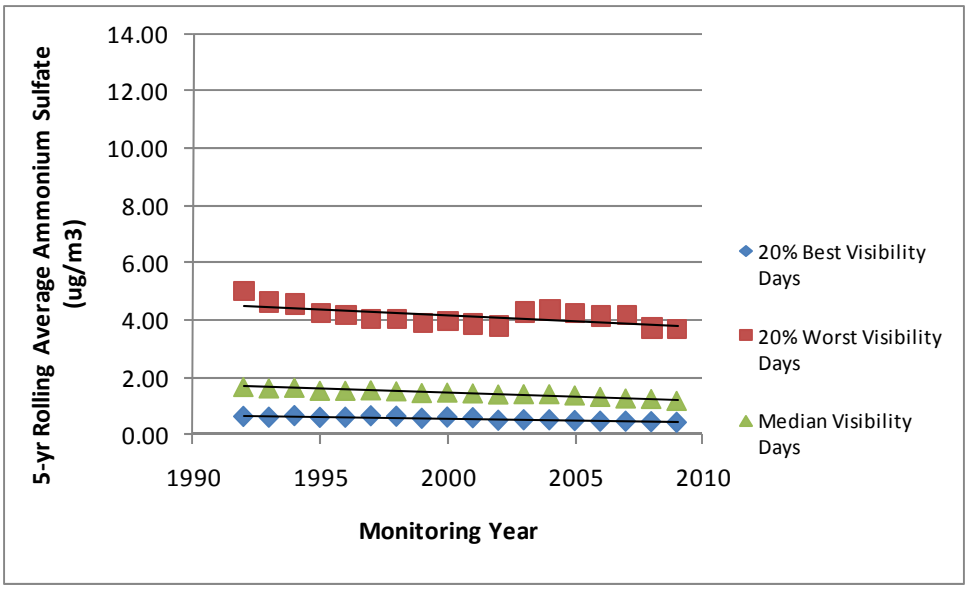



**Figure 8** **Five-year rolling average ammonium sulfate concentrations (µg/m3) and linear trend lines for the BOWA1 IMPROVE monitoring site in northeast Minnesota, based on data for January 1992 through December 2009.**

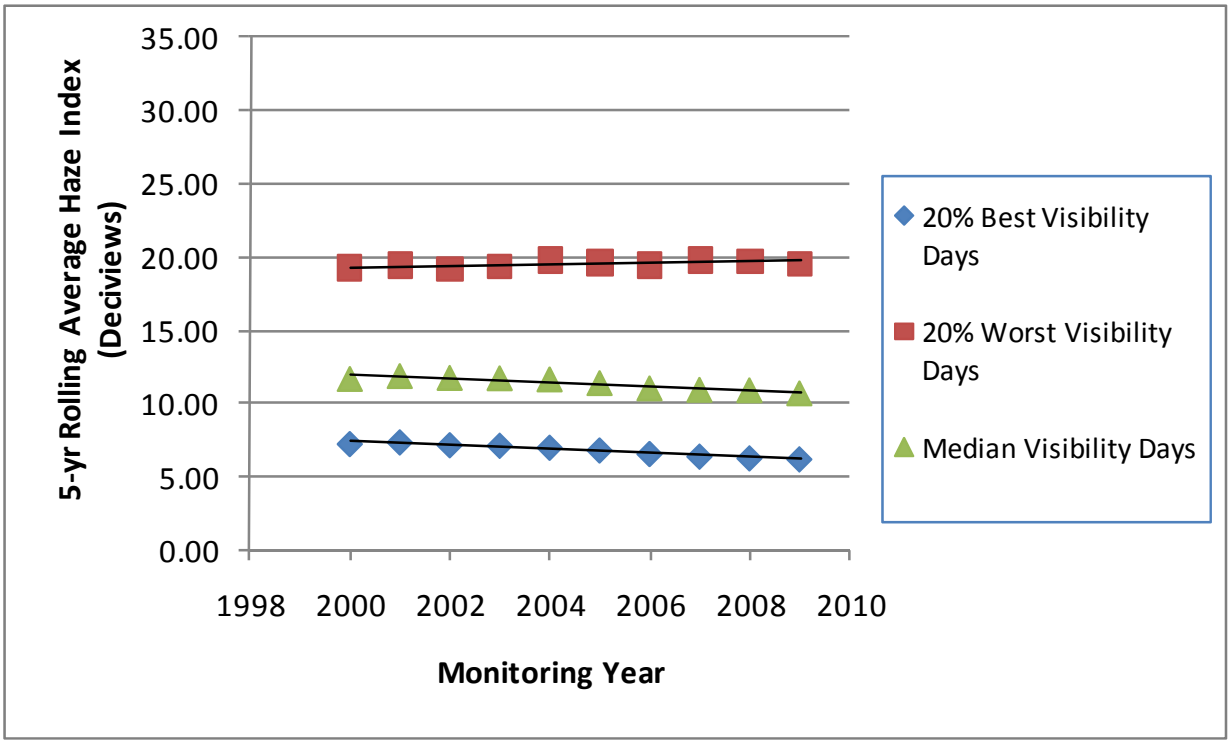



**Figure 9** **Five-year rolling average of the haze index (deciviews) and linear trend lines for the VOYA2 IMPROVE monitoring site in northeast Minnesota, based on data for January 2000 through December 2009.**

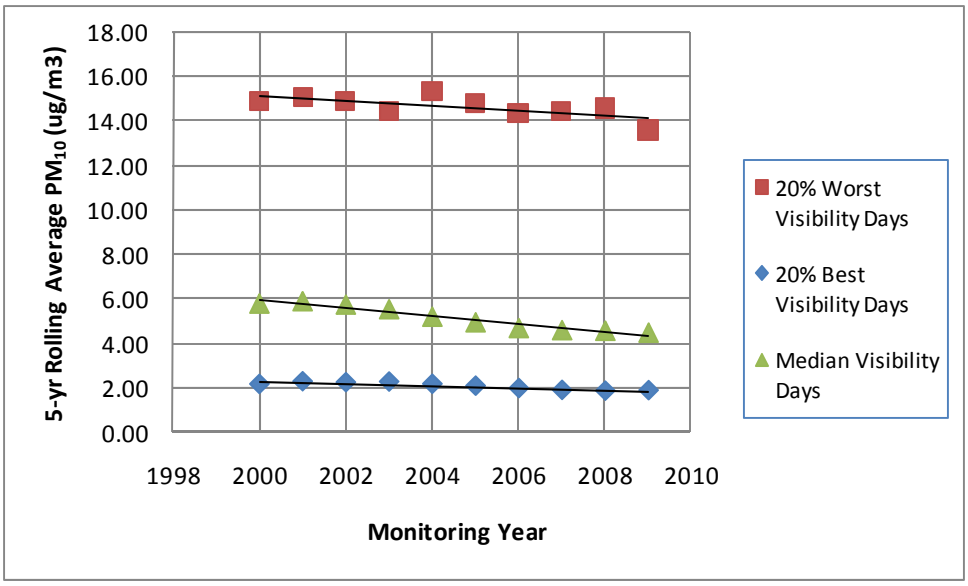



**Figure 10** **Five-year rolling average PM10 concentrations (µg/m3) and linear trend lines for the VOYA2 IMPROVE monitoring site in northeast Minnesota, based on data for January 2000 through December 2009.**

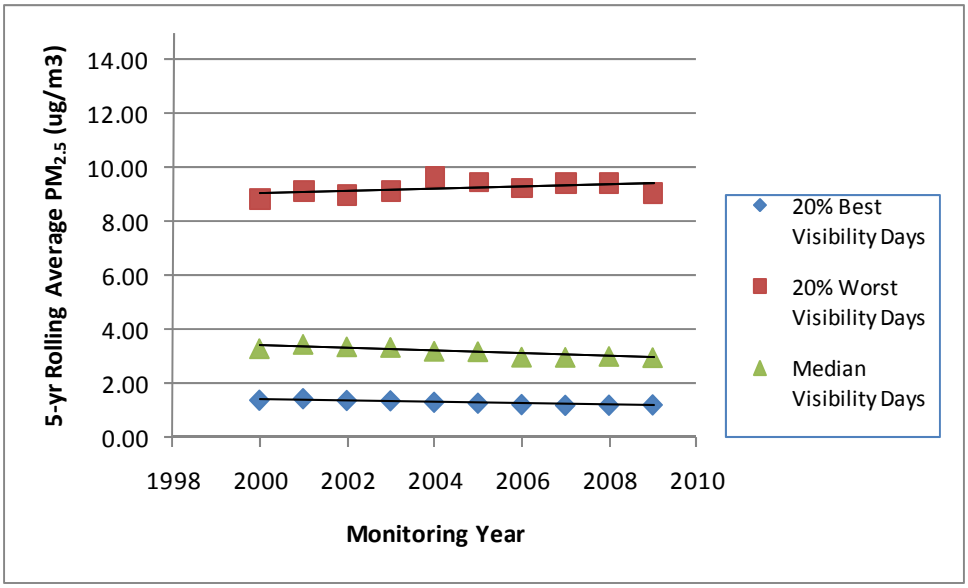



**Figure 11** **Five-year rolling average PM2.5 concentrations (µg/m3) and linear trend lines for the VOYA2 IMPROVE monitoring site in northeast Minnesota, based on data for January 2000 through December 2009.**

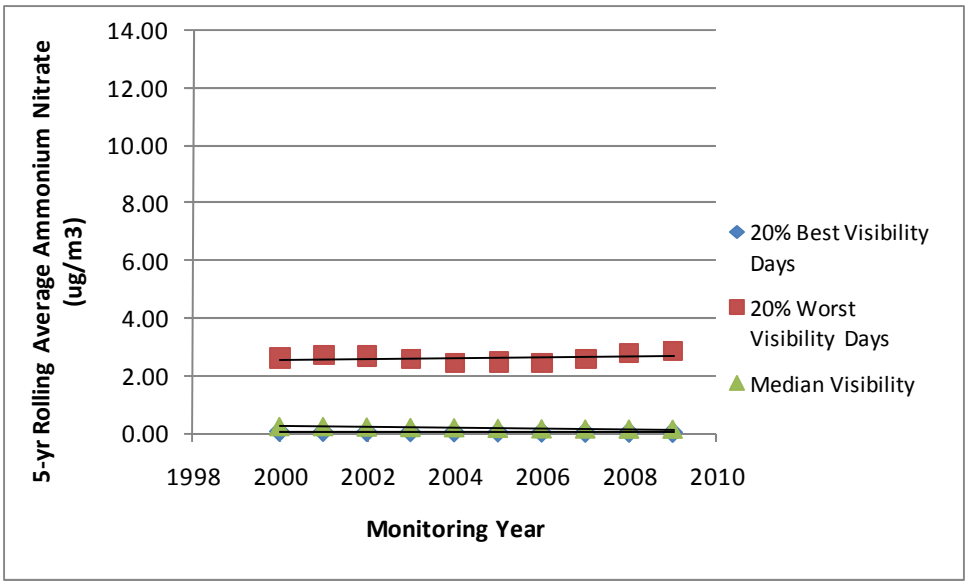



**Figure 12** **Five-year rolling average ammonium nitrate concentrations (µg/m3) and linear trend lines for the VOYA2 IMPROVE monitoring site in northeast Minnesota, based on data for January 2000 through December 2009.**

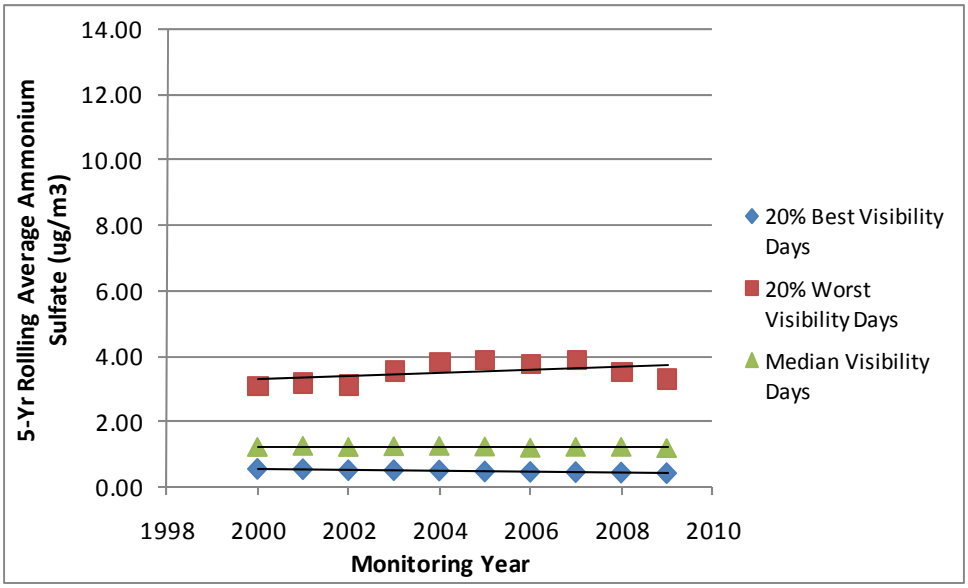



**Figure 13** **Five-year rolling average ammonium sulfate concentrations (µg/m3) and linear trend lines for the VOYA2 IMPROVE monitoring site in northeast Minnesota, based on data for January 2000 through December 2009.**

## 3.4 Emission Source Contributions to Haze

Various emission sources are estimated to contribute to visibility impairment in the Federal Class I areas located in Minnesota. These sources include natural, local, state, national and global contributions that all factor in to the overall visibility impairment in VNP and BWCAW.

### 3.4.1 Natural and Global Contributions

Natural concentrations are those that would be present in the absence of *any* anthropogenic emissions. Globally, the long-range transport of fine particles, including soil dust from Asian sources, contributing to relatively high particulate air concentrations at the international boundaries has been known for some time (references(24)(25)). The MPCA Regional Haze SIP (reference(3)) indicates that boundary conditions (BC), or sources outside of the modeling domain, account for 11% and 15% of the visibility impairment for BWCAW and VNP respectively. The modeling domains used in developing the Minnesota Regional Haze SIP are shown below in Figure 14. Sources outside of the modeling domain are considered part of the BC.

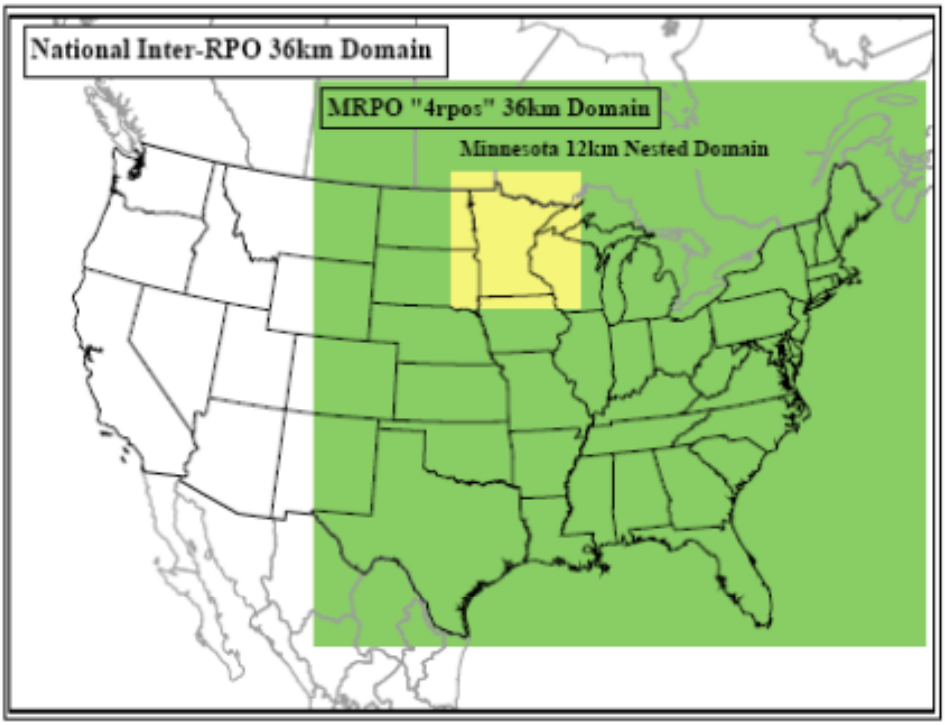
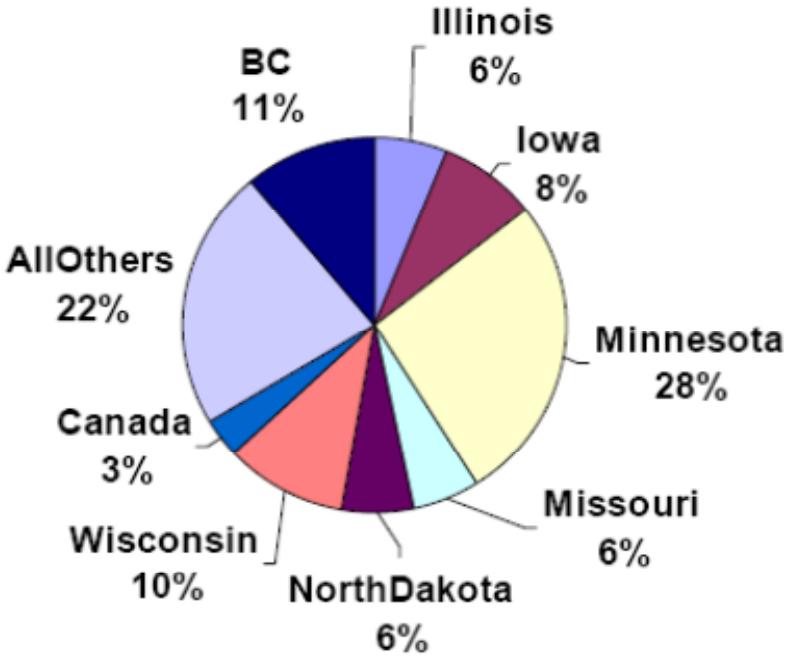



**Figure 14 Modeling Domains used for MN Regional Haze SIP Evaluations (figure from reference (3))**

### 3.4.2 Regional and Local (Minnesota) Contributions

Although it has been generally known that fine aerosol particulate that impairs visibility travels long distances and requires time in the atmosphere to react, the modeling done for the Minnesota Regional Haze SIP has provided a great deal of specific information regarding the geographic sources of these particulates. Presented here are some of the highlights from the Minnesota Regional Haze SIP.

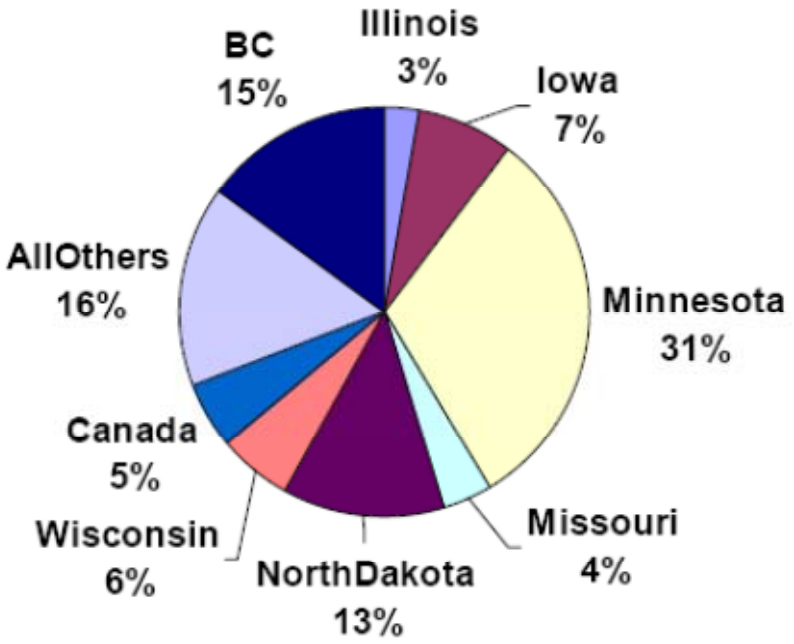
Figure 15 shows the contributions to visibility impairment from ammonium sulfate and ammonium nitrate on the 20% worst days for the BWCAW based on the Minnesota Regional Haze SIP modeling. Although Minnesota sources contribute the largest amount of any single state, 72% of the contribution is from out of state. The states contributing more than 5% are Illinois, Iowa, Missouri, North Dakota and Wisconsin.




Source: MN Regional Haze SIP, December 2009, available at: http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/general-air-quality/minnesota-regional-haze-plan.html?menuid=&missing=0&redirect=1

**Figure 15 State/Regional Contributions to Light Extinction for ammonium sulfate and ammonium nitrate on the 20% Worst Days in Boundary Waters Canoe Area Wilderness in Northern Minnesota.**

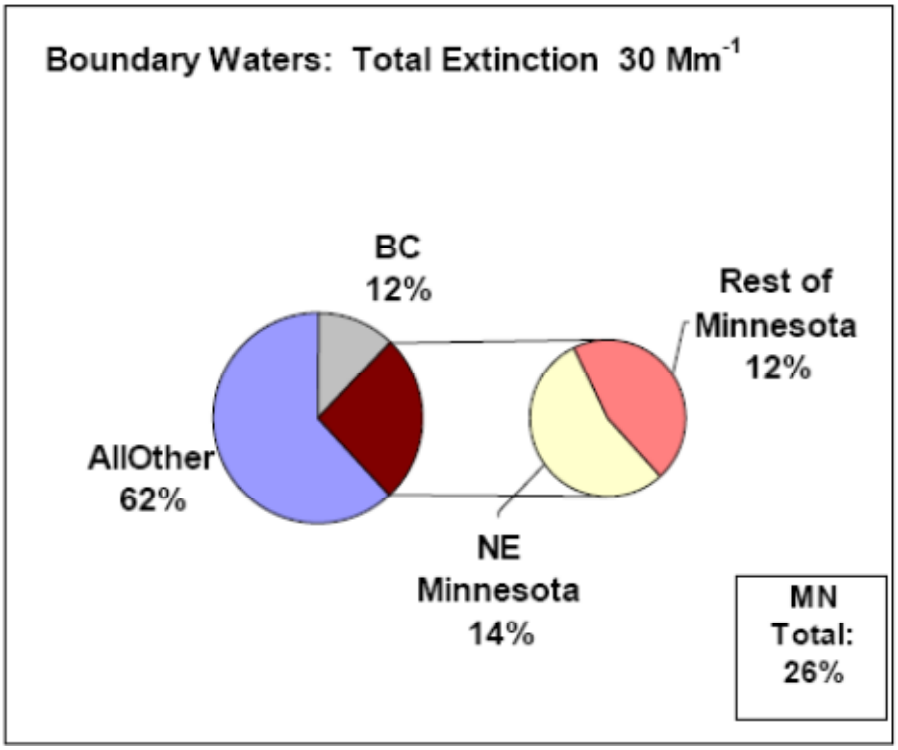
See Figure 16 for a similar view for contributions to visibility impairment in VNP for the 20% worst days due to ammonium nitrate and ammonium sulfate. Similar to the BWCAW, the majority of the impairment is due to out of state sources at 69%. The distribution of the remaining impairment is slightly different for VNP than was estimated for the BWCAW. States contributing more than 5% are Iowa, Wisconsin and North Dakota.




Source: MN Regional Haze SIP, December 2009, available at: http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/general-air-quality/minnesota-regional-haze-plan.html?menuid=&missing=0&redirect=1

**Figure 16 State/Regional Contributions to Light Extinction for ammonium sulfate and ammonium nitrate on the 20% Worst Days in Voyageurs National Park in Northern Minnesota.**

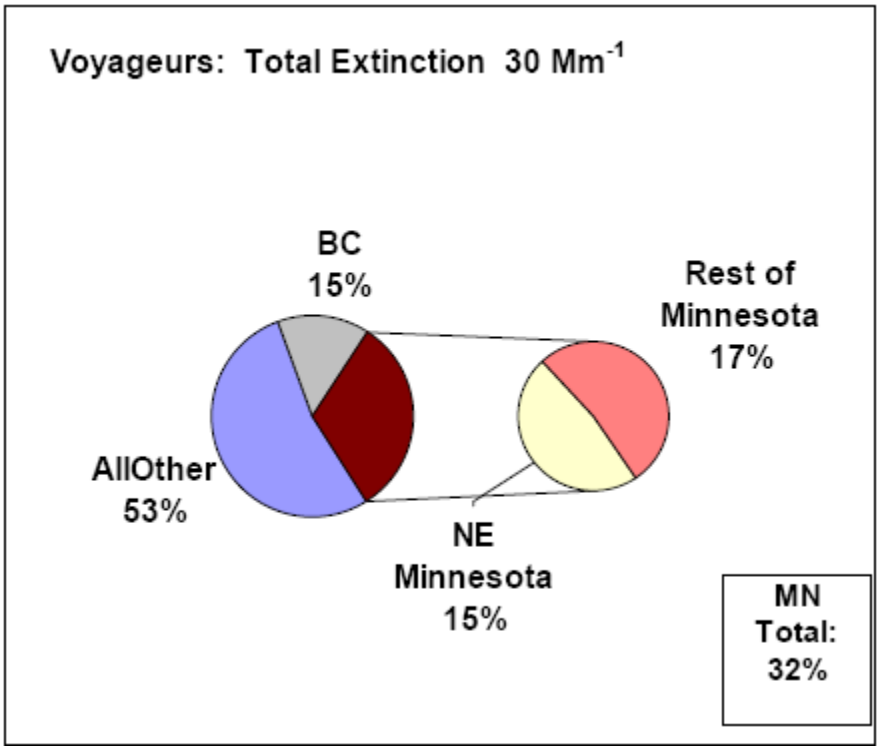
Figure 17 shows the contributions to total light extinction in the BWCAW for the 20% worst days, but breaks out the estimated contribution from sources in northeastern Minnesota. The contribution from Minnesota sources to total light extinction is 26% and the specific contribution from northeastern Minnesota sources is 14%. The remaining 12% of the contribution from Minnesota comes from elsewhere in the state.




Source: MN Regional Haze SIP, December 2009, available at: http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/general-air-quality/minnesota-regional-haze-plan.html?menuid=&missing=0&redirect=1

**Figure 17 Estimated Percentage Contribution of Sources in Northeast Minnesota to Light Extinction for the 20% Worst Days in the Boundary Waters Canoe Area Wilderness Compared to the Estimated Contribution from Sources in the Rest of Minnesota.**

For VNP, the contribution from Minnesota sources to total light extinction is estimated to be about 32% for the 20% worst days. Northeast Minnesota sources are estimated to be responsible for approximately 15% of the light extinction. This is illustrated in Figure 18.




Source: MN Regional Haze SIP, December 2009, available at: http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/general-air-quality/minnesota-regional-haze-plan.html?menuid=&missing=0&redirect=1

**Figure 18 Estimated Percentage Contribution of Northeast Minnesota Sources to Light Extinction on the 20% Worst Days in Voyageurs National Park Compared to the Estimated Contribution from Sources in the Rest of Minnesota.**

Overall, out-of-state sources contribute the most to visibility impairment in both VNP and BWCAW, approximately 70%, while Minnesota sources are estimated to contribute about 30% (26% for BWCAW; 32% for VNP). The estimated contributions from northeast Minnesota sources to light extinction in both VNP and BWCAW is relatively small compared to the total, about 14 – 15%. Northeast Minnesota sources account for about half of the total contribution from Minnesota sources.

# 4.0 Summary of State and National Emission Trends

The primary air pollutants from the proposed projects in northeast Minnesota (see Table 1) being assessed for potential cumulative effects that may affect visibility and particulate matter air concentrations in the federal Class I areas are $SO_2$, $NO_x$ ,$PM_{10}$ and $PM_{2.5}$. As was shown in the previous section, air quality in remote federal Class I areas such as the BWCAW and VNP, including air concentrations of pollutants responsible for visibility degradation, is affected not only by the emission increases and decreases in the area nearest the federal Class I areas, but also regional and national emission increases and decreases. To give perspective on these emissions, this section includes a summary of local, state and national emission trends.

Data from the MPCA Criteria Pollutant Emission inventory is complete and available for stationary sources through 2008. State-wide emission estimates, including, stationary, non-stationary and mobile sources, is available through 2009. National emission data from the EPA's NEI are estimated through 2008.

## 4.1 Local (Six-County Zone of Interest) Emissions and Trends

In this section, we compare the potential new emissions (potential to emit basis) of $SO_2$, $NO_x$ and $PM_{10}$ from the proposed projects to actual emissions from existing facilities in the zone of interest (six county area that includes Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook Counties). Data for $PM_{2.5}$ emissions are currently not available.

Table 1 in Section 1.0 of this report, provides estimated emissions of $PM_{10}$, $SO_2$ and $NO_X$ from the proposed projects on a "potential to emit" basis. In addition, new major sources will incorporate the best available control technology into their design which will minimize both their potential and actual emissions. Actual emissions from the proposed projects may be lower than these potential emissions. Because the regulatory permitting programs require that emissions for new sources be based on potential to emit or maximum controlled emissions, actual emissions for the proposed projects are not available at this time. Therefore, potential emissions from the proposed projects will be compared to the estimates of actual emissions from existing facilities for previous and future years.

The emission estimates for the proposed projects and the existing facilities include both stack and fugitive emissions. This is a very important consideration for $PM_{10}$ emissions. For certain types of operations/facilities such as mining, fugitive emissions can account for a significant amount of the total facility $PM_{10}$ emissions. For example, for the NorthMet Project, over 70% of the $PM_{10}$ emissions are

from fugitive sources. At this time, no attempts have been made to separate the stack emission from the fugitive emissions. As discussed in Section 1.1, the larger particles typically associated with ground-level fugitive emissions ($PM_{2.5}$ to $PM_{10}$) tend to settle out near an emission source (references(6)(26)). The inclusion of $PM_{10}$ fugitive emissions in this analysis overestimates the potential cumulative impacts from the proposed projects on $PM_{10}$ air concentrations in the federal Class I areas in Minnesota.

### 4.1.1 Sulfur Dioxide ($SO_2$)

Table 6 compares the estimated cumulative potential $SO_2$ emissions from the proposed projects to the existing facility emissions in the six-county area since 1990. The year 2015 is selected as the comparison year due to the assumption that the proposed projects and reductions are likely to be in full operation by that time. The estimated 2015 emissions for existing facilities do not take into consideration reductions due to foreseeable regulatory actions, except for reductions from Hill Wood Products, Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities along with reductions required under BART for United Taconite and Northshore Mining.

Table 6 indicates that the cumulative potential emissions from the proposed projects will potentially increase the local emissions in the six-county area by a relatively small amount (2,807 tons per year – see Table 1). This represents an approximate 7% increase above 2008 $SO_2$ emissions of 40,115 tons in the six-county area if all projects reach their potential to emit. However, when decreases in $SO_2$ from the proposed projects are included (see Table 1, "Reductions"), the emissions will decrease by 34% compared to the 2008 levels. Proposed and in-progress concurrent voluntary emission reductions in the six-county area are summarized below in Section 4.1.4. Additional local emission reductions due to ongoing regulatory requirements are likely, as summarized in Section 4.4.

**Table 6 Annual and projected sulfur dioxide ($SO_2$) emissions for existing major emission sources in the six-county "zone of interest" in northeast Minnesota.**
(Six-county project area: Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook).

| Actual and Projected $SO_2$ Emissions (tons per year) [1] | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Itasca County | St. Louis County | Cook County | Lake County | Koochiching County | Carlton County | Total 6-County Area |
| **1990** | 21,612 | 6,443 | 0 | 689 | 604 | 1,315 | 30,663 |
| **1991** | 14,275 | 4,949 | 337 | 1,082 | 199 | 931 | 21,772 |
| **1992** | 12,622 | 5,131 | 3,899 | 705 | 118 | 1,426 | 23,902 |
| **1993** | 15,479 | 5,153 | 2,210 | 1,441 | 81 | 1,158 | 25,522 |
| **1994** | 20,228 | 6,028 | 2,685 | 1,881 | 86 | 1,447 | 32,355 |
| **1995** | 19,129 | 4,887 | 1,865 | 1,071 | 81 | 1,413 | 28,446 |
| **1996** | 15,054 | 8,782 | 1,184 | 1,466 | 68 | 1,520 | 28,074 |
| **1997** | 14,409 | 8,836 | 1,992 | 1,294 | 71 | 1,871 | 28,472 |
| **1998** | 16,327 | 7,835 | 3,278 | 1,516 | 93 | 1,767 | 30,815 |
| **1999** | 17,374 | 8,910 | 2,961 | 1,872 | 99 | 1,536 | 32,752 |
| **2000** | 15,212 | 10,860 | 3,255 | 2,062 | 60 | 1,324 | 32,773 |
| **2001** | 18,740 | 9,250 | 91 | 1,857 | 72 | 446 | 30,457 |
| **2002** | 21,215 | 9,646 | 3,113 | 2,292 | 68 | 214 | 36,549 |
| **2003** | 20,027 | 7,598 | 5,503 | 2,371 | 80 | 222 | 35,800 |
| **2004** | 19,843 | 9,338 | 5,575 | 2,881 | 71 | 475 | 38,184 |
| **2005** | 20,036 | 9,493 | 5,237 | 2,673 | 83 | 393 | 37,914 |
| **2006** | 20,477 | 8,921 | 5,388 | 2,781 | 51 | 218 | 37,836 |
| **2007** | 21,722 | 10,293 | 5,064 | 2,936 | 97 | 274 | 40,386 |
| **2008** | 21,643 | 11,164 | 4,722 | 2,312 | 86 | 188 | 40,115 |
| **2015[2]** | 11,902 | 9,464 | 3,173 | 1,785 | 86 | 189 | 26,598 |

[1] Historical data obtained from http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded in June 2010, and http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-and-monitoring/criteria-air-pollutant-emission-inventory/facility-actual-emissions-data.html; downloaded in May 2011.
[2] 2015 emission estimates for existing facilities is 2008 emissions summed with reductions and increases for the proposed projects for each county in NE Minnesota as described in Table 1 using 2008 instead of 2009 as a baseline year to estimate reductions because countywide emission data is only available through 2008. This estimate does not account for potential emission reductions due to foreseeable regulatory actions, except for those noted in Table 1. Emissions from projects located in two counties were split evenly between the two counties.

### 4.1.2 Nitrogen Oxides ($NO_x$)

Table 7 provides historical emissions from existing major emission sources in the six-county project area (Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook counties). The cumulative potential $NO_x$ emissions from the proposed projects are compared to the existing facility emissions in this six-county "zone of interest". The year 2015 is selected as the comparison year due to the assumption that the proposed projects and reductions are likely to be in full operation by that time. The estimated 2015 emissions for existing facilities do not take into consideration reductions due to foreseeable regulatory

actions except for reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, Hill Wood Products and Northshore Mining.

Table 7 indicates that the cumulative potential emissions from the proposed projects will be an increase in the local emissions in the six-county area of Itasca, St. Louis, Lake, and Cook by a relatively small amount (6,635 tons). This represents a maximum potential increase of about 12% compared to 2008 local $NO_x$ emissions of 54,350 tons. However, when decreases in $NO_x$ from the proposed projects are included (see Table 1, "Reductions"), the emissions will decrease by about 25% compared to the 2008 levels. Proposed and in-progress concurrent voluntary emission reductions in the six-county area are summarized below in Section 4.1.4. Additional local emission reductions due to ongoing regulatory requirements are likely, as summarized in Section 4.4.

**Table 7 Annual and projected nitrogen oxide ($NO_x$) emissions trends for existing major emission sources in the six-county area of interest in northeast Minnesota.**
(Six counties of interest: Carlton, Koochiching, Itasca, St. Louis, Lake, Cook)

| Actual and Projected $NO_x$ Emissions (tons per year) [1] | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Itasca County | St. Louis County | Cook County | Lake County | Koochichin g County | Carlton County | Total 6-County Area |
| **1990** | 20,061 | 25,601 | 0 | 6,037 | 1,416 | 1,860 | 54,974 |
| **1991** | 17,816 | 24,588 | 540 | 1,350 | 1,333 | 1,801 | 47,429 |
| **1992** | 15,845 | 21,377 | 4,318 | 2,086 | 943 | 1,634 | 46,203 |
| **1993** | 16,967 | 22,470 | 2,106 | 6,313 | 900 | 1,652 | 50,408 |
| **1994** | 13,977 | 14,597 | 2,717 | 6,912 | 1,141 | 1,412 | 40,756 |
| **1995** | 14,650 | 16,020 | 1,709 | 5,717 | 956 | 1,370 | 40,421 |
| **1996** | 13,563 | 34,016 | 984 | 3,695 | 1,012 | 1,645 | 54,914 |
| **1997** | 13,587 | 40,723 | 1,498 | 3,848 | 952 | 1,361 | 61,968 |
| **1998** | 13,857 | 37,618 | 1,925 | 3,029 | 904 | 1,065 | 58,399 |
| **1999** | 12,411 | 33,824 | 2,670 | 3,294 | 842 | 1,264 | 54,307 |
| **2000** | 13,167 | 34,232 | 2,796 | 3,869 | 683 | 1,616 | 56,362 |
| **2001** | 14,190 | 28,651 | 104 | 3,175 | 699 | 1,520 | 48,337 |
| **2002** | 15,049 | 35,850 | 2,321 | 3,950 | 880 | 1,563 | 59,613 |
| **2003** | 15,443 | 27,912 | 3,381 | 4,092 | 971 | 1,471 | 53,270 |
| **2004** | 13,210 | 34,116 | 3,388 | 4,120 | 925 | 1,652 | 57,411 |
| **2005** | 14,851 | 14,851 | 3,242 | 4,242 | 894 | 1,356 | 39,437 |
| **2006** | 13,996 | 28,469 | 3,241 | 3,767 | 964 | 1,414 | 51,851 |
| **2007** | 15,031 | 28,685 | 3,017 | 3,931 | 900 | 1,526 | 53,090 |
| **2008** | 16,034 | 29,838 | 2,374 | 3,681 | 911 | 1,512 | 54,350 |
| **2015 [2]** | 10,846 | 23,244 | 1,264 | 2,722 | 911 | 1,674 | 40660 |

[1] Historical data obtained from http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded in June 2010, and http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-and-monitoring/criteria-air-pollutant-emission-inventory/facility-actual-emissions-data.html; downloaded in May 2011.

[2] 2015 emission estimates for existing facilities is 2008 emissions summed with reductions and increases for the proposed projects for each county in NE Minnesota as described in Table 1 using 2008 instead of 2009 as a base year to estimate reductions because countywide emission data is only available through 2008. This estimate does not account for potential emission reductions due to foreseeable regulatory actions except for those noted in Table 1. Emissions from projects located in two counties were split evenly between the two counties.

### 4.1.3 Particulate Matter ($PM_{10}$)

Table 8 provides historical $PM_{10}$ emissions from existing major facilities in the six-county area since 1990. The cumulative potential $PM_{10}$ emissions from the proposed projects are compared to the existing facility emissions in the six-county "zone of interest". The year 2015 is selected as the comparison year due to the assumption that the proposed projects are likely to be in full operation by that time. Table 8 indicates that the cumulative potential emissions from the proposed projects will increase the local emissions in the six-county area of Itasca, St. Louis, Lake, and Cook by about 6,274 tons (potential to emit basis including fugitive emissions). This represents a maximum potential increase of about 42% over 2008 actual $PM_{10}$ emissions of 15,045 tons in the six-county area if all projects reach their potential to emit. Likely concurrent voluntary emission reductions in the six-county area are summarized below in Section 4.1.4. Additional local emission reductions due to ongoing regulatory requirements are likely, as summarized in Section 4.4.

**Table 8 Annual and Projected PM10 emissions trends for existing major emission sources in the six- county area of interest in northeast Minnesota.**
(Six counties of interest: Carlton, Koochiching, Itasca, St. Louis, Lake, Cook)

| Actual and Projected $PM_{10}$ Emissions (tons per year) [1] | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Itasca County | St. Louis County | Cook County | Lake County | Koochiching County | Carlton County | Total 6-County Area |
| **1990** | 1,995 | 35,929 | 0 | 616 | 838 | 321 | 39,700 |
| **1991** | 1,931 | 28,461 | 56 | 1,960 | 604 | 483 | 33,495 |
| **1992** | 1,350 | 20,747 | 166 | 1,683 | 270 | 361 | 24,576 |
| **1993** | 1,259 | 22,854 | 214 | 2,371 | 735 | 480 | 27,913 |
| **1994** | 1,198 | 23,120 | 235 | 2,126 | 216 | 699 | 27,594 |
| **1995** | 1,379 | 26,457 | 401 | 2,076 | 219 | 913 | 31,445 |
| **1996** | 1,109 | 9,691 | 294 | 424 | 136 | 683 | 12,337 |
| **1997** | 2,189 | 10,657 | 350 | 409 | 145 | 987 | 14,738 |
| **1998** | 2,383 | 13,704 | 451 | 599 | 215 | 1,743 | 19,095 |
| **1999** | 2,180 | 15,678 | 416 | 567 | 333 | 988 | 20,162 |
| **2000** | 2,453 | 18,624 | 388 | 943 | 270 | 884 | 23,563 |
| **2001** | 2,394 | 10,822 | 48 | 543 | 170 | 801 | 14,778 |
| **2002** | 3,113 | 11,963 | 202 | 592 | 142 | 517 | 16,529 |
| **2003** | 3,101 | 12,748 | 324 | 630 | 152 | 507 | 17,461 |
| **2004** | 2,601 | 13,909 | 323 | 749 | 152 | 726 | 18,459 |
| **2005** | 2,894 | 9,829 | 1,000 | 1,067 | 141 | 583 | 15,514 |
| **2006** | 2,701 | 8,867 | 1,021 | 1,114 | 138 | 549 | 14,392 |
| **2007** | 3,409 | 8,969 | 1,076 | 978 | 127 | 404 | 14,963 |
| **2008** | 3,616 | 9,056 | 788 | 1,050 | 116 | 419 | 15,045 |
| **2015 [2]** | 6,047 | 12,707 | 788 | 1,199 | 116 | 448 | 21305 |

[1] Historical data obtained from http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded in June 2010, and http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-and-monitoring/criteria-air-pollutant-emission-inventory/facility-actual-emissions-data.html; downloaded in May 2011.
[2] 2015 emission estimates for existing facilities is the 2008 emissions summed with reductions and increases for the proposed projects for each county in NE Minnesota as described in Table 1 using 2008 instead of 2009 as a base year to estimate reductions because countywide emission data is only available through 2008. This estimate does not account for potential emission reductions due to foreseeable regulatory actions except for those noted in Table 1. Emissions from projects located in two counties were split evenly between the two counties.

### 4.1.4 Emission Reductions in Northeastern Minnesota

There are several emission reductions occurring in northeastern Minnesota that will significantly reduce emissions of visibility impairing pollutants, $SO_2$, $NO_X$, $PM_{10}$, and $PM_{2.5}$. These emission reductions are included in Table 1. Two projects are part of the Minnesota Power Arrowhead Regional Emission Abatement Plan, one at the Laskin Energy Center in Hoyt Lakes and one at the Taconite Harbor Energy Center. Minnesota Power is also reducing emissions at the Boswell Energy Center in Cohasset. U. S. Steel Minntac and Hill Wood Products are also proposing projects that will reduce emissions. In addition, BART emission reductions are expected from Northshore Mining Company and United Taconite.

Work began on the Minnesota Power Laskin Energy Center in Hoyt Lakes in October and November 2006. The project entails replacing existing coal burners with low $NO_x$ burners and overfire air systems on both Laskin coal-fired generating units. Overfire air systems feature additional air ports as well as software that tracks combustion conditions and automatically modifies fuel/air input to more completely burn fuel. These improvements reduce $NO_x$ emissions from coal-burning. Work was completed in 2010, and the expected emission reductions will be 1,381 tons per year of $NO_x$ from 2002 levels (reference(3)). Because actual emissions at Laskin Energy Center through 2009 have been reduced the amount of any possible further reduction from the installation from the low $NO_x$ burners in future years is unknown.

Work is currently in progress at the Taconite Harbor Energy Center in Schroeder and includes installing and optimizing Mobotec multi-pollutant control technology on each of the three 75 MW coal-fired units. The company will install equipment within the combustion chamber of each boiler to modify combustion conditions and inject reagents to reduce $NO_x$, $SO_2$, and mercury emissions. Expected emission reductions from 2009 actual emissions will be 423 tons per year $NO_x$ and 1,549 tons per year $SO_2$ (reference (3)).

Minnesota Power also broke ground on an emission reduction project at the Boswell Energy Center in May 2007 and completed installation by the end of 2009. The project will decrease emissions of $NO_x$ and $SO_2$ by replacing an existing wet scrubber on Unit 3 with a selective catalytic reduction system, activated carbon injection, a fabric filter and a wet flue gas desulfurization scrubber (reference (27)). The project was fully operational in April 2010. Emission reductions through 2009 have been 3,311 tons per year $NO_x$

and 7,729 tons per year $SO_2$ and expected additional emission reductions starting in 2010 are 6,372 tons per year of $NO_x$ and 4,224 tons per year of $SO_2$ (reference (3)(28)).

In addition to these projects at power plants, two taconite facilities are proposing emission reductions, United Taconite and U. S. Steel Minntac. The United Taconite reductions are related to BART requirements and will be implemented at the Fairlane plant in Forbes. Emission reductions from 2009 levels are expected to be 1,954 tons per year of $SO_2$ (reference (3)).

The U. S. Steel project at Minntac is a reduction in $NO_x$ emissions due to a backwards looking PSD analysis that resulted in permit conditions to conduct pilot testing to prove a $NO_x$ control technology. As a result of this testing, one low $NO_x$ burner was installed in May 2010 to meet the new permit limit and another low $NO_x$ burner was installed in April 2011. The goal is a $NO_x$ reduction of 9,310 tons per year from the backward looking permit limit (reference (3)(29)). The expected $NO_x$ reductions from 2009 levels are 1,973 tons per year (reference (29)(30)).

Reductions from a proposed project at Hill Wood Products for the replacement of several old units with newer units is expect to result in a 14 tons per year reduction in $PM_{10}$ emissions. Finally, BART requirements for Northshore Mining's facility in Silver Bay, Lake County are expected to result in reductions of 583 tons per year and 1,159 tons per year of $SO_2$ and $NO_x$ respectively.

### 4.1.5 Summary of Local (Six-county Project Area) Emissions

As shown above, if all proposed projects included in this analysis move forward to construction as planned, they would potentially increase stationary source emissions from 2008 levels in the six-county area of interest by approximately 7% for $SO_2$, 12% for $NO_x$, and 42% for $PM_{10}$. These potential increases do not take into account the proposed reductions associated with the voluntary actions described for some of the projects in Section 4.1.4 or the additional likely reductions required by foreseeable future regulatory and other actions summarized in Section 4.4. When reductions from various projects including Minnesota Power facilities and BART requirements are included, the emissions of $SO_2$ in the six-county area will be reduced from 2008 levels by 13,517 tons per year or 34% and the emissions of $NO_x$ by 13,690 tons per year or 25%. Particulate emissions from the Minnesota Power facilities are not being reduced from their 2008 levels.

**Table 9 Summary of Local Emissions and Proposed Changes in Emissions.**

| | 2008 Six-County Emissions TPY | Proposed Project Emissions TPY | Proposed Net Emission Change, Increases Plus Reductions, TPY[1] | Proposed Net Emission Change, Increases Plus Reductions, %[1] |
|---|---|---|---|---|
| **$SO_2$** | 40,115 | 2,807 | -13,517 | -34 |
| **$NO_x$** | 54,350 | 6,635 | -13,690 | -25 |
| **$PM_{10}$ (Includes Fugitives)** | 15,045 | 6,274 | 6,260 | 42 |

[1] Reductions included are those by Minnesota Power facilities in the six-county area, US Steel Minntac, Hill Wood Products and the required BART reductions.

When comparing the potential emissions from the proposed projects and reductions with historical and existing emissions in the six-county project area the following can be concluded:

- $SO_2$: projected emissions for 2015, calculated using the 2008 actual emission data and including existing sources with reductions from Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities along with reductions required under BART for United Taconite and Northshore Mining and the potential change in emissions from the proposed projects, are lower than historical emissions. See Figure 19.
- $NO_x$: projected emissions for 2015, which include existing sources with reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, and Northshore Mining, the potential change in emissions from the proposed projects are lower than historical emissions. See Figure 20.
- $PM_{10}$: projected emissions for 2015, which include existing sources with reductions from Hill Wood Products and the potential change in emissions from the proposed projects, are within the range of historical emissions (see Figure 21).

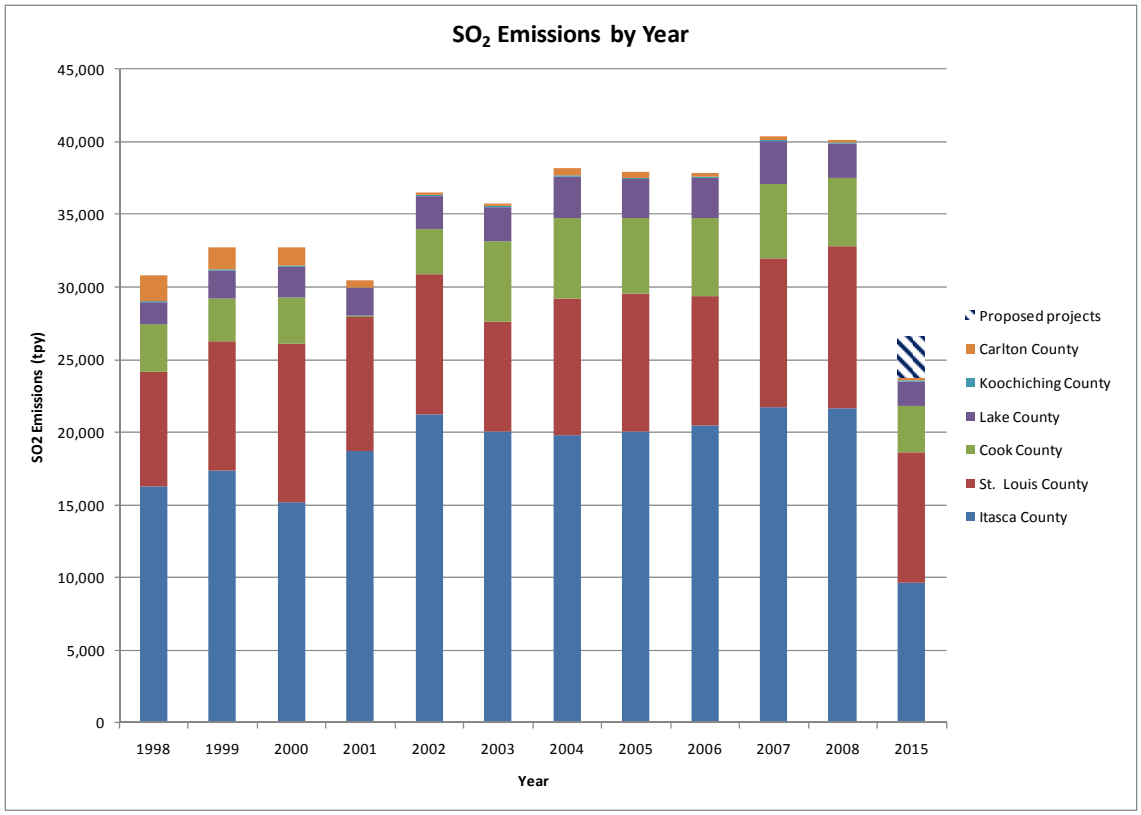



**Figure 19 Sulfur Dioxide ($SO_2$) Emissions in Northeast Minnesota.**

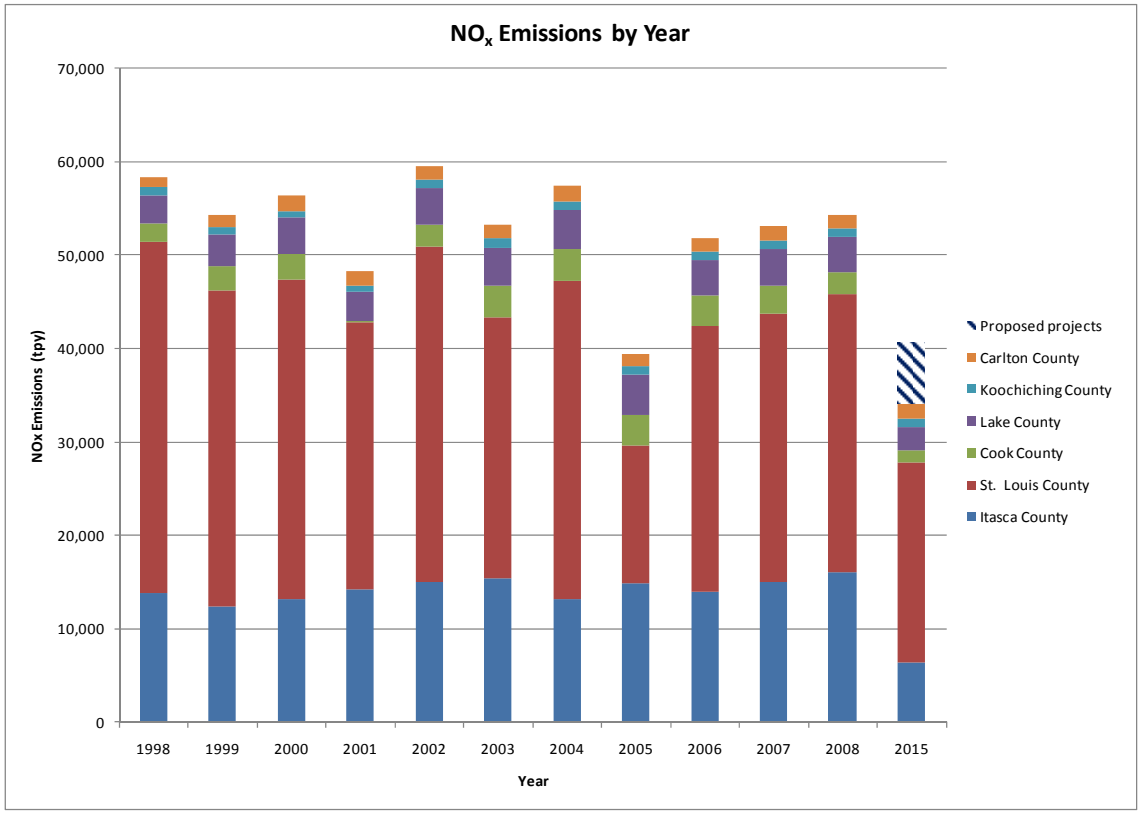



**Figure 20 Nitrogen Oxides ($NO_x$) Emissions in Northeast Minnesota.**

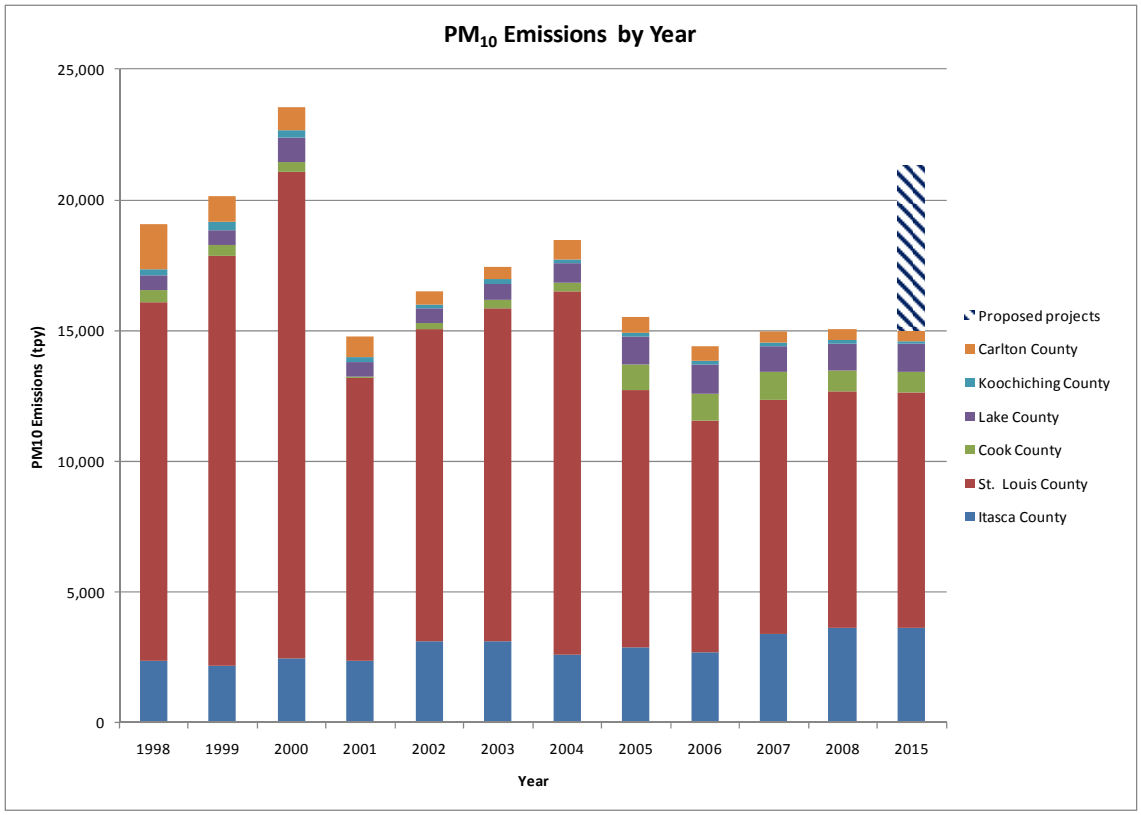



**Figure 21 Particulate Matter less than 10 microns ($PM_{10}$) Emissions in Northeast Minnesota.**

## 4.2 Statewide Emissions and Trends

This section first summarizes statewide emission trends for $SO_2$, $NO_x$, and $PM_{10}$. In addition, the statewide emission inventory data for the most recent year available (2009) is further broken down between northeastern Minnesota and the rest of the state. Note that due to the economic downturn, much of the taconite industry was idle in 2009. Therefore, changes between 2008 and 2009 emissions for the mining industry may be more representative of the economic climate and not long term emission trends in the mining sector in Minnesota.

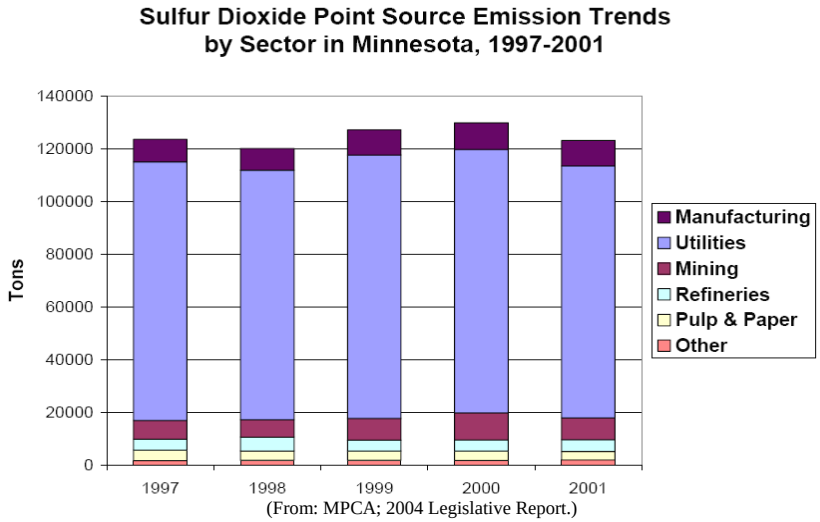
### 4.2.1 Sulfur Dioxide ($SO_2$)

Following large reductions in $SO_2$ emissions from the electric utility sector between 1980 and 1985 (reference (31))and more modest reductions through the mid-90's, by 1994, total statewide emissions were slightly more than 140,000 tons/yr.

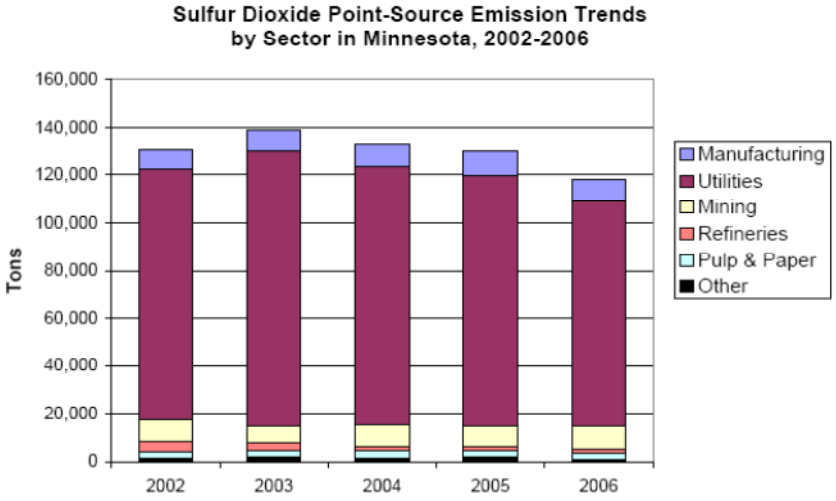
Since 1994, statewide $SO_2$ emissions have decreased to about 101,000 tons/yr in 2009 (reference (32)). Currently, stationary source emissions make up approximately 71% of the statewide $SO_2$ emissions (reference (32)) and are estimated to be approximately 72,000 tons/year in 2009. The potential $SO_2$

emissions from the proposed projects (2,807 tons), compared to total statewide actual emissions of approximately 101,000 tons/yr, represent an approximate increase of about 2.8% on a statewide basis. When the potential $SO_2$ emissions from the projects are compared to stationary source $SO_2$ emissions only (~72,000 tpy), the potential increase is approximately 4%. As can be seen from Figure 22, the potential $SO_2$ emissions added by the proposed projects are within the annual variability of statewide stationary source emissions from 1997 to 2009. This comparison indicates that on a statewide level the potential increase in $SO_2$ emissions from the proposed projects will be small.

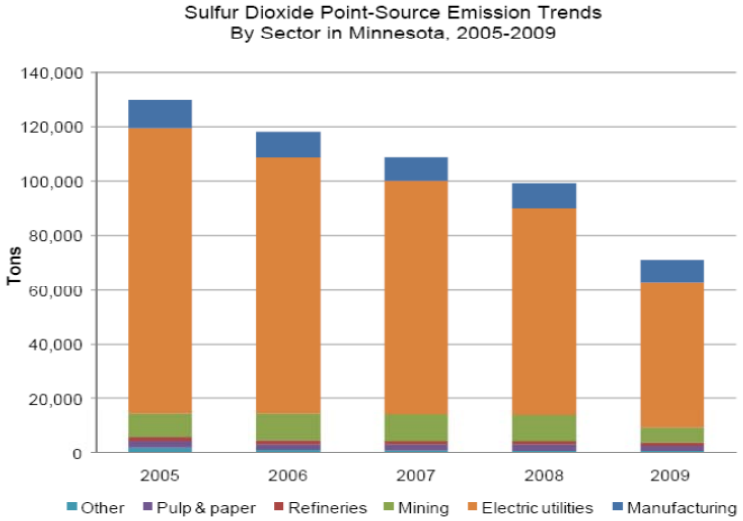
The $SO_2$ emissions from the proposed projects (2,807 tpy) do not take into account the expected emission reductions from Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities, United Taconite and Northshore Mining. See Section 4.4 for details of these reductions. When emission reductions are included, the emission change will be a reduction of 13,517 tons per year, which is a reduction of 19% in stationary source emissions compared to 2009.




(From: MPCA; 2004 Legislative Report.)




From: MPCA Annual Pollution Report to the Legislature. April 2008.

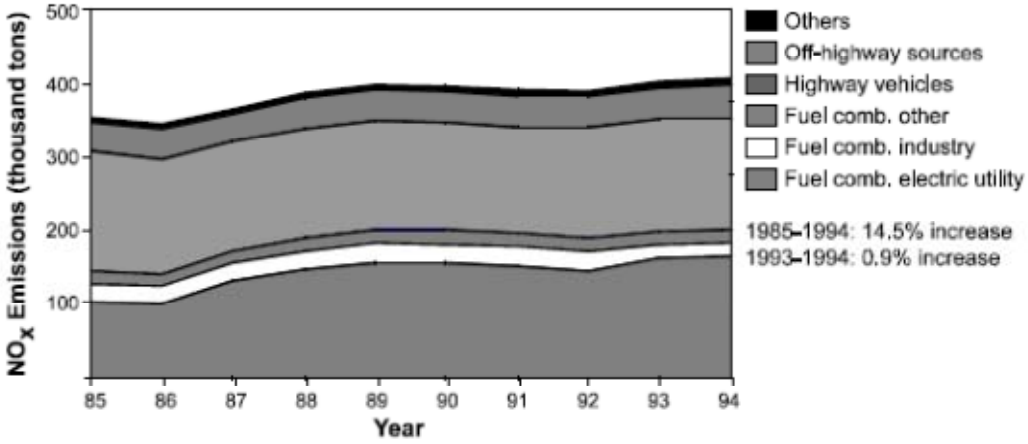



From: MPCA Annual Pollution Report to the Legislature. April 2011.

**Figure 22 Statewide stationary source sulfur dioxide ($SO_2$) emission trends, 1997 – 2009.**

### 4.2.2 Nitrogen Oxides ($NO_x$)

Figure 23 summarizes Minnesota $NO_x$ emission trends between 1985 and 1994, which is the last detailed analysis that is publicly available from the MPCA (1997). These data show that statewide $NO_x$ emissions increased gradually from 1985 to 1994, reaching about 416,000 tons/yr in 1994 (reference (33)).



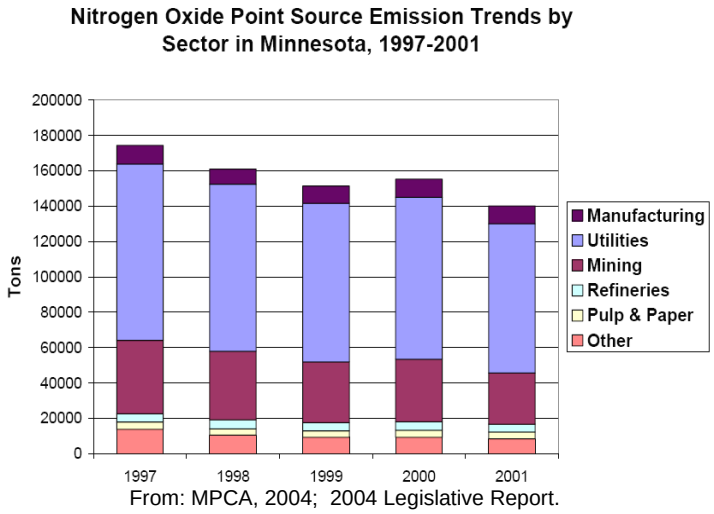

From: MPCA, 1997.

**Figure 23 Sources of nitrogen oxide emissions in Minnesota, 1985 – 1994.**

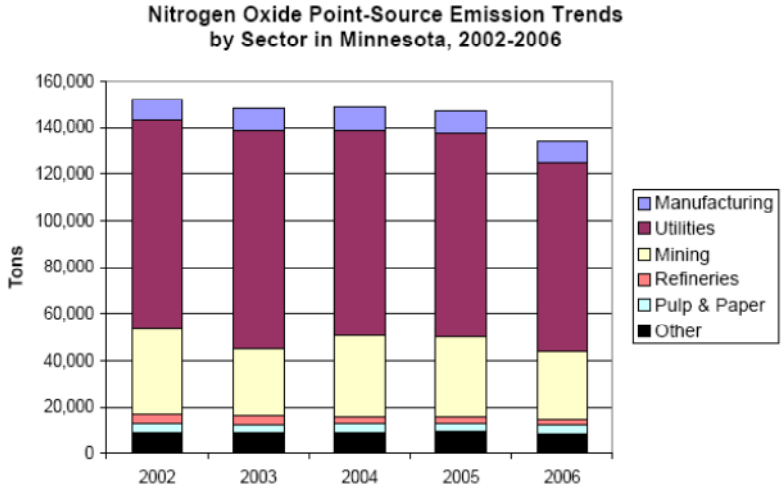
MPCA has recently estimated that since 1994, $NO_x$ emissions have decreased to about 353,000 tons by 2009 (reference (32)). As identified by the MPCA, stationary source emissions account for approximately 22% of the statewide $NO_x$ emissions while gasoline and diesel sources account for approximately 40% of $NO_x$ emissions and non-road sources, including off-road transportation, contribute approximately 29% of $NO_x$ emissions. Figure 24 provides stationary-source emissions of $NO_x$ in Minnesota for the 1997 to 2009 time period, broken down by industrial sector (references (34)(32)). Figure 24 indicates that $NO_x$ emissions gradually declined from stationary sources in Minnesota from 1997 to 2001, but have remained relatively steady from 2002 to 2005 with a decrease in 2006 through 2009. These reductions were mainly due to the mining and utility sectors (references (35)(32)).

In comparison to statewide $NO_x$ emissions of 353,000 tons/year in 2009, the potential increase in $NO_x$ emissions from the proposed projects is small (6,635 tons/year), an approximately 2% increase. When the potential emissions increase from the proposed projects is compared to stationary source emissions only (78,000 tpy), the potential increase is approximately 8.5%. Based on the relatively small amount of $NO_x$ estimated to be emitted from the proposed projects, it is concluded that the $NO_x$ emissions from the proposed projects is within the variability exhibited by statewide $NO_x$ emissions since 1997 (Figure 24). Additionally, stationary sources, or point sources do not account for the majority of $NO_x$ emissions in Minnesota; approximately 78% of statewide $NO_x$ emissions are from on and off road sources.

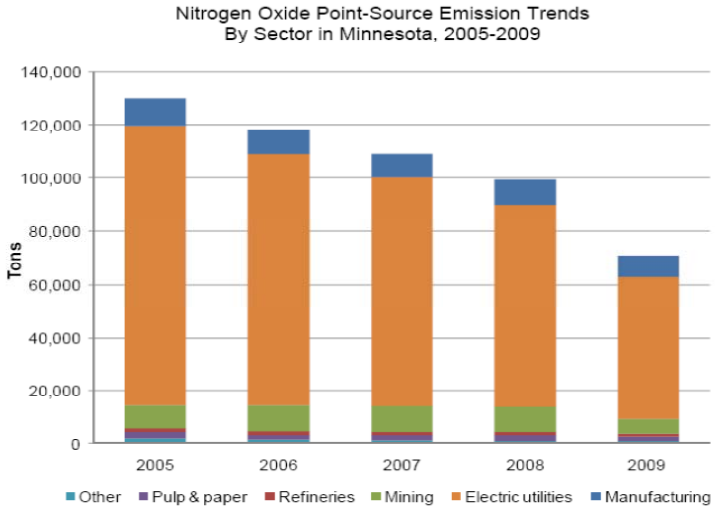
The $NO_x$ emissions from the proposed projects (6,635 tpy) do not take into account the expected emission reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, and Northshore Mining. See Section 4.4 for details of these reductions. When emission reductions are included, the emission change will be a reduction of 13,690 tons per year, which is a reduction of approximately 18 percent in stationary source emissions compared to 2009.




From: MPCA, 2004; 2004 Legislative Report.




From: MPCA Annual Pollution Report to the Legislature. April 2008




From: MPCA Annual Pollution Report to the Legislature. April 2011

**Figure 24 Nitrogen oxide stationary source emission trends in Minnesota by sector, 1997-2009.**

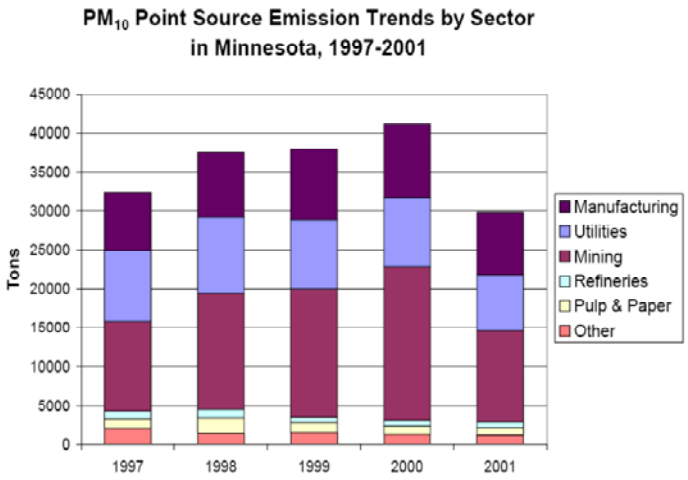
### 4.2.3 Particulate Matter ($PM_{10}$)

Coarse particles are generally emitted from sources such as vehicles traveling on unpaved roads, materials handling, crushing and grinding operations, and windblown dust (reference (35)). It is estimated that $PM_{10}$ emissions were approximately 786,930 tons/year in 2009 (reference (32)). As identified by the MPCA, stationary source emissions account for approximately 3% of the statewide $PM_{10}$ emissions, while transportation related activities including unpaved roads account for approximately 59% of $PM_{10}$ emissions.

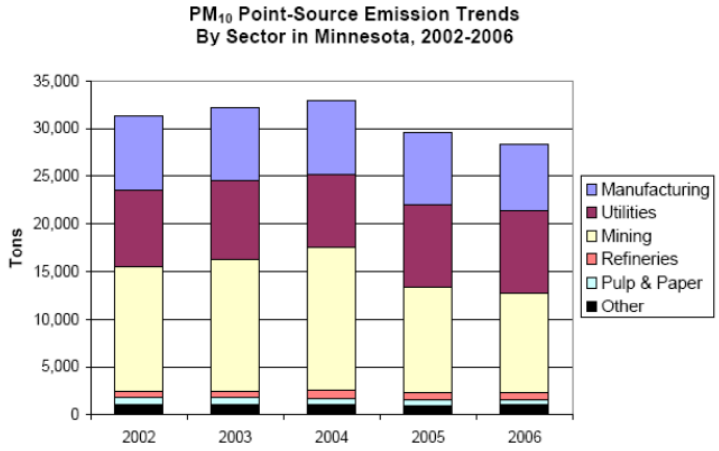
Figure 25 below summarizes $PM_{10}$ stationary source emission trends between 1997 and 2009 (references(32)(34)). These data show that statewide $PM_{10}$ emissions increased gradually from 1997 to 2000. In 2001, emissions decreased markedly in part due to the closing of LTV Steel Mining Company and a general decline in taconite processing. Since 2002, $PM_{10}$ emissions have increased slowly up to 2004, but are well within historic levels (Figure 25). In 2005 there was a decrease mainly due to mining sources. In 2006 emissions dropped due to decreases in all source sectors except refining (reference (35)). $PM_{10}$ emissions remained relatively constant from 2006 through 2008 and decreased in 2009 due to production decreases in mining (reference (32)).

In comparison to statewide $PM_{10}$ emissions of 768,930 tons/year in 2009, the potential increase in $PM_{10}$ emissions from the proposed projects is small (6,274 tons/year), an approximately 1% increase. When the potential emissions increase from the proposed projects is compared to stationary source emissions only (~23,000 tons/year), the potential increase is approximately 27%. Based on the emissions data from 1997 to 2009 (Figure 25), the potential increase in $PM_{10}$ emissions associated with the proposed projects is within the variability exhibited by statewide $PM_{10}$ point source emissions. Additionally, point sources only contribute 3% of the statewide $PM_{10}$ emissions, with agriculture and road dust contributing the bulk of the statewide emissions.

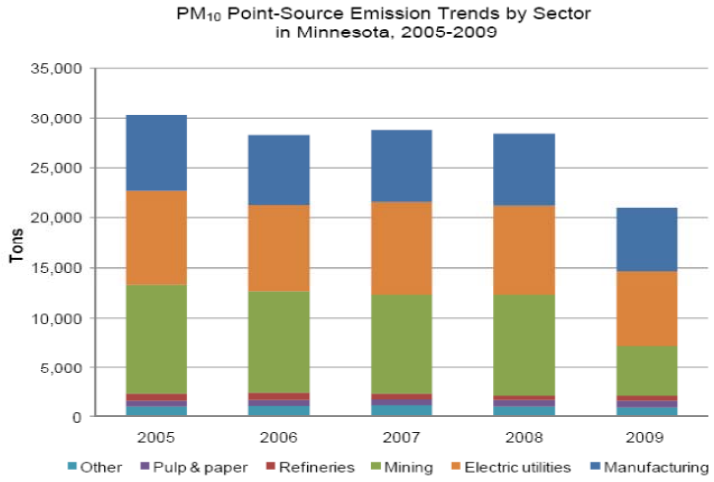
The $PM_{10}$ emissions from the proposed projects (6,274 tpy) do not take into account the expected $PM_{10}$ emission reductions from Hill Wood Products. See Section 4.4 for details of these reductions.




From: MPCA 2004. Annual Pollution Report to the Legislature.




From: MPCA 2008. Annual Pollution Report to the Legislature




From: MPCA Annual Pollution Report to the Legislature. April 2011

**Figure 25 Trend in stationary source emissions of particulate matter (PM10) in Minnesota, 1997 - 2009.**

### 4.2.4 Northeast Minnesota and Statewide Stationary Source Emissions

Stationary source emissions of $SO_2$, $NO_x$, and $PM_{10}$ are not distributed evenly in the state. When 2008 statewide stationary source emissions of $SO_2$, $NO_x$, and $PM_{10}$ are compared to the 2008 emissions from the major stationary sources in the northeast region of the state (Carlton, Koochiching, Itasca, Lake, Cook and St. Louis counties), the northeast sources contribute about 39% of the stationary source $SO_2$ emissions, about 42% of the stationary source $NO_x$ emissions, and approximately 49% of the stationary source $PM_{10}$ emissions.

While the northeast region of the state has a notable percentage of total statewide stationary source emissions of $SO_2$ (39%), $NO_x$ (42%), and $PM_{10}$ (49%) these emissions do not seem to have a correlation with ammonium sulfate, ammonium nitrate or haze index monitored values in VNP and the BWCAW. Figure 26 shows the annual $SO_2$ emissions from northeast Minnesota stationary sources compared to the annual median ammonium sulfate value for the BOWA1 monitoring site. The trend of the $SO_2$ emissions is increasing while the median ammonium sulfate air concentrations are trending down at the BOWA1 monitor, indicating that local emissions are not necessarily the driving force for the particulate sulfate in Minnesota Class I areas. A similar lack of apparent correlation is seen between the 6-county $SO_2$ emissions and ammonium sulfate monitored at the VOYA2 monitoring site. Figure 27 shows the annual $NO_x$ emissions from northeast Minnesota stationary sources compared to the annual median ammonium nitrate value for the BOWA1 monitoring site. Although the data shows more variability in the trends, increases or decreases in local emissions are not reflected with a corresponding increase or decrease in monitored ammonium nitrate concentrations and often show the opposite, indicating that local point source $NO_x$ emissions are not necessarily the driving force for the particulate nitrate in Minnesota Class I areas. The monitoring data at VOYA2 also shows a similar apparent lack of direct correlation with point source $NO_x$ emissions from northeast Minnesota. Visibility impairment is a complex system that involves multiple pollutants, sources, and atmospheric reactions. In addition to the point source emissions discussed in this report, seasonality, humidity, the availability of ammonia and other emission source categories, such as mobile and area sources, are all factors that may contribute to the level of visibility impairment in any region.

The proposed projects combined with the Minnesota Power, US Steel Minntac, Hill Wood Products and BART reductions will decrease the northeast region emissions by about 19% overall ($SO_2$, $NO_x$ and $PM_{10}$ combined) compared to 2008 emissions.

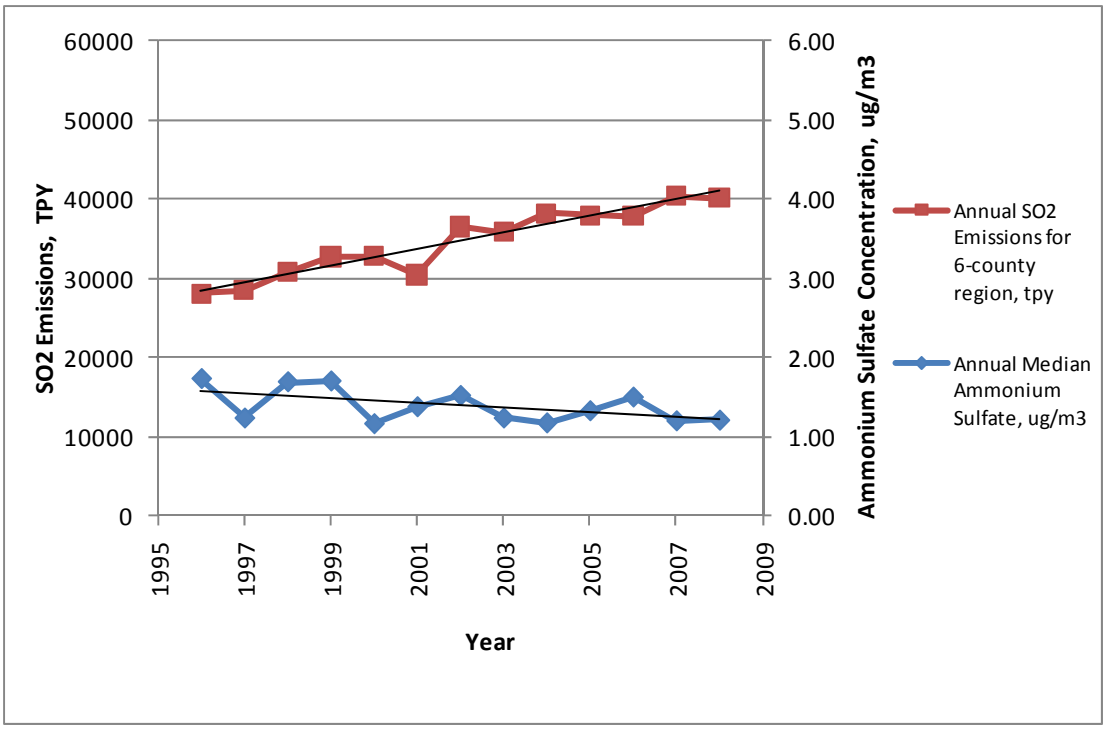



**Figure 26 Historical emissions of $SO_2$ (1996 – 2008) in six-county area from MPCA inventory data compared to historical annual median ammonium sulfate values in the BWCAW.**

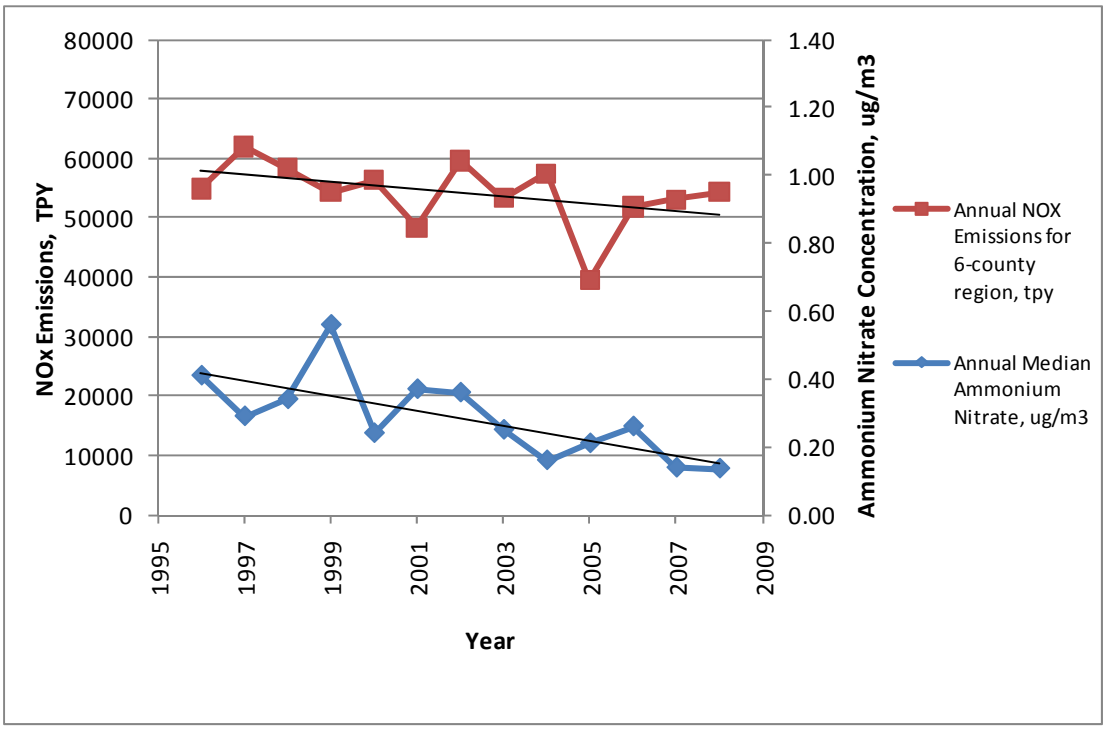



**Figure 27 Historical emissions of $NO_x$ (1996 – 2008) in six-county area from MPCA inventory data compared to historical annual median ammonium nitrate values in the BWCAW.**

### 4.2.5 Statewide Emission Trend Summary

As shown above, if all proposed projects included in this analysis move forward to construction as planned, when combined with reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, Hill Wood Products and United Taconite and Northshore Mining, they would potentially change stationary source emissions in the state by approximately -19% for $SO_2$, -18% for $NO_x$, and +27% for $PM_{10}$ compared to 2009 emissions. These potential increases and decreases do not take into account the likely reductions required by foreseeable regulatory and other actions besides the anticipated BART reductions shown in Table 1 (see Section 4.4).

When comparing the potential emissions from the proposed projects with statewide emissions, the following can be concluded:

- For $SO_2$: the potential change in emissions from the proposed projects combined with the reductions from Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities, United Taconite and Northshore Mining will be an 8% reduction in stationary source emissions from 2009, or approximately 5,500 tons per year. Total stationary source annual emission including these changes would be approximately 66,000 tons per year which is less than historical emissions which have ranged from approximately 120,000 to 140,000 tons per year (Figure 22).
- For $NO_x$: the potential change in emissions from the proposed projects combined with the reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, and Northshore Mining will be a 4% reduction in stationary source emissions from 2009, or approximately 3,300 tons per year. Total stationary source annual emission including these changes would be approximately 74,000 tons per year which is less than historical emissions which have ranged from approximately 130,000 to 170,000 tons per year (Figure 24).
- For $PM_{10}$: the potential change in emissions from the proposed projects combined with the reduction from Hill Wood Products, is a 27% increase in stationary source emissions from 2009, or approximately 6,260 tons per year. Total stationary source annual emission including these changes would be approximately 30,000 tons per year which is within the range of historical emissions which have varied from approximately 28,000 to 41,000 tons per year (Figure 25). (Note that much of the increase in $PM_{10}$ emissions is in coarse, fugitive emissions, which are unlikely to impact regional haze in the National Parks, even when emitted in northeast Minnesota.)

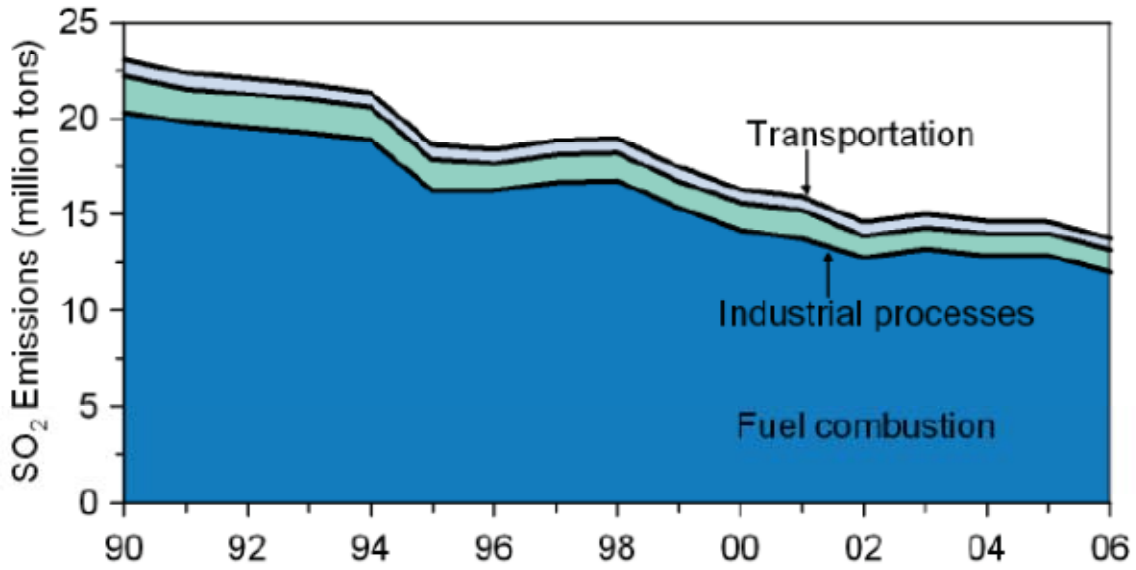
## 4.3 National Emission and Trends

National emission trends are also important to the visibility in federal Class I areas in Minnesota. As described in Section 3.4, out-of-state emissions contribute a major portion of the $PM_{2.5}$ to VNP and the BWCAW. Therefore, the trends in national emissions are expected to be reflected in the air concentration trends in VNP and the BWCAW. Due to the long-range transport of pollutants and their importance in federal Class I area air concentrations, national emissions of $SO_2$, $NO_x$, and $PM_{10}$ are discussed below.

### 4.3.1 Sulfur Dioxide ($SO_2$)

Nationally, total $SO_2$ emissions (including mobile sources) have decreased by about 50% from 1990 to 2008 (reference (36)). Total $SO_2$ emissions in the U.S. in 2008 were about 11.4 million tons/yr. EPA data on historic $SO_2$ emission trends through 2006 is summarized below in Figure 28. More detailed historical criteria pollutant emission trends are available through EPA's web site:

- http://www.epa.gov/ttnchie1/trends/
- http://www.epa.gov/airtrends/sulfur.html.




From http://www.epa.gov/airtrends/sulfur.html

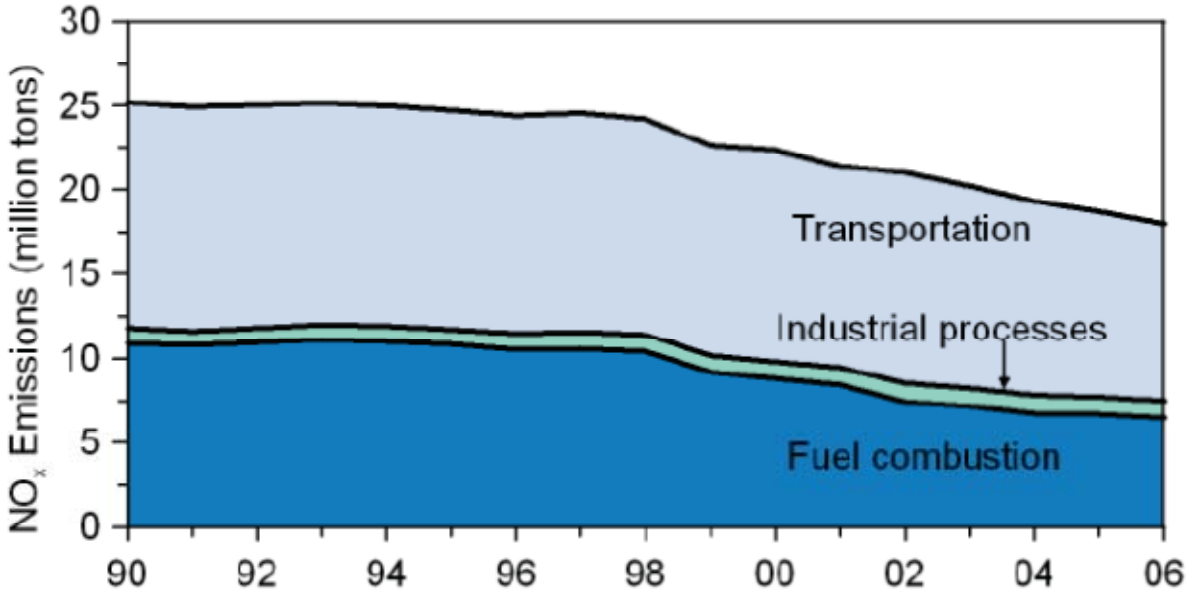
**Figure 28 National sulfur dioxide emission trends from 1990 to 2006.**

National $SO_2$ emissions from electric generation units were anticipated to level off at 8.7 million tons annually by 2010. Data is not yet available for 2010, however, actual emissions were almost at this level in 2007. The Cross State Air Pollution Rule (CSAPR), which was finalized in July 2011 and replaces CAIR, places additional caps on $SO_2$ emissions of electric generating units in covered states. The anticipated reduction in $SO_2$ emissions in these states is 6.4 million tons per year by 2014 compared to base case 2005 emissions (reference (37))

### 4.3.2 Nitrogen Oxides ($NO_x$)

Nationally, total $NO_x$ emissions (mobile plus stationary sources) have declined about 36% since 1990(36), with the biggest decline starting in about 1999 (Figure 29). Stationary source $NO_x$ emissions have declined about 43% from 1990 to 2008 and are currently approximately 6.9 million tons/year. The decline in national $NO_x$ emissions is expected to continue due to regulatory actions. The Cross State Air

Pollution Rule, which was fianlized in July 2011 anticipates reducing $NO_x$ emissions by 1.4 million tons per year within the covered 27 state area compared to base case 2005 emissions (reference(37)).




From http://www.epa.gov/airtrends/nitrogen.html

**Figure 29 National nitrogen oxide emission trends from 1990 to 2006.**

### 4.3.3 Particulate Matter ($PM_{10}$ and $PM_{2.5}$)

Nationally, total $PM_{10}$ emissions (including condensibles for both mobile and stationary sources and including miscellaneous sources) have declined since 1990 by 47%. Stationary source $PM_{10}$ emissions (including condensibles and miscellaneous sources) have declined since 1990 by about 47% and were at about 14.3 million tons/year in 2008. Estimated total emissions of $PM_{2.5}$ have declined about 5% over the same period. Stationary source emissions of $PM_{2.5}$ have declined about 35% and in 2008 were 4.5 million tons/year (reference (36)).

$PM_{10}$ and $PM_{2.5}$ emission reductions are expected to occur over the next decade, from a number of regulatory actions including the implementation of the revised National Ambient Air Quality Standard for $PM_{2.5}$. Models predicting the effect of the emission reductions due to the regulatory actions show that all areas in the eastern U.S. will have lower $PM_{2.5}$ concentrations in 2015 relative to present-day concentrations (reference (6)).

### 4.3.4 Summary of National Emissions and Trends

Nationally, there is a declining trend in $NO_x$, $SO_2$ and $PM_{10}$ emissions over the time period from approximately 1990-2008 (reference (36)). Specifically:

- $SO_2$: Between 1990 and 2008, total $SO_2$ emissions have declined approximately 50%
- $NO_x$: Between 1990 and 2008, total emissions have declined approximately 35%
- $PM_{10}$: From 1990 to 2008, direct emissions of $PM_{10}$ have decreased approximately 47%
- $PM_{2.5}$: From 1990 to 2008, direct emissions of $PM_{2.5}$ have decreased approximately 35%

EPA and the states have put in place a number of control programs that will continue to reduce particle-forming emissions that impair visibility. These future declines in emissions are expected to result in a continued downward trend in emissions nationally and a decrease in visibility impairment in VNP and the BWCAW.

## 4.4 Foreseeable Regulatory and Other Actions and Expected Emission Reductions

Predicting the exact schedule or scale that existing sources in Minnesota will reduce $SO_2$, $NO_x$, and $PM_{10}$ emissions over the next ten to fifteen years is outside the scope of this report. However, there are several "on the books" or "on the way" regulatory programs that are likely to reduce or constrain emissions from both existing taconite facilities and existing coal-fired power plants. These include at least the following initiatives that will be implemented in Minnesota or throughout the country:

- Minnesota's Acid Rain Rule (Minn. Rule parts 7021.0010-7021.0050) (will serve to constrain emissions);
- EPA Acid Rain Program (Title IV of the 1999 Clean Air Act Amendments); Phase II began implementation in 2000. (will serve to constrain emissions);
- Boiler Maximum Achievable Control Technology (MACT) Standards, 40 CFR Part 63
- The Clean Air Interstate Rule (CAIR) replacement called the Cross State Air Pollution Rule (CSAPR), modifying 40 CFR Parts 51, 52, 72, 78, 97
- Regional Haze Rule, including Best Available Retrofit Technologies (BART) requirements for certain sources. On July 6, 2005, the U.S.EPA published final amendments to its 1999 regional haze rule in the Federal Register, including Appendix Y, the final guidance for Best Available Retrofit Technology (BART) determinations (70 FR39104-39172).
- National Ambient Air Quality Standards: 1-hr standards for $NO_x$ and $SO_2$, reconsiderations of the 2008 Ozone standards, and additional changes to the standards for $PM_{2.5}$.
- Mobile source reductions
- SIPs from nearby states for upcoming ozone and $PM_{2.5}$ NAAQS standards

How these programs will work together, which units will be affected, and on what schedule are yet to be determined. Therefore, a detailed assessment of the potential emission reductions due to these regulations is outside the scope of this report. Nevertheless, while the timing of each of these regulatory initiatives is different, each could affect emissions of pollutants that impair visibility from existing sources in northeastern Minnesota and throughout the state.

### 4.4.1 Minnesota's Acid Rain Rule

Minnesota's Acid Rain Rule was established in July 1986 and includes the following provisions:

- A deposition standard that allows no more than 11 kilograms per hectare of wet sulfate to be deposited within the designated sensitive resource areas of Minnesota during any 52-week period (reference (33)).
- An emissions control plan that caps statewide $SO_2$ emissions at 194,000 tons/year.
- System-wide $SO_2$ emission limit of 93,500 tons/year for Northern States Power Company (now known as Xcel Energy).
- System-wide $SO_2$ emission limit of 40,390 tons/year for Minnesota Power.

As of 2009, statewide $SO_2$ emissions are estimated at 101,000 tons/year (reference (32)). Under Minnesota's Acid Rain Rule, $SO_2$ emissions would be allowed to increase and as such will not require any further reductions. However, current federal regulatory actions (e.g., the EPA acid rain program), foreseeable future actions, and voluntary actions (Minnesota Power's AREA Project; Xcel Energy's MERP) will continue to keep the statewide emissions below the 194,000 tons/year emissions cap.

### 4.4.2 EPA's Acid Rain Program

The goal of EPA's Acid Rain Program is to improve public health and the environment by reducing emissions of $SO_2$ and $NO_x$. The program was implemented in two phases: Phase I for $SO_2$ began in 1995 and targeted the largest and highest emitting coal-fired power plants. Phase I for $NO_x$ began in 1996. Phase II for both pollutants began in 2000 and sets restrictions on Phase I plants as well as smaller coal-, gas-, and oil-fired plants. Approximately 3000 emission units are now affected by the Acid Rain Program (see http://www.epa.gov/airtrends/ acidrain.html and http://www.epa.gov/airmarkets/progsregs/arp/).

By 2010, the Acid Rain Program has reduced annual $SO_2$ emissions from electric utilities to about half that emitted in 1980. The program sets a permanent cap of 8.95 million tons on the total amount of $SO_2$ that may be emitted by power plants nationwide. It employs an emissions trading program to achieve emission reductions more efficiently and cost-effectively. Sources are allocated allowances each year (one allowance equals 1 ton of $SO_2$ emissions), which can be bought or sold or banked for future use. This approach gives sources the flexibility and incentive to reduce emissions at the lowest cost and the cap ensures that emission reductions are maintained over time.

The $NO_x$ component of the Acid Rain Program limits the emission rate for all affected utilities, resulting in a 2 million ton $NO_x$ reduction from 1990 levels by 2001. There is no cap on total $NO_x$ emissions, but under this program a source can choose to over-control at units where it is technically easier to control emissions, average these emissions with those at their other units, and thereby achieve overall emissions reductions at lower cost.

Minnesota's electric utilities are subject to EPA's Acid Rain Program. As discussed below, additional emission reductions for $SO_2$ and $NO_x$ may not be expected from Minnesota's sources.

### 4.4.3 Maximum Achievable Control Technology (MACT) Standards

The Industrial, Commercial, and Institutional Boilers and Process Heaters (Boiler) MACT (Subpart DDDDD) has been re-proposed and was finalized February, 2011. Affected emission units under the Boiler MACT are boilers and indirect-fired process heaters, characterized by 11 sub-categories of units. These MACT rules set requirements that will reduce precursors to $PM_{2.5}$ and visibility impairing pollutants.

On March 16, 2011, the EPA also issued a new proposed rule that would reduce emissions of toxic air pollutants from power plants (utility boilers). Specifically, the proposal would reduce emissions from new and existing coal- and oil-fired electric utility steam generating units (EGUs). Under a court-imposed consent decree, the EPA must issue the final rule by November 16, 2011. A 30 day extension period has extended this deadline to December 16, 2011. Although this proposed rule is directed primarily at reducing emissions of mercury and other metallic pollutants from electric power plants, it could drive additional reductions in $SO_2$, $NO_x$, $PM_{10}$, and $PM_{2.5}$ emissions at some plants. See http://www.epa.gov/airquality/powerplanttoxics/actions.html.

### 4.4.4 Cross State Air Pollution Rule (CSAPR)

The Cross State Air Pollution Rule (CSAPR) was developed to replace CAIR, which was vacated by the D.C. Circuit Court of Appeals in July of 2008 and remanded in December 2008 to the EPA for rewriting to address the flaws identified in the court's July findings. CSAPR takes effect January 1, 2012.

CSAPR requires 27 states to reduce emissions that contribute to ozone and fine particle pollution in other states. The reductions in this rule were developed to assist states in meeting the 1997 ozone and 2006 $PM_{2.5}$ standards. An additional supplemental notice of proposed rulemaking related to CSPAR would require summertime $NO_x$ reductions under the CSPAR ozone season control program and bring the number of states covered by CSAPR to 28. CSAPR sets an emissions budget for each state and allows limited interstate trading among power plants, within the emission ceiling of each state. CSAPR sets emissions budgets that are expected to reduce $NO_x$ emissions by 1.4 million tons per year and $SO_2$ emissions by 6.4 million tons per year by 2014 compared to 2005 base levels (reference (37)).

Minnesota is included in CSPAR and will have annual budgets of 29,572 tons of $NO_x$ and 41,981 tons $SO_2$ starting in 2012 for facilities generating electrical power for sale. Voluntary reductions by Minnesota sources may meet or exceed the emission reductions that will be required under CSAPR. For example, Minnesota Power has completed or is proceeding with voluntary projects to reduce emissions at the Laskin Energy Center in Hoyt Lakes, the Taconite Harbor facility on Lake Superior (Lake County) and the Boswell station in Cohasset.

Various bills regarding the implementation of CSAPR have been introduced in the US House of Representatives that would either delay or negate this rule. However, it is uncertain if any of these bills will be passed into law. At the current time there is no change to the timing of the implementation CSAPR. EPA has proposed technical adjustments to CSAPR that include increasing certain state budgets. The Minnesota state budgets are not changed in these adjustments. The total increases to all state budgets will increase the overall CSAPR budgets by approximately 1% (reference (38)).

### 4.4.5 Best Available Retrofit Technology (BART) and Regional Haze

BART requirements are part of the EPA effort to improve visibility in federal Class I areas, such as VNP and the BWCAW. The MPCA Regional Haze SIP includes a summary of sources with units subject to BART in Minnesota, which includes six taconite facilities and five electric generating units in Minnesota. BART will require $SO_2$ and $NO_x$ reductions from three generating plants in the area: Minnesota Power's Boswell Energy Center Unit 3 and Taconite Harbor Unit 3 and Northshore Power Unit 2. In addition, electric generating units in other parts of the state will also be required to implement BART including Rochester Public Utilities Silver Lake Units 3 and 4 and Xcel Energy's Sherco plant.

In late 2009, Minnesota submitted its Regional Haze State Implementation Plan to EPA and it is currently under review to verify that the plan complies with all of the rule requirements. Under a court imposed consent decree, the EPA must approve the MN SIP by May 15, 2012. The plan, as submitted, proposes a goal of a 30% reduction in the six-county northeastern Minnesota region by 2018. Additional $SO_2$ and $NO_x$ reductions may be required in Minnesota as part of the Regional Haze SIP requirements to meet federal visibility goals.

### 4.4.6 Other Actions

There are several other actions that will help to reduce $PM_{10}$, $PM_{2.5}$ and other visibility impairing pollutants. These have been implemented since 2009 or will be implemented in the next several years and include:

- Heavy Duty engine standards

- Low sulfur fuel standards
- Federal control programs for nonroad mobile emissions
- Control of emissions from unregulated non-road engines
- $PM_{2.5}$ and Ozone SIPs for Wisconsin and Michigan
- 2008 Ozone NAAQS Reconsideration
- Ozone NAAQS Review
- Primary NAAQS Standards for $SO_2$ and $NO_x$
- PM NAAQS Review
- Inclusion of $PM_{2.5}$ in the PSD rule, including increments, Significant Impact Levels and Significant Monitoring Concentrations

# 5.0 Cumulative Impacts on Visibility and the Minnesota Regional Haze Long Term Strategy

As has been described in previous sections of this report, the Regional Haze Rule requires visibility improvements in Minnesota's Class I areas on the 20% worst days and no degradation on the 20% best days. To achieve this goal, the rule requires that Minnesota develop a long term strategy with initial implementation through 2018 and reassessment and revision every 10 years. The ultimate goal is to reach natural visibility conditions in both Class I areas by 2064.

Under the current Regional Haze Plan for Minnesota, the MPCA has set a reasonable progress goal (RPG) that they believe can be met under the long term strategy. The goal is to achieve a haze index of 18.6 deciviews for the 20% worst days at BWCAW and 18.9 deciviews at VNP by 2018. The current 20% worst visibility, based on 2008 5-yr rolling averages of IMPROVE data, are 19.6 for BWCAW and 19.5 for VNP.

To reach the reasonable progress goal, further reductions in emissions will be required not only in northeast Minnesota, but the rest of Minnesota and in other states. Control strategies that will ensure reductions are made and the goal is met include regulations already on the books, voluntary reductions and additional control measures. Voluntary control measures that were not quantified in earlier sections of this report, but that will decrease impairment in the BWCAW and VNP include large reductions in $SO_2$ and $NO_x$ from electric utilities not located in the 6-county area. These include reductions being implemented by Xcel Energy at four of their plants, and reductions at the Otter Tail Power Hoot Lake facility. The MPCA expects to exceed the reasonable progress goal due to factors that were not included in the assessment, but which are expected to help reduce impacts on visibility. These include the Minnesota Renewable Energy Standard requiring 25% of the state's energy to be from renewable sources by 2025, reductions made in response to climate change issues and reductions from other states required by SIPs for $PM_{2.5}$ and ozone.

To develop the long term strategy, the MPCA modeled the visibility impacts of all sources affecting the Class I areas with the 2002 emissions and the 2018 expected emissions. The modeling for 2018 included all sources existing in 2002 plus several anticipated new sources. The new sources included Mesabi Nugget, NorthMet, Essar Steel, Northshore Mining Silver Bay Furnace 5, and the restart of a production line at United Taconite. In essence, the 2018 modeling is a cumulative assessment of the impact on visibility from these sources, including reductions and control measures.

The modeling clearly showed that the largest contributors to visibility degradation in both the BWCAW and VNP are ammonium sulfate, ammonium nitrate and organic carbon. The ammonium sulfate and ammonium nitrate are the result of emissions of $SO_2$ and $NO_x$. The organic carbon is believed to be of natural or biogenic origin. The largest contributors to impairment on the 20% worst days vary by season with ammonium sulfate and organic carbon dominating in the summer and ammonium nitrate and sulfate dominating in the winter. The largest stationary source contributors are electric generating units. The majority of the impairment is not from sources within the 6-county area of interest, nor from sources within the state of Minnesota. Emissions from Minnesota sources represent the single largest contribution of any state, however, the total from sources in other states and Canada make up the majority of the impairment.

As part of the long term strategy to meet the visibility goals, the MPCA, in conjunction with the FFLMs for the Class I areas, developed the Northeast Minnesota Plan. This plan is expected to ensure that emissions in the northeastern 6 counties in the state are reduced over time to facilitate meeting the RPG. The plan includes the following provisions:

- Includes sources over 100 tpy of either $SO_2$ or $NO_x$ based on 2002 emissions.
- Targets a 20% reduction in combined $SO_2$ and $NO_x$ by 2012 and 30% reduction by 2018 compared to 2002 levels. Estimates of emissions in 2015 show an overall reduction of $SO_2$ and $NO_x$ of approximately 25 percent when compared to 2002, including the proposed projects and reductions.
- MPCA will review emissions and progress towards the visibility goals when any new major source applies for a permit or an existing source gets a PSD permit and will share the information with the FLMs.
- Taconite sources (Northshore, Keetac, Minntac, Hibbing Taconite, United Taconite, Mittal; all in the 6-county area) will be required to monitor starting in 2008.
- If the EGU and taconite reductions aren't adequate, the MPCA will require other sources to reduce through a "state retrofit" requirement.

# 6.0 Findings and Conclusions

### Visibility Trends

Visibility in the BWCAW is gradually improving on the 20% worst visibility days, based on the 5-year rolling average haze index. Figure 30 compares the 5-year rolling average haze index to the reasonable progress goals (RPGs) set in the Regional Haze Plan (reference (3)). The 2018 RPG appears to be roughly consistent with the trend seen in the 5- year rolling averages. An obvious trend in visibility in VNP is not evident based on the NPS statistical assessment of the monitoring data.

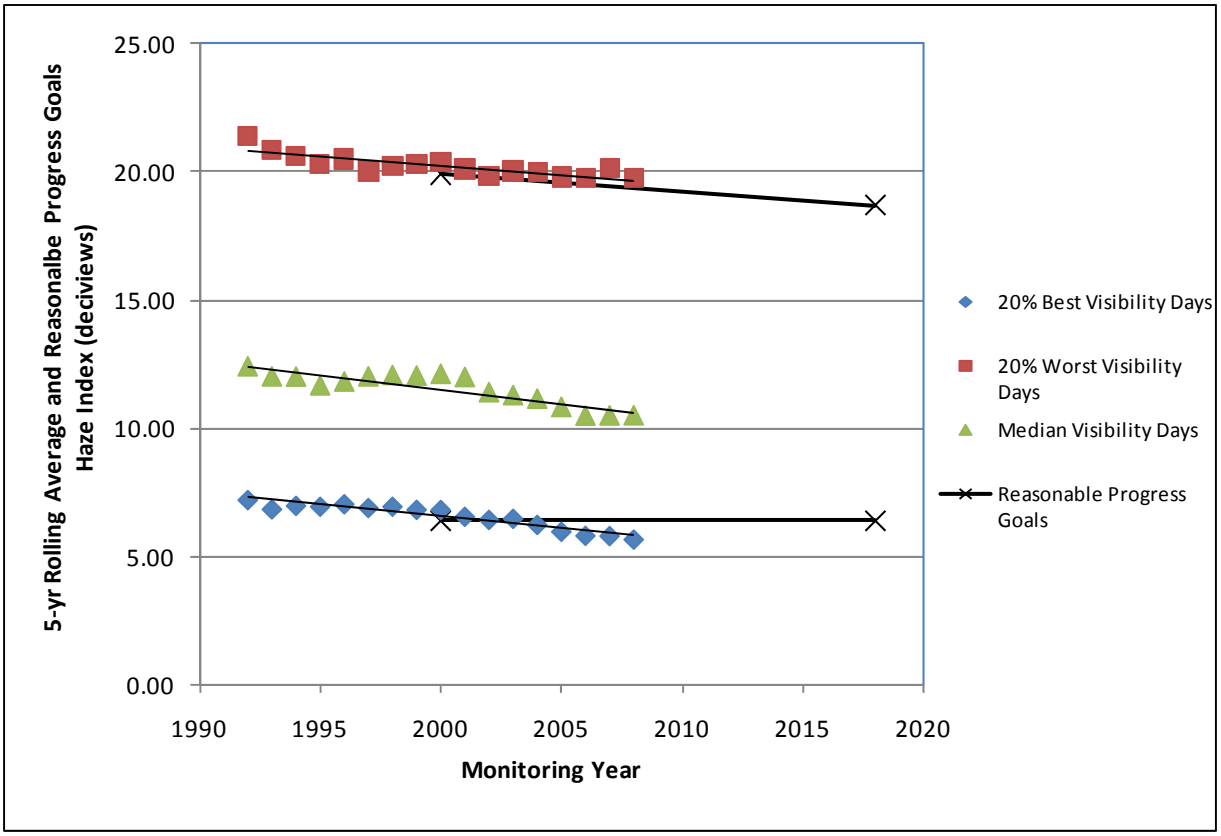



**Figure 30 Minnesota Regional Haze Plan Reasonable Progress Goals for the BWCAW and five-year rolling averages of the haze index (deciviews) and linear trend lines for the BOWA1 IMPROVE monitoring site based on data for Jan 1992 through Dec 2008.**

### Source Contribution

1. Source apportionment of fine particulate indicates that northeast Minnesota sources contribute approximately 14 – 15% of visibility impairment to the Class I areas on the 20% worst days.

2. Minnesota emission sources contribute about 32% and 26% of fine particles to VNP and the BWCAW, respectively. The majority of impairment (approximately 70%) is caused by emissions from out-of-state sources.

3. The major contributors to visibility impairment are ammonium sulfate and ammonium nitrate, secondary aerosols formed from $SO_2$ and $NO_x$ emissions. The proposed projects combined with the concurrent voluntary reductions result in a net decrease of both $SO_2$ and $NO_x$. Although $PM_{10}$ emissions will increase from the projects, direct particulate emissions are not a significant contributor to visibility impairment in either of Minnesota's Class I areas.

### Emission Trends

1. The potential $PM_{10}$, $SO_2$ and $NO_x$ cumulative emissions increase from the proposed projects are relatively small in comparison to statewide emissions. To the extent local emissions affect visibility in the BWCAW and VNP, the potential increases in $SO_2$, $NO_x$ and $PM_{10}$ stationary source emissions from the proposed projects are within historical emission variability for the six-county project area and the state as a whole.

| Emission Category | $PM_{10}$ (tons/yr) | $SO_2$ (tons/yr) | $NO_x$ (tons/yr) |
|---|---|---|---|
| Proposed Projects: | 6,274 | 2,807 | 6,635 |
| Statewide Emissions (all sources, 2009): | 768,930 | 101,000 | 353,000 |
| 2008 Six-County Area Emissions (stationary sources only) | 15,045 | 40,115 | 54,350 |
| Maximum Increase From Projects from 2009 Statewide (approximate): | 1% | 3% | 2% |

2. The potential emission increases from the proposed project will be offset by reductions from other northeast Minnesota sources due to voluntary actions and current and foreseeable federal regulations such as mobile source reductions and Regional Haze/BART. In northeast Minnesota, Minnesota Power, US Steel Minntac, Hill Wood Products and BART requirements will reduce $SO_2$ and $NO_x$ emissions by 16,467 tons/year and 20,996 tons/year, respectively, resulting in a net decrease in these pollutants. In other parts of the state, Xcel Energy, Otter Tail Power and Rochester Public Utilities will reduce both $NO_x$ and $SO_2$ significantly.

3. Although there is a net increase in $PM_{10}$ emissions from the proposed projects, a large percentage are fugitive emissions that will likely deposit nearby the source based on air dispersion/deposition modeling results in Class II areas and contribute little, if any, to visibility impairment in the more distant Class I areas. Direct particulate emissions are not a significant contributor to visibility

impairment in either of Minnesota's Class I areas and these potential emission increases are not expected to change this.

4. It is likely that the national emission reductions in $SO_2$, $NO_x$, and $PM_{10/2.5}$ from the foreseeable regulatory actions and the implementation of the Regional Haze Plan Long Term Strategy, which may require additional future reductions, will lead to declining $PM_{10/2.5}$ air concentrations and decreased visibility impairment in VNP and the BWCAW (references (3)(39)).

### Conclusion

The net effect from the proposed projects, the voluntary reductions of Minnesota Power, the mining companies and the foreseeable regulatory actions will be to reduce emissions of $SO_2$ and $NO_x$ in Minnesota. Within the context of anticipated regulatory changes, and expected emission reductions the current trend in visibility improvement is not likely to be changed by the proposed projects in northeast Minnesota. Although direct emissions of $PM_{10}$ will increase, a large percentage is fugitive emissions that will deposit nearby the source. Subsequently, foreseeable emission reductions in Minnesota should continue to improve the visibility in VNP and the BWCAW, although it is uncertain as to the degree of visibility improvement that will be obtained from the emission reductions in Minnesota alone. Additional improvement in the air quality of VNP and the BWCAW is expected due to national, statewide and regional reductions of $SO_2$, $NO_x$, and $PM_{10/2.5}$ emissions. Therefore, gradual visibility improvement in VNP and the BWCAW is expected in the future.

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# 8.0 Abbreviations / Acronyms / Selected Definitions

[Visibility related abbreviations and definitions adapted from EPA 2003; Guidance for Tracking Progress Under the Regional Haze Rule; EPA-454/B-03-004.]

| | |
|---|---|
| BART | Best Available Retrofit Technology |
| BWCAW | Boundary Waters Canoe Area (Wilderness); located in northeast Minnesota |
| CAA / CAAA | Clean Air Act / Clean Air Act Amendments |
| CAIR / CAMR | Clean Air Interstate Rule / Clean Air Mercury Rule |
| CENRAP | Central States Regional Air Partnership: one of five regional planning organizations for Implementing the Regional Haze Rule. Member states include Minnesota, Iowa, Nebraska, Missouri, Arkansas, Kansas, Oklahoma, Texas, Louisiana |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| CIRA | Cooperative Institute for Research in the Atmosphere, Colorado State University |
| COHA | Causes of Haze website; sponsored by the WRAP and CENRAP (http://coha.dri.edu/) |
| CM | Coarse particle mass (same as PMC) |
| DRI | Direct Reduced Iron |
| DMS | dimethyl sulfide (from Park et al. 2005) |
| Dv or dv | Deciview, unit of the haze index |
| EC | Elemental carbon |
| EIS | Environmental Impact Statement |
| EPA, USEPA | United States Environmental Protection Agency |
| IMPROVE | Interagency Monitoring of Protected Visual Environments |
| km | kilometer |
| LAC | Light absorbing carbon |
| MACT | Maximum Achievable Control Technology |
| MERP | Xcel Energy's Metropolitan Emission Reduction Project |
| MDNR | Minnesota Department of Natural Resources |
| MPCA | Minnesota Pollution Control Agency |
| $Mm^{-1}$ | Inverse megameter ($10^{-6}$ $m^{-1}$) |
| $NO_X$ | Oxides of nitrogen |
| NPS | National Park Service |
| LAC | Light absorbing carbon |

| | |
|---|---|
| OC | Organic carbon |
| OMC | Organic carbon mass |
| PIXE | Proton induced x-ray emission spectroscopy |
| PM | Particulate matter |
| PMC | Particulate matter, coarse (aerodynamic size fraction between 10 and 2.5 microns) (same as CM) |
| PMF | Particulate matter, fine (typically referred to as $PM_{2.5}$) |
| $PM_{2.5}$ | Particulate matter with an aerodynamic diameter less than 2.5 microns |
| $PM_{10}$ | particulate matter with an aerodynamic diameter less than 10 microns |
| PSD | Prevention of Significant Deterioration |
| PTE | Potential-to-emit as defined at 40 CFR 52.21(b)(4) |
| RH | Relative humidity |
| RPO | Regional Planning Organization |
| SIP | State Implementation Plan |
| $SO_2$ | Sulfur dioxide |
| $SO_x$ | Sulfur oxides – including all of the oxides of sulfur |
| ton | Short ton = 2,000 pounds |
| ton, long | Long ton = 2240 pounds |
| ton, metric | Metric ton = 2204.6 pounds |
| $\mu g/m^3$ | micrograms per cubic meter |
| µm | micrometer or micron; one-millionth of a meter. |
| U.S. | United States |
| VNP | Voyageurs National Park; located in northeast Minnesota |
| WRAP | Western Region Air Partnership. One of five regional planning organizations formed to implement the Regional Haze Rule. Member states include: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming |
| Yr or yr | year |

### Selected Definitions

Aerosols – suspensions of tiny liquid and/or solids particles in air.

Class I Area – Under the Clean Air Act, a Class I area is one in which air quality is protected more stringently than under the national ambient air quality standards; Federal Class I areas include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. Mandatory Federal Class I areas include certain national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres), and international parks that were in existence as of August 1977.

Federal Class I Areas in Minnesota – Boundary Waters Canoe Area Wilderness and Voyageurs National Park.

Coarse mass – mass of particulate matter with an aerodynamic diameter greater than 2.5 microns but less than 10 microns.

Deciview (dv) – the unit of measurement of haze, as in the haze index (HI) defined below.

Fine soil – particulate matter composed of pollutants from the Earth's soil, with an aerodynamic diameter less than 2.5 microns. The soil mass is calculated from chemical mass measurements of fine aluminum, fine silicon, fine calcium, fine iron, and fine titanium as well as their associated oxides.

Haze Index – a measure of visibility derived from calculated light extinction measurements that is designed so that uniform changes in the haze index correspond to uniform incremental changes in visual perceptions, across the entire range of conditions from pristine to highly impaired. The haze index [in units of deciviews (dv)] is calculated directly from the total light extinction [$b_{ext}$ expressed in inverse megameters ($Mm^{-1}$)] as follows:

$$HI = 10 \ln(b_{ext}/10)$$

Light absorbing carbon – carbon particles in the atmosphere that absorb light; also reported as elemental carbon.

Least-impaired days – data representing a subset of the annual measurements that correspond to the clearest, or least hazy, days of the year.

Light extinction – a measure of how much light is absorbed or scattered as it passes through a medium, such as the atmosphere. The aerosol light extinction refers to the absorption and scattering by aerosols, and the total light extinction refers to the sum of the aerosol light extinction, the absorption of gases (such as NO2), and the atmospheric light extinction (Rayleigh scattering).

Most impaired days – data representing a subset of the annual measurements that correspond to the dirtiest, or haziest, days of the year.

Nitrate – solid or liquid particulate matter containing ammonium nitrate [$NH_4NO_3$] or other nitrate salts. Atmospheric nitrate aerosols are often formed from the atmospheric oxidation of oxides of nitrogen ($NO_X$).

Organic carbon – aerosols composed of organic compounds, which may result from emissions from incomplete combustion processes, solvent evaporation followed by atmospheric condensation, or the oxidation of some vegetative emissions.

Particulate matter – material that is carried by liquid or solid aerosol particles with aerodynamic diameters less than 10 microns. The term is used for both the in situ atmospheric suspension and the sample collected by filtration or other means.

Particulate matter, coarse (PMC) – particulate matter with an aerodynamic diameter less than 10 microns but greater than 2.5 microns.

Particulate matter, fine (PMF) – particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$).

Rayleigh scattering ($b_{RAYLEIGH}$) – light scattering of the natural gases in the atmosphere. At an elevation of 1.8 kilometers, the light extinction from Rayleigh scattering is approximately 10 inverse megameters ($Mm^{-1}$). This is the standard value used in visibility calculations regardless of site elevation in keeping with the practice of rounding each constant in the aerosol extinction coefficient to one significant digit and to simplify comparisons of values among sites at a variety of elevations.

Relative humidity – partial pressure of water vapor at the atmospheric temperature divided by the vapor pressure of water at that temperature, expressed as a percentage.

Sulfate – solid or liquid particulate matter composed of sulfuric acid [$H_2SO_4$], ammonium bisulfate [$NH_4HSO_4$], or ammonium sulfate [$(NH4)_2SO_4$]. Atmospheric sulfate aerosols are often formed form the atmospheric oxidation of sulfur dioxide.

Taconite – low-grade iron ore processed by crushing and concentrating to yield a pellet for use in iron smelters. Taconite has low mercury concentrations but large volumes of the material are heated during processing, which releases mercury into the atmosphere.

Total carbon – sum of the light absorbing carbon and organic carbon.

Visibility impairment – any humanly perceptible change in visibility (light extinction, visual range, contrast, coloration) from that which would have existed under natural conditions. This change in atmospheric transparency results from added particulate matter or trace gases.

# 9.0 Attachment A: Comments and Responses Related to Cumulative Visibility Report

**Report Name: Cumulative Impacts Analysis Assessment of Potential Visibility Cumulative Impacts in Federal Class I Areas in Minnesota NorthMet Project dated May 2011**
**Date: 6/21/2011**
**Compiled by: Suzanne Baumann**
**Team**: Catherine Neuschler, MPCA; Trent Wickman, USFS; Joy Wiecks, FdL

| Comment ID | Initials | Chapter | Page | Para/ Sentence | Comment | PolyMet/Barr Response | Commenter Review of Response | PolyMet/Barr Response |
|---|---|---|---|---|---|---|---|---|
| 00001 | CN | Tech Summ | 1 | | Line 3 typo | This will be corrected in the revised report. | OK | No response necessary. |
| 00002 | CN | Tech Summ | 1 | 3 | Feel like the chemistry needs a little more clariy. SO2 and NOx react with ammonia to form sulfate and nitrates. Also, we generally refer to secondary organic aerosols rather than compounds. | Chemistry will be elaborated in the text of the revised report. | OK | No response necessary. |
| 00003 | CN | Tech Summ | 2 | 2 | The rule sets a **goal** of no man-made visibility impairment by 2064. | Difference between requirement and goal noted and text will be changed appropriately. | OK | No response necessary. |
| 00004 | CN | Tech Summ | 3 | 1 | 2009 data is available for both parks. | As of May 2011 only the concentration data was available for 2009 through the VIEWS website. Calculated visibility data (haze index and deciview contribution of components) was not available. Currently, calculated data (haze index) is also available for 2009 and will be added to the report. | OK | No response necessary. |
| 00005 | CN | 1.0 Intro | 5 | 2 | Seems like a repetitive paragraph. Could probably be shortened. | Noted. The scope of the cumulative assessment is quite important (see comments 00032, 00034, 00038, 44, 48, 58, 61, 66), so the origin of the scope is included in detail in this section to define what the report intends to address. We recommend keeping this section in the report. | OK | No response necessary. |
| 00006 | CN | 1.3 | 7 | 3 | Mentions that Table 1 shows that emissions will be reduced due to large reductions from Minnesota Power's facilities. Some part of these reduction projects were likely already in place and operating as of the 1/1/2010 date and so could be impacting the 2009 visibility data. | Many of the power emissions reduction projects were partially underway by 1/10/2010, however, none were complete. It is reasonable to expect, therefore that emissions in the "future" (post 1/1/2010) would be reduced compared to historical emissions. Because some projects may have relalized some reduction prior to full project completion, the expected reductions from 2002 base emissions have been adjusted to account for any reductions that have already taken place up through 2009, based on actual 2002 and 2009 emissions. The reductions cited in Table 1, will be adjusted to account for any reductions that have taken place prior to 1/1/2010. The following methodology will be used for calculating anticipated future reductions from all projects.<br><br>Future reduction = anticipated reduction from 2002 baseline - (2002 actual emissions - 2009 actual emissions) | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| | | | | | | Note1: Negative reductions will be considered to be zero (it is possible that reductions beyond the anticipated reduction have already occured).<br>Note2: If actual emissions have increased since 2002, the projected decrease will be set equal to the decrease from 2002 (decrease is capped).<br>Note3: When reductions are compared to 2008 data (i.e. NE MN emission inventory) the 2008 actual emissions will be used to account for any reduction already achieved. | | |
| 00007 | CN | Table 1 | 8 | | Taconite Harbor Unit 2 is shown with a footnote that says "facility shutdown" - I'm not aware that MP plans to shut down this unit. Also, we will need to pay close attention to what is listed on the table as occurring since 2010. The emission estimates on the NE MN tracking spreadsheet are all estimated reductions from 2002 emissions, so this raises the same issue as identified above: all the emission reductions may be portrayed as occurring since 2010 when part might have already been completed. | The footnote regarding the Taconite Harbor Unit 2 shutdown was in error and will be removed. See response to comment 00006. | OK | No response necessary. |
| 00008 | CN | 1.4.3 | 13 | 2 | Typo - kept subscript too long | Will be corrected in text | OK | No response necessary. |

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| 00009 | CN | 1.4.4 | 15 | | The plural of FLM is "FLMs" not "FLM's" | Will be corrected in text | OK | No response necessary. |
| 00010 | CN | 1.4.4 | 16 | Rule Reqs | The bullets are inconsistent - one has 2014 - 2018 and one 2013 - 2017 | Will be corrected in text | OK | No response necessary. |
| 00011 | CN | 1.5 | 17 | Bulleted List | Aren't speciationation and size fraction two different things, so the FLMs request an assessment of PM, differentiated both into size fractions and species? The sentence after the bulleted list seems to say this, but the sentence before seems to conflate the two. | The categories will be de-conflated in the text. | OK | No response necessary. |
| 00012 | CN | 2.1 | 18 | 2 | This sentence is very confusing. "For monitoring data, visibility information from the IMPROVE network are available for full calendar years from 1992 to 2008, depending on the site and concentration data for key species affecting visibility are available for full calendar years from 1992 to 2009, depending on the site (see section 3.0 for more information)." I believe all data is available through 2009. Even if not, the sentence needs a semi-colon or something in the middle. | See comment 00004. | OK | No response necessary. |
| 00013 | CN | 2.2 | 19 | Bulleted List | Good that this emission reductions piece seems to parse out and include only those projects that are not yet completed (I think, based on the fact that it says things like "Tac Harbor 2" rather than just the whole facility). | Noted. | OK - the baseline issue is going to have to be looked at carefully as we go through this process | Noted |
| 00014 | CN | 3.1 | 23 | Table 3 | Footnote 2 here seems to address my earlier comment about the available data through 2009. The footnote is very clear should perhaps be used in place of the sentence mentioned in comment 12. | See comment 00004. | OK, but will the language in the text be clarified? | Language will be more clear in revised report now that all data through 2009 is available. |
| 00015 | CN | 3.3 | 25 | Table 5 | Not sure why this part went all the way back to 1992; nothing else goes back that far. Also, the sentence should mention that for VOYA it was 2000 (which is in the table title but not in the text). Maybe also mention the baseline used in the Regional Haze SIP. | The full range of data available for each monitoring site is represented in the table. The general public may not be aware of the improvements in air quality or the trend of improving visibility in the BWCAW. The report is meant to provide information on what data has been collected and what it means (e.g., trends in data). The trend in improving visibility is an important factor for the public to understand and to consider in assessing the potential for significant impact from the cumulative emissions from the proposed projects. The timeframe of the VOYA2 site will be added to the text. It is understood that in addition to overall trends the regulatory timeframe of the regional haze rule is also important and it will be addressed in the revised report where appropriate, including Table 5. | Trent: The report needs to note that the direction of a trend in visibility is completely dependant on the base year selected. As such the public should also know that there is a decrease in visibility across all northern CIAs since 2000 (http://vista.cira.colostate.edu/improve/Publications/Reports/2011/2011.htm) | The visibility decrease referred to in section 9.4.1 of the IMPROVE V report is not a trend analysis but a comparison of the average of 2000-2004 data and 2005-2009 data for the BWCAW. In this case there is one particularly high visibility year in the first time period and one particularly low visibility year in the second period. When the two time periods are compared and presented as a trend in this way it does appear that visibility has decreased over the entire decade. However, a trend analysis using 5-year rolling averages does not highlight the effects of these two particular years in the same way and shows fairly consistent visibility, if not a slight improvement in visibility over the decade.<br>The revised cumulative visibility assessment report will note that the trend improving visibility is greater in the 1990's and relatively flat in the past decade in the BWCAW. |
| 00016 | CN | 3.3 | 26 - 31 | Figures | It would be nice if there was some way to emphasize the deciviews/haze index figures, as these seem to me to be the most important. | The haze index figures are first the the series for each park. The size of these figures relative to the others will be increased in the revised report. | OK | No response necessary. |
| 00017 | CN | 3.4.1 | 32 | | If you talk about sources outside of the modeling domain, might be good to briefly mention what the modeling domain covered. | Figure of modeling domains will be added to the report. | OK | No response necessary. |
| 00018 | CN | .1.1 and 4.1. | 39 -40 | | I think these tables are quite useful. | OK | | No response necessary. |
| 00019 | CN | 4.1.4 | 42 | | I like the description of the projects; is there some way here to try to sort out pre and post-2010? Also, there seem to be footnotes here that I'm not sure where they go? If they are references, then I'm not sure the MN Haze SIP really gives enough info to discuss the pre and post 2010 stuff. | To our knowledge, none of these projects were complete prior to 2010. See response to comment 00006 regarding emissions reductions compared to 2009 emissions. | OK | No response necessary. |

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| 00020 | CN | 4.1.5 | 43 | | Says that the actions in section 4.1.4 are voluntary, but they are not all - many of them are BART and therefore not voluntary. | It will be clarified in the text that not all are voluntary. | OK | No response necessary. |
| 00021 | CN | .2.1 and 4.2. | 46 | | It doesn't really seem necessary to take this much of a historical look. Going back to 1990 or 1995 or so would be enough. | The historical look at SO2 emissions will be scaled back. | OK | No response necessary. |
| 00022 | CN | 4.2.1 | 46 | | Typo, second to last line (stationary) | this will be corrected in text | OK | No response necessary. |
| 00023 | CN | 4.2.2 | 48, 51, 53 | Figures 22, 24, 25 | Using three separate graphs here is confusing, especially as the colors change. Could you recreate the graphs and make the colors consistent, or only include the most recent one? The most recent years are probably the most critical. | The figures are from MPCA reports. As identified for each figure, the respective figure was taken directly from the MPCA legislative reports for 2004, 2008 and 2011 respectively, which dictated the year ranges and colors. Data is not readily and publically available to recreate the graphs in a more aesthetically pleasing format. | OK | No response necessary. |
| 00024 | CN | 4.3.1 | 57 | | Seems odd to say that emissions will level off in 2010. Either they were expected to, or did. Also, this seems to treat the issue of banked allowances as completely separate from CAIR or TR, when in fact the application of the TR may prevent sources from using too many banked allowances. | Wording will be clarified in text. | OK | No response necessary. |
| 00025 | CN | 4.3.3 | 58 | | Might want to mention that the PM2.5 NAAQS revision is also likely to include a revision of the PM10 NAAQS. | Point will be noted in text. | OK | No response necessary. |
| 00026 | CN | 4.4 | 59 | | I would prefer it if we could separate "on the books/way" programs that will reduce emissions from programs that serve to constrain emissions. The Minnesota and Federal Acid Rain programs really aren't serving to further reduce emissions, though they do likely provide some constraint on emissions growth. (This is elaborated well later, but it's not very clear in the first bulleted list.) | will be noted in text. | OK | No response necessary. |
| 00027 | CN | 4.4 | 59 | | We keep putting "Wisconsin and Michigan ozone and PM2.5 SIPs" in this category, and I'm not aware that anything is really going to come from those. I believe both states are pursuing redesignation requests rather than developing full SIPs, at least for PM2.5, and the 2008 ozone standard isn't being implemented. Maybe this should be changed to more broadly say "SIPs from nearby states for upcoming ozone and PM2.5 NAAQS standards" | Change will be made in text. | OK | No response necessary. |
| 00028 | CN | 4.4.4 | 62 | | The ozone standard is expected to be final in July 2011 - it has already been proposed. | It will be noted in the text of the revised report that the rule is finalized and the text will be updated to reflect the Cross-State Air Pollution Rule instead of the Transport Rule. | Trent: The ozone standard is no longer a rule to c | The revised report will reflect the most recent status of rules and standards at the time of submission. |
| 00029 | CN | 5 | 64 | | I do not belive the SIP referenced the renewable energy standard as a reason that we expected to have more visibility improvement than the RPGs. | The renewable energy standard is included in the 2010 SIP under the section titled "Potential Future Projects and Impacts" that discusses likely actions that were not included in the RPGs. (p.106) | OK | No response necessary. |
| 00030 | CN | 5 | 64 | | Two facilities were added as proposed “east mine” (Polymet) and “west mine” (Essar). The emissions projections also reflect lines at UTAC line 1 and Northshore Mining Silver Bay Furnace 5, that did not operate during 2002. Emissions for the Mesabi Nugget taconite plant were also added to the future year inventory. | Noted. Northshore Mining Furnace 5 will be added to the existing list. | OK | No response necessary. |

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| 00031 | tw-1 | | 3 | | Summary finding #1 is sensitive to the baseline chosen. Recent analysis for the upcoming IMPROVE report shows that since 2000 the BWCA and Voyagers monitors (along with the 2 other "northern" class I areas) are the only ones in the eastern US where visibility has degraded. Map will be provided. Please include this data and change summary finding #1 to reflect the fact that using a more recent baseline date of 2000 a decrease is seen. | The scope of the Cummulative Impact Analysis for Visibility assesment for the SDEIS differs from the Minnesota Regional Haze SIP. The Cumulative Impact Analysis for Visibility is provided to determine whether or not the proposed project will result in degredation of the visibility resource when considered "cumulatively" with exisiting and other known future projects. Therefore, is is appropriate to use the entire dataset available regarding the visibility resource for determining trends regarding visibility and emissions. | Please include a statement in the report that the direction of a trend in the dataset is dependent on the baseline date selected and that trends since 2000 show a worsening of visibility. | The revised cumulative visibility assessment will note that the trend of improving visibility is greater in the 1990's and relatively flat in the past decade in the BWCAW. See response to Comment 00015 for additional supporting information. |
| 00031 cont. | | | | | | The 2011 IMPROVE report, published in June 2011, does have a case study for the BWCAW, however, it only compares the average of two regulatory five year periods, not trends in the BWCAW. The case study also indicates that several high bext episodes in 2005 seem to be driving most of the apparent difference between the two time periods. The Visibility Cumulative Impacts Analysis is addressing trends in visibility, not the regulatory 5 year period comparisons used in the case study. The speciation trend analysis that is presented in the 2011 IMPROVE report shows either decreasing trends or no significant trend for the concentration of all visibility impairing constituents for short term trends at both BOWA1 and VOYA2 and long term trends at BOWA1.<br><br>However, the regulatory timeframe associated with the Regional Haze Rule is acknowledged and a discussion of trends since 2000 for BWCAW will be added to the text where appropriate. | | |
| 00032 | tw-2 | | 3 | | after summary finding # 3 please add a finding that discusses whether or not NE MN will make the 20% by 2012 and 30% by 2018 goals in the regional haze SIP. Emissions must go down to meet the goals of the regional haze SIP so it is not a significant finding that emissions in the future may go down. The significant question is whether it will go down enough. Please use the tracking spreadsheet maintained by MPCA and discuss the impact of including excelsior energy in this spreadsheet on whether the goals will be met. | Whether or not the goals set in the regional haze SIP are met is beyond the scope of this report. See response to comment 00031. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, within the scope of the report | Our understanding is that the regulatory agencies will work directly with ERM on developing the discussion of the Regional Haze SIP for the SDEIS. Therefore, further revision to the report to address this topic is not necessary. |
| 00033 | tw-3 | | 3 | | how the emission reductions are calculated that supports finding #3 in some cases leads to the double counting of emission reductions - as will be discussed in later comments | To be addressed as pertains to later comments. | | Please see responses to other comments. |
| 00034 | tw-4 | | 4 | | Finding #6 "Over the next decade, voluntary and mandatory reductions in SO2, NOx and direct particulate emissions from existing sources in Minnesota and nationwide (including transportation sources) are likely to more than offset emissions from the proposed projects." again the significance of this conclusion is not clear. emissions must go down (more than an offset) to meet the regional haze SIP and the significant question is whether they will go down enough | The "findings and conclusions" in the July 2011 Cumulative Visibility Report, that "net decrease" or "offsets" lead to visibility improvement, are the same conclusions reached by the MPCA in their modeling for the Regional Haze SIP. In that modeling, five projects were included as emission increases (Mesabi Nugget Phase I, NorthMet, Essar, UTac Line 1, Northshore Silver Bay Furnace 5) (MPCA 2009). However, even with the three proposed new mining projects (Mesabi Nuggest Phase I, Essar, PolyMet), the SO2 and NOx emissions for the 2018 modeled year showed a net decrease from the 2002 modeled year (MPCA 2009). Therefore, the Cumulative Visibility Report is consistent with the findings from the Regional Haze SIP modeling results that visibility improves even with the addition of proposed projects. Whether the improvement is enough to meet reasonable progress goals or natural visibility by 2064 is beyond the scope of this Cumulative Visibility Analysis. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, within the scope of the report | Our understanding is that the regulatory agencies will work directly with ERM on developing the discussion of the Regional Haze SIP for the SDEIS. Therefore, further revision to the report to address this topic is not necessary. |
| 00035 | tw-5 | | 6 | | The statement that emission changes will only be included if they occurred after 1/1/10 (because the monitoring data available goes through 12/31/09) is a key statement establishing the baseline and one that is not followed throughout the document | Only emissions reductions that will be fully implemented after 12/31/09 are included and only future projects that have yet to be fully implemented by 12/31/09 are included. See response to comment 00006. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |

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| 00036 | tw-6 | | 8 | | there is a problem with some of the emission reduction values in Table 1. For example Minntac's reduction of 7624 tons of NOx is based on the difference between its current permit limit and its emissions in 2002. Unless Minntac is currently in noncompliance with its permit, that reduction has already taken place. See the 2009 NOx emissions for Minntac. | Please see response to comment 00006 with regards to how antipicated future reductions are calculated. The low NOx burners were installed at Minntac in 2010 and 2011 so any reductions from the low NOx burner installation is considered a future reduction. | regardless of whether the burners were installed or not, the<br>NOx emissions from Minntac in 2009 were 5963 tons according to the MPCA tracking spreadsheet. Further reductions from 5963 tons are unlikely. | Communications between US Steel and the Minnesota Pollution Control Agency have stated a goal of 3,990 tons per year NOx emissions at Minntac. Recent pilot test results indicates that progress is being made toward this goal and there are no indications at this time that this target has been changed.<br>The revised report will reflect and cite this information as appropriate. |
| 00037 | tw-7 | | 18 | | section 2.1 Timeframe - historical emission rates back to 1990 are irrelevant. As stated on page 6 the baseline should be determined based on the date of available monitoring data. Also see discussion regarding "reasonably foreseeable" where 2009 is determined to be baseline based on availablility of IMPROVE data | Within the context of cumulative impacts and long term trends in visibility, long term trends in emissions are relevant. IMPROVE monitoring data and visibility calculations are available for the BOWA1 site starting in 1992, so the emissions from the corresponding time period is relevant. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, relevant | Ultimately the lead agencies (MDNR, USACE, USFS) determine what information will be included in the SDEIS. It is not unreasonable to provide all potentially informative data in the cumulative visibility report for consideration. |
| 00038 | tw-8 | | 26 | | please include a section (#3.4) that discusses where the improve data is in relation to the reasonable progress goals set for BOWA snd VOYA in the regional haze SIP | This discussion is already included in section 6.0 (see figure). | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 00039 | tw-9 | | 25 | | why is there no discussion regarding the increase in NH3NO3? | The difference between 20% best and median days and 20% worst days will be added to the text. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 00040 | tw-10 | | 38 | | "The estimated 2015 emissions for existing facilities do not take into consideration any reductions due to foreseeable regulatory actions, but do include reductions from Hill Wood Products, Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities along with reductions required under BART for United Taconite and Northshore Mining." This statement is inaccurate, many of the reductions listed are related to meeting BART and/or the Transport Rule which are listed under section 4.4 | As stated, the reductions related to meeting BART and certain Power Industry reductions are included. Wording will be changed to make this point more clear. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 41 | tw-11 | | 39 | | same comment as above - many of the reductions listed are related to meeting BART and/or the Transport Rule which are listed under section 4.4 | The footnote to the table will be edited to indicate which reductions are included. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 42 | tw-12 | | 40 | | "This represents a maximum potential increase of about 12% compared to 2008 local NOx emissions of 54,350 tons. However, when decreases in NOx from the proposed projects are included (see Table 1, "Reductions"), the emissions will decrease by about 26% compared to the 2008 levels." This needs to be reconsidered in light of comment 6. Comparisons here with reductions calculated in table 1 are problematic because it assumes the baseline for the reduction calculations are 2009 which is not the case and can lead to paper reductions - i.e. Minntac | Please see response to comment 00006 with regards to how anticipated future reductions are calculated.<br><br>Also note that all emissions increases from projects are to a certain extent "paper increases" because they are based on forseeable potential to emit. Actual future emission cannot be known, but using the potential does overstate what the actual increases will be. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 43 | tw-13 | | 46 | | 2009 is an anomalous year due to the economic downturn and shuttering of most of taconite industry. This should be noted or another year used to represent current emissions | A statement will be added to clarify that mining sector emission changes from 2008 to 2009 may be driven more by economics than long term emission trends. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 44 | tw-14 | | 47 | | "emissions added by the proposed projects are within the annual variability of statewide stationary source" Being within the range of natural variablility is not a goal. To achieve the goals in the RH SIP emissions must go down enough to meet the RPG. | This statement is meant to put the emissions from the proposed projects in perspective of historical emissions, not to imply that that the emissions will meet the RH SIP goal. Assessing whether or not the RPG will be met is beyond the scope of the cummulative impacts analysis. Section 4.4 outlines actions that either reduce or constrain emissions and does imply that the overall trend in the regulatory framework is toward reducing emissions. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, within the scope of the report | Our understanding is that the regulatory agencies will work directly with ERM on developing the discussion of the Regional Haze SIP for the SDEIS. Therefore, further revision to the report to address this topic is not necessary. |

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| 45 | tw-15 | | 47 and 49 | | Comparisons here with reductions calculated in table 1 are problematic because they assume the baseline for the reduction calculations are 2009 which is not the case and can lead to paper reductions - i.e. Minntac comment 6. Predictions of reductions for 2015 for SO2 and NOx in Tables 6 and 7 are greater than the 2012 or 2018 predictions in MPCA tracking spreadsheet. Just use the MPCA tracking spreadsheet to show future emissions. | Please see the response to comments 00006 and 42. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 46 | tw-16 | | 54 | | Section 4.2.4 should be removed. To understand the impact of the sources in NE MN finer scale work using back trajectories and dispersion modeling should be employed. For example the results of subject to BART modeling done by MPCA should be discussed. Another example is work done by LADCO showing most of the sources in NE MN included in the top 30 impairing sources list. The lack of a correlation between the NE MN EI and the annual average IMPROVE monitoring data does not prove a lack of impact. There are many other reasons to explain the data. | Section 4.2.4 is essential for providing the public with information regarding how sensitive the visibility in Class I areas is to emissions from NE MN. While it is intuitive that closer sources have a greater impact, it is misleading to imply that reducing emissions in NE MN will be a driver in improving visibility. This section does not imply that emissions from NE MN have no impact on visiblity, but that they cannot be assumed to be the driving factor. The complexity of the systems that are involved in visibility impairment will be acknowledged in the text. Figures 17 and 18 in section 3.4.2 demonstrate the relative importance of NE MN emission to visibility impairment. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, a driving factor or what is helpful or essential information for the public to know. Please include a reference for (or a copy of) the LADCO report referenced. | We understand that there may be differing opinions on what data is relevant and how the data should be interpreted. The purpose of this report is to provide information to the Lead Agencies and the EIS contractor and other interested parties. The lead agencies (MDNR, USACE, USFS) will determine what information is presented in the SDEIS. |
| | | | | | | The data (Fig. 26 and 27) presented in Section 4.2.4 indicate that monitored concentrations of ammonium sulfate and ammonium nitrate do not parallel or track with emissions from northeast MN sources. This is confirmed by the CAMx modeling conducted for the Regional Haze SIP, that was calibrated for estimating baseline and future visibility impairment, and that modeling showed about 70% of the visibility impairment is due to out of state sources.<br>The BART modeling with CALPUFF was not calibrated to any baseline conditions. The CALPUFF model is known to overestimate potential visibility impairment and the relationship of CALPUFF modeling results to actual visibility impairment and/or visibility related monitoring data is highly uncertain. Therefore, presenting CALPUFF modeling results that may have no real relationship to visibility impairment does not seem helpful at this time.<br>The most recent LADCO summary indicates that impairment on 20% worst days is predominantly from southern MN and discusses source apportionment, but not source sensitivity. | | LADCO report is available here:<br><br>http://www.ladco.org/reports/rpo/consultation/products/regional_haze_in_the_upper_midwest_summary_of_technical_information_v2.2_feb_22_2008.pdf |
| 47 | tw-17 | | 56 | | "These potential increases and decreases do not take into account the likely reductions required by foreseeable regulatory and other actions" as stated previously many of these address BART and the transport rule (see comment 10) | Text will be updated to clarify that anticipated reductions from BART are included. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 48 | tw-18 | | 56 | | Somewhere in 4.1.5 local emissions section a discussion needs to take place concerning whether these emissions will go down enough to meet the 20 and 30% targets in the MN Regional Haze plan. Again, emissions MUST go down to acieve the goals of the regional haze plan - so showing that they are going down doesn't address the key question of whether they will go down enough to meet the goals (RPGs) in the regional haze plan | Whether the improvement is enough to meet reasonable progress goals or or the 2012 or 2018 emission goals is beyond the scope of this Cumulative Visibility Analysis. Please see response to comment 00031. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, within the scope of the report | Our understanding is that the regulatory agencies will work directly with ERM on developing the discussion of the Regional Haze SIP for the SDEIS. Therefore, further revision to the report to address this topic is not necessary. |
| 49 | tw-19 | | 57 | | In 2010 acid rain sources emitted 5.1 MM tons of SO2. The affect of allowances leveling off at 8.7 MM tons or the CAIR rule bringing emissions down 5 MM tons from 2005 (2005 emissions were 10.2 MM ton so that would mean down to 5.2 MM ton) are both nil. Current emissions are already below these levels. | The text already acknowledges that the function of the Acid Rain rule is to constrain and not reduce emissions. It is included in the report to emphasize the number of current rules already in place that at a minimum constrain emissions on a broad scale. The text will be updated to reflect the recently promulgated Cross State Air Pollution Rule, which replaced CAIR. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 50 | tw-20 | | 59 | | What is the relevance of trends with a baseline in 1990? that is 21 years ago | Please see response to comment 00015 | see previous comments | see previous responses |

| Comment ID | Initials | Chapter | Page | Para/ Sentence | Comment | PolyMet/Barr Response | Commenter Review of Response | PolyMet/Barr Response |
|---|---|---|---|---|---|---|---|---|
| 51 | tw-21 | | 59 | | The following programs have already been implemented, the specific reductions at NE MN facilities included, or, for the CAIR/Transport rule, the current emissions are already below the cap. Please remove them from this section.<br>. Minnesota's Acid Rain Rule (Minn. Rule parts 7021.0010-7021.0050);<br>• EPA Acid Rain Program (Title IV of the 1999 Clean Air Act Amendments); Phase II began implementation in 2000.<br>• The Clean Air Interstate Rule (CAIR) replacement called the Transport Rule, modifying 40 CFR Parts 51, 52, 72, 78, 97<br>• Regional Haze Rule, including Best Available Retrofit Technologies (BART) requirements for certain sources. On July 6, 2005, the U.S.EPA published final amendments to its 1999 regional haze rule in the Federal Register, including Appendix Y, the final guidance for Best Available Retrofit Technology (BART) determinations (70 FR39104-39172). | The emission constraint function of the EPA and MN acid rain programs is explained in Section 4.4<br>The Cross-State Air Pollution Rule (replacement to Transport Rule, which is replacement to CAIR) does call for emissions reductions with goals for 2012 and 2014 and was recently promulgated.<br>Certain aspects of BART for some facilities is still being determined and has yet to be implemented (e.g. UTac)<br>The discussion of these rules is relevant to the discussion of programs intended to reduce or restrict emissions and to illustrate that current programs either constrain or reduce emissions at both the State and National levels. The discussion of regulations anticipated to improve visibility will be updated to reflect recent poltical developments (e.g. recent statements by the President). | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 52 | tw-22 | | 62 | | "The plan, as submitted,proposes a goal of a 30% reduction in the six-county northeastern Minnesota region by 2018. Additional SO2 and NOx reductions may be required in Minnesota as part of the Regional Haze SIP requirements to meet federal visibility goals." this is one of the most important conclusions in the document and it is buried in the back. please add this to the summary findings | The summary and conclusion sections contain summary points that are related specifically to the cummulative analysis of visibility as pertains to known future projects in NE MN. A statement pertaining to possible additional future reductions will be added to finding #4 under "Emission Trends" | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 53 | tw-23 | | 64 | | "These include reductions being implemented by Xcel Energy at four of their plants..." Is this refering to MERP? Aren't these already done? | Please see response to comment 00006. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 54 | tw-24 | | 64 | | The discussion on future O3 and PM2.5 SIPs is extremely speculative. It is not clear what the future NAAQS will be or the distribution of future nonattainment areas. It is not clear that WI or MI would ask for any reductions from MN. In addition the purpose of the Transport Rule is to address these interstate transport issues related to O3 and PM2.5 and the affect of this rule is potentially minimal as illustrated in comment 19. | The text acknowledges that future responses are uncertain, but that future actions may be necessary to meet the SIP requirements in other areas and these actions will have emission reductions as a goal. It is not relevant whether or not WI or MI will require MN to make additional reductions to meet their SIP requirements. Because visibility in MN Class I areas is impacted by emissions in other states, any reduction in WI or MI will also lead to improvement in visibility in MN. All discussion of the Transport rule will be updated to reflect the recently promulgated Cross State Air Pollution Rule. | Has MN ever been asked by another state to make reductions? | The issue of pollution transport between states is addressed in the Cross State Air Pollution Rule. The response to the original comment may not have been clear. The intent was that if WI or MI reduce emission to address issues in other states (not MN), the reductions would also potentially have a positive effect in MN. |
| 55 | tw-25 | | 64 | | The following is another key point that deserves to be a summary finding "Under the current Regional Haze Plan for Minnesota, the MPCA has set a reasonable progress goal (RPG) that they believe can be met under the long term strategy. The goal is to achieve a haze index of 18.6 deciviews for the 20% worst days at BWCAW and 18.9 deciviews at VNP by 2018. The current 20% worst visibility, based on 2008 5-yr rolling averages of IMPROVE data, are 19.6 for BWCAW and 19.5 for VNP." Also since the baseline year for the rule (2000) the 20% worst days have gotten worse, so achieveing the RPG is getting harder all the time. | The resonable progress goals are addressed in Section 6.0: Visibility Trends. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 56 | tw-26 | | 65 | | The FLMs have been told this will not be implemented so please remove "and investigate control technologies and pollution prevention practices for indurating furnaces through pilot tests or other mechanisms during 2011-2012 and report cost and feasibility to the MPCA." | Statement will be removed from text. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 57 | tw-27 | | 66 | | "Visibility in the BWCAW is gradually improving on the 20% worst visibility days," again this is sensitive to the baseline year selected. The opposite is true if you choose the RH Rule baseline year of 2000. Please note this fact | Please see response to comments 00015 and 00031. | see previous responses | see previous responses |

| Comment ID | Initials | Chapter | Page | Para/ Sentence | Comment | PolyMet/Barr Response | Commenter Review of Response | PolyMet/Barr Response |
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| 58 | tw-28 | | 67 | | "are within historical emission variability for" and" increases from the proposed project will be offset by reductions" these are not criteria specified in the regional haze rule. Visibility is currently impaired and therefore emissions must go down. Reduction goals are set in the MN regional haze rule: ambient air stds (reasonable progress goals as measured by IMPROVE) and emission goals for NE MN sources (20% and 30% by 2012 and 2018). | New projects within the state will result in new emissions, just as the retirement of exisitng sources will result in the retirement of their emissions. This statement puts the potential emissions increase from all proposed projects within the context of statewide and historical emissions. The "net emissions" based on the increases from known new projects and reductions from existing facilities is also discussed in this section. | disagree. As a cooperating agency the Forest Service has a<br>say in determining what is, or is not, an appropriate context within which to describe the emissions. | Our understanding is that the regulatory agencies will work directly with ERM on developing the discussion of the Regional Haze SIP for the SDEIS. Therefore, further revision to the report to address this topic is not necessary. |
| 59 | tw-29 | | 68 | | "gradual visibility improvement in VNP and the BWCAW is expected in the future." see comment 29 | As stated in the text, based on the long term trends in visibility in MN Class I areas and the regulatory programs that are either in place or expected in the future, visibility is expected to improve. | disagree. Recent trends show a decline in visibility. Listed<br>regulatory porgrams are for the most part implemented or are so far in the future so as to make their mention extremely speculative and uncertain (note the recent Ozone NAAQS withdrawl and movements in Congress to delay implementation of other EPA regulations) | See comments 00015 and 00028 |
| 60 | JW1 | 1 | 2 | 1 | While it is true that the majority of haze-causing pollutants come from out of state, MN is the largest contributor to its own regional haze problems, with 28-31% of haze-causing pollutants coming from within the state (Fig. 8.3, RH SIP). The next largest contributors emit only 6-10% of the total. The current text gives a false sense of the issue. | The report highlights that ~70% of the emissions come from outisde of Minnesota, while Minnesota is the single largest contributor. Both statements are correct. The introductory statements in the Technical Summary provide some scale to the contribution of Minnesota sources to visibility conditions at MN Class I areas. The contibution of other states (next largest contributors) is covered in more detail in section 3.4. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 61 | JW2 | 1 | 3 | Item #3 | FdL agrees that the emissions of haze-causing pollutants emitted in MN are projected to decrease overall, it is still true that the state is not projected to meet its regional haze goals even when upcoming regulations are included in the projections. | The scope of the Cummulative Impact Analysis for Visibility assesment for the SDEIS does not include assesing the projected SIP goals. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 62 | JW3 | 1 | 3 | Item #4 | Same as for #1 above. From Fig. 8.5 in the RH SIP, NE MN contributes about 15% whereas the rest of the state contributes from 12-17%. Fig. 8.6 (BWCA) shows NE MN's contribution ranging from 3-19%. Shows that there is a real contribution from the NE MN area, especially when you consider that only roughly 5% of the state's population lives there. Also, sources in NE MN have been described as "traditionally undercontrolled". The report itself admits that half of the effects on RH from the state of MN come from the Arrowhead Region, consisting of maybe 15-20 facilities. | The full details and all topics are not covered in the Technical Summary. Item #4 is a summary statement regarding the emissions of the proposed projects in relation to existing emissions within MN. The details on project and state emissions are found in sections 1.3 and 4. | Mining sources are still traditionally under-controlled compared with, say, utilities. This is a reason why the NE MN Plan exists and is a reason why agencies are expecting more from this sector in the long term. What is missing from this discussion is a sense of what long-term visibility improvement can be expected when several new sources are being/may be constructed. | The visibility cumulative assessment report does not predict future actual levels of visibility, but does compare current and historical trends in visibility and presents information on the relative contributions of different areas to visibility impairment and the emissions of different regions (local, state, national). The conclusions drawn from these comparisons is that anticipated projects in NE MN, most of which are subject to BACT, are not expected to change current trends in visibility. (see section 6.0) |
| 63 | JW4 | | 4 | Item #6 | Proximity to a Class 1 area has a large impact, so we can't rely heavily on national emissions reductions for RH improvement in MN. | Close proximity is not necessarily an indicator of contribution to impairment. We acknowledge that Minnesota is the single largest contributor, but only contributes 30% of the total impact with 70 percent coming from outside MN. National programs aimed at reducing emissions will impact sources both in and outside of Minnesota, in theory reducing all emissions. Because 70% of haze causing pollutants are from out of state, reduction of emissions nationwide will be necessary to affect visibility in Minnesota. Even if the emissions in MN were reduced to zero, 70% of the haze causing pollutants would still be available. Reductions in national emissions are essential to continuing visibility improvements in MN Class I areas. | JOY: Again, the NE MN Visibility Plan was developed to address sources in this area. As the author of the Plan, the MPCA feels the contribution of local sources is important, as do the tribes.<br>TRENT: both national and state reductions are necessary - as recognized by the Hg TMDL for which MN as a lesser contribution than for visibility. | It seems that the commenter's concern has been addressed in the response to other comments and/or will be addressed by the planned coordination between the Agencies and ERM on preparing the discussion of the regional haze SIP for the SDIES. If this is not the case, additional follow-up can be provided. |
| 64 | JW5 | | 19 | | Isn't there a Utac fuel-switching project, too, that should be considered? | See the United Taconite Green Production Project in Table 1. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |

| Comment ID | Initials | Chapter | Page | Para/ Sentence | Comment | PolyMet/Barr Response | Commenter Review of Response | PolyMet/Barr Response |
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| 65 | JW6 | | 36 | | Proximity to a Class 1 area has a large impact. | As noted at the end of section 3.4.2 "Northeast Minnesota sources account for about half of the total contribution from Minnesota sources." | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 66 | JW7 | | 42 | | Even with reductions, MN is not expected to meet the glide path for the RH SIP. | Whether Minnesota meet its reasonable progress goals is beyond the scope of this Cumulative Visibility Analysis. This issue is better suited to be addressed within the context of a SIP reassessment. | This issue needs to be addressed. If beyond the scope of this document, then the MPCA needs to address. | Our understanding is that the regulatory agencies will work directly with ERM on developing the discussion of the Regional Haze SIP for the SDEIS. Therefore, further revision to the report to address this topic is not necessary. |
| 67 | JW8 | | 59 | | Ozone and PM reductions from WI's/MI's upcoming SIP's cannot be predicted. It is not even certain what the NAAQS are going to be, much less what areas these reductions will come from. Reductions are meant to address interstate transport, not NE MN's RH issues. | See response to comment 54. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 68 | JW9 | | | | The MN RH SIP is not enforcable yet, the text should mention this. We've already seen one taconite facility use their proposed "RH reduction" for other purposes, and there is nothing to preclude other facilities from doing this. | Section 1.4.4 states that the MN SIP is under current review by the EPA. A footnote will be added to Table 1 indicating that the MN SIP is not yet approved and that BART requirements are not finalized. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |
| 69 | JW10 | 4 | | | The text should mention that some reductions in emissions came from plant shutdowns due to economic conditions, and were one-time occurances. | See response to comment 43. | | It will be assumed that the absence of a comment in Column H indicates that the original comment has been adequately addressed unless the commenter indicates otherwise. |

**Attachment O**

**Assessment of Potential Ecosystem Acidification Cumulative Impacts in Northeast Minnesota**

# *Cumulative Impacts Analysis*

## *Assessment of Potential Ecosystem Acidification Cumulative Impacts in Northeast Minnesota*

## *NorthMet Project*

***Prepared for***

***PolyMet Mining Inc.***

***Version 2: November 2011***

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# Cumulative Impacts Analysis

# Assessment of Potential Ecosystem Acidification Cumulative Impacts in Northeast Minnesota

## Version 2: November 2011

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## Appendices

Appendix A1 Regional Acid Deposition Monitoring Data

Appendix A2 Minnesota Acidic Deposition Monitoring Sites and Data

# Technical Summary

PolyMet Mining, Inc. (PolyMet) plans to construct and operate a mine area near the town of Babbitt, MN, to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailing Basin near Hoyt Lakes, MN and to build a hydrometallurgical ore processing facility at the former LTVSMC site. The proposed project is referred to as the NorthMet Project (Project). The project description is provided in the March, 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement (reference (1)) and the NorthMet Project Description Version 3 Submitted September 13, 2011. The Lead Agencies for the Environmental Impact Statement, Minnesota Department of Natural Resources (MDNR), US Army Corps of Engineers, and US Forest Service have concluded the proposed project requires a Supplemental Draft Environmental Impact Statement (SDEIS).

This report evaluates whether the cumulative air emissions of sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_X$) from the Project and emissions from other proposed nearby projects could cause or significantly contribute to ecosystem acidification in northeast Minnesota. The focus is on emissions of $SO_2$ and $NO_X$ because they are the two primary air pollutants that can lead to ecosystem acidification (acid precursors). These projects' potential cumulative air quality impacts are to be evaluated within the context of increasingly strict state and federal regulations to be implemented over the next decade.

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

## Scope of Analysis

The approved scope for this assessment requires a semi-quantitative approach to assess potential cumulative impacts of ecosystem acidification. Critical elements of the analysis include:

- A summary of acid deposition trends in Minnesota, including analyses by the Minnesota Pollution Control Agency (MPCA) (reference (2)) in setting an acid deposition standard and emissions control plan, and analyses by the National Acid Precipitation Assessment Program (reference (3)).
- The potential maximum emissions from the Project and other proposed projects, plus the potential emissions increases and decreases due to the following reasonably foreseeable actions and potential regulatory actions:

- Proposed projects:
    - Excelsior Energy, Mesaba Energy Project, Coal Gasification Power Plant
    - Mesabi Nugget Company, Phase I Large Scale Demonstration Plant
    - Mesabi Nugget Company, Phase II Project
    - Essar Steel Minnesota LLC, Mining/Taconite/DRI/Steel Plant
    - Essar Steel Minnesota LLC, project modification
    - Northshore Mining Company, Furnace 5 Reactivation Project
    - PolyMet Mining, NorthMet Project
    - SAPPI Cloquet Plant Expansion
    - UPM/Blandin Paper Mill Expansion, Project Thunderhawk
    - U. S. Steel Keetac, Expansion Project
    - United Taconite Green Production Project
- Emission Reductions
    - Minnesota Power Taconite Harbor Energy Center Unit 2, Emission Control Modifications
    - U. S. Steel Minntac BACT Reductions
    - Northshore Mining Company: BART Reductions
    - United Taconite BART Reductions
- Regulatory and other actions:
    - Implementation of the Regional Haze Rule and Best Available Retrofit Technology (BART) Rule;
    - Implementation of the Cross State Air Pollution Rule (CAIR Replacement Rule)
    - State acid rain rule and statewide $SO_2$ emissions cap
    - Title IV of the 1990 Clean Air Act Amendments.
    - On-road mobile source programs
        - Fuel blending standards
        - Tier II/Low sulfur gasoline
    - Non-road mobile source programs
        - Non-road diesel rule
        - Control of emissions from unregulated non-road engines

- Locomotive/Marine engine reductions
- RACT requirements under the Wisconsin and Michigan $PM_{2.5}$ and ozone SIPs
- Updates and additions to the NAAQS for $SO_2$, $NO_X$, $PM/PM_{2.5}$ and ozone, including 1-hr $NO_X$ and $SO_2$ standards
- Xcel Energy's Riverside plant re-powering project

This semi-quantitative assessment uses emission trend analysis to assess the potential for cumulative acidification impacts of these reasonably foreseeable actions. The relationship between acid precursor emissions and acid deposition is first summarized, and then potential acid precursor emissions from the proposed projects are compared to the emissions from existing taconite facilities and coal-fired power plants in the six-county project area (Carlton, Cook, Itasca, Koochiching, Lake, and St. Louis). Finally, the potential for acidification impacts to lakes in the region was assessed using historic and predicted nationwide emission trends.

## Relationship between Emissions and Deposition

Both $SO_2$ and $NO_X$ are long-range transport pollutants. This means that they can travel long distances in the atmosphere while subject to complex atmospheric chemical and physical processes before being washed out or deposited back down onto land, lakes, and rivers. For example, the MPCA has determined that about 90% of the acid deposition in northeastern Minnesota is caused by emissions from sources located outside the state, primarily from states to the south and east of Minnesota (reference (2)). The MPCA's analysis, along with similar findings from other states and NAPAP (reference (3)) provided the original basis for the U. S. Environmental Protection Agency (EPA) to develop the federal Acid Deposition Control Program rather than relying solely on individual state regulatory actions.

## Acid Deposition in Minnesota: Regulation, Current Status, Trends

Depending on watershed buffering capacity and other factors, aquatic ecosystems can be harmed when precipitation pH is less than 4.7. And, in general, sulfate ($SO_4$) is a good proxy for deposition of acidic materials associated with $SO_2$ emissions, and nitrate ($NO_3$) is a proxy for the deposition of acidic materials associated with $NO_X$ emissions. The Minnesota Acid Deposition Control Act of 1982 required the MPCA to identify sensitive resources in the state and adopt an acid deposition standard and emissions control plan. In 1986, the MPCA established an annual wet sulfate deposition standard of 11 kilograms per hectare (kg $ha^{-1}$) and a statewide $SO_2$ emissions cap of 194,000 tons per year (tons/yr) (emissions cap effective on January 1, 1994). Currently, annual wet sulfate deposition in northeast Minnesota is below the 11 kg $ha^{-1}$ standard (~ 3 to 7 kg $ha^{-1}$ in 2010). Total statewide

$SO_2$ emissions are estimated by the MPCA to be approximately 101,000 tons/yr (71,710tons/yr stationary sources) in 2009.

National reductions in $SO_2$ emissions have reduced acid deposition across the United States, particularly in the eastern half of the country. Wet sulfate deposition in northern Minnesota and other parts of the Midwest has declined by about one-third since the early 1980's, with the largest declines occurring between 1992 and 1994. Since 1997, however, sulfate deposition in northern Minnesota has declined more slowly despite continued nationwide emission reductions. Nevertheless, wet sulfate deposition rates in Minnesota are below the state annual wet sulfate deposition standard of 11 kg $ha^{-1}$, a level that is designed to protect the most acid-sensitive ecosystems in the state. Further, these sulfate deposition rates are expected to continue to slowly decline as foreseeable regulatory actions are implemented.

Nitrogen deposition (total inorganic nitrogen from nitrate and ammonium), which contributes about 40% of the acid inputs to ecosystems, remained at approximately the same levels from the mid-1980s through 2009 in northern Minnesota. Nitrate wet deposition has shown a small but statistically significantly decline since about 1997, while ammonium wet deposition has increased. As a result, total inorganic nitrogen deposition has not declined to any great extent from 2000 to 2010. Overall, wet nitrate deposition in Minnesota is expected to remain the same or decline slightly over the next decade because of anticipated power plant and mobile-source emission reductions. Ammonium wet deposition, which is related primarily to agricultural operations, may continue to increase in the future.

## Cumulative Project Emissions and Statewide Trends

Cumulative potential $SO_2$ emissions from the reasonably foreseeable projects are approximately 2,807 tons/yr. (Actual cumulative emissions from these sources would be less). In 1980, statewide actual $SO_2$ emissions were about 250,000 tons/yr (reference (3)). By 2009, total (all sources) actual $SO_2$ emissions in Minnesota were reduced to approximately 101,000 tons/yr (reference (4)). Stationary source emissions, which make up approximately 71% of the total emissions, were estimated to be approximately 72,000 tons/year in 2009 (reference (4)). The potential $SO_2$ emissions from the proposed projects (2,807 tons), compared to total statewide actual emissions of approximately 101,000 tons/yr, represent an approximate increase of about 3% on a statewide basis. When the potential $SO_2$ emissions from the projects are compared to stationary source $SO_2$ emissions only, the potential increase is approximately 4%.

This potential increase in $SO_2$ emissions from the proposed projects is expected to be offset by the planned reductions associated with voluntary actions in northern Minnesota or the likely reductions

required by foreseeable regulatory and other actions which are listed above. Therefore, even if all the currently proposed projects on the Iron Range move forward, statewide $SO_2$ emissions are likely to continue to decline, and will remain well below the 194,000 tons/yr limit in Minnesota's acid rain rule.

Cumulative potential $NO_X$ emissions from the reasonably foreseeable projects are approximately 6,635 tons/yr. Although stationary-source $NO_X$ emissions have declined recently, total statewide $NO_X$ emissions have been increasing gradually since the mid-1980's, and were estimated to be about 353,000 tons/yr by 2009 (reference (4)). Therefore, the potential 6,635 tons/yr increase in $NO_X$ emissions due to the projects is about 2% of total statewide emissions. This potential increase is within the year to year variability in actual statewide point-source emissions.

Similar to $SO_2$ emissions, the projects' potential increase in $NO_X$ emissions has been, or will be partially offset by the planned reductions associated with voluntary actions in northern Minnesota and/or foreseeable regulatory and other actions.

## National Emission Trends

Nationally, total $SO_2$ emissions were about 11.4 million tons/yr in 2008, which is about 50% below that emitted in 1990 (reference (6)). In 2010, national $SO_2$ emission allowances from electric generation units were estimated to level off at 8.7 million tons annually. Actual emissions were near this level in 2008, but could increase due to the use of previously banked emission allowances. In addition, EPA's Cross State Air Pollution Rule (CSAPR) will also require reductions of $SO_2$ and $NO_X$ in eastern and southern states. This rule sets emissions budgets that are expected to reduce $NO_X$ emissions by 1.4 million tons and $SO_2$ emissions by 6.4 million tons by 2014 compared to 2005 base levels (reference (7)).

Nationally, total $NO_X$ emissions (mobile plus point sources) have declined about 35% since 1990, with the biggest decline starting about 1999 (Figure 6-8). Stationary source $NO_X$ emissions have declined about 43% from 1990 to 2008 and are currently approximately 6.9 million tons/year. The decline in national $NO_X$ emissions is expected to continue due to regulatory actions such as CSAPR, described above.

## Summary and Conclusions

- The potential cumulative emissions from all "reasonably foreseeable" projects are small in comparison to 2009 statewide emissions of 101,000 tons/yr $SO_2$ and 353,000 tons/yr $NO_X$. The proposed projects could potentially increase current statewide $SO_2$ emissions by 3% and statewide $NO_X$ emissions by about 2%.
- Existing $SO_2$ emissions in Minnesota have a small contribution to acid deposition in the state; approximately 10% of the acid deposition falling in Minnesota is due to in-state sources. Approximately 90% comes from outside the state (references (2) and (9)). Therefore, the estimated 2-3% potential increase in statewide $NO_X$ and $SO_2$ emissions from the proposed projects is not expected to measurably increase acid deposition in Minnesota.
- Current levels of acid deposition in northeastern Minnesota are below thresholds of concern. Wet sulfate deposition is less than 11 kg $ha^{-1}$ (~3-7 kg $ha^{-1}$ in 2010), and the pH of annual precipitation is greater than 4.7 (reference (10)). Even with the small increase in potential emissions from the proposed projects, wet sulfate deposition and the pH of annual precipitation is expected to remain well below these thresholds of concern.
- Lake survey data from the early 1990s that were evaluated for trends in acidification indicates that Minnesota's aquatic and terrestrial ecosystems have sufficient buffering capacity to withstand current levels, and projected future levels, of acid deposition (reference (11)). Similarly, Minnesota's terrestrial ecosystems are well-buffered against negative impacts of acid deposition. Due to this inherent buffering capacity, no adverse impacts to aquatic and terrestrial ecosystems are expected due to the potential emissions from the proposed projects.
- Minnesota's $SO_2$ and $NO_X$ emissions are expected to continue to decline over the next decade. In addition, because about 90% of Minnesota's acid deposition comes from outside the state, the foreseeable national emission reductions should continue to decrease acid deposition in Minnesota.

For the reasons summarized above, the cumulative potential emissions from the proposed projects do not have the potential to cause or significantly contribute to ecosystem acidification in Northeast Minnesota.

# 1.0 Introduction

The Final Air Impact Assessment Planning Summary Memo for the SDEIS requires an updated assessment of the cumulative potential effects on ecosystem acidification in Northeastern Minnesota (reference (12)). This assessment is to address not only the impacts of the proposed project, but also that of other past and "reasonably foreseeable" proposed projects on the Iron Range (see Table 1-1 and Figure 1-1). In addition, the project's potential cumulative air quality impacts are to be evaluated within the context of increasingly strict state and federal regulations to be implemented over the next decade.

Cumulative analyses to be conducted for air quality impacts include visibility in Class I areas in Minnesota and local mercury deposition as well as this report on ecosystem acidification. These assessments are to address not only the potential impacts of the Project but also that of other past and "reasonably foreseeable" proposed projects. In addition, the likely impact of foreseeable regulatory actions is to be considered in the evaluation as well.

This report assesses whether the total acid rain precursor emissions (sulfur dioxide, $SO_2$; and nitrogen oxides, $NO_X$) have the potential to contribute significantly to acid deposition and ecosystem acidification in northeast Minnesota.

## 1.1 What Are "Cumulative Impacts"?

Federal and state environmental guidance provide a starting point. First, the Council on Environmental Quality's (CEQ) regulations, which implement the National Environmental Policy Act (NEPA), define "cumulative effects" as: "The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions." (40 CFR 1508.7). The Minnesota Environmental Quality Board environmental review rules use a similar definition, but for "cumulative impacts." (See Minnesota Rules, part 4410.0200, Subp. 11).

Some regulatory programs, in effect, require a form of quantitative cumulative impact assessment as part of a permit review. For example, air quality modeling of all significant nearby emission sources is required for "New Source Review" air permits. Likewise, water discharge permits often require the applicant to account for the impact of other discharges that affect the same water body as the proposed project. But for most cumulative impact issues, such as those to be addressed for the NorthMet SDEIS, there are only general guidelines. Therefore, the approach used to assess cumulative impacts must be developed case by case (reference (13)).

## 1.2 Acidification "Cumulative Impact" Approach

The scope of the assessment requires a "semi-quantitative" analysis to assess the cumulative impacts from the $SO_2$ and $NO_X$ emissions from the proposed projects and foreseeable actions on acidification, and does not entail quantitative air quality modeling. In addition to assessing trends in national and statewide emissions, this analysis summarizes point-source emission trends in the six-county area encompassed by Itasca, St. Louis, Lake, Carlton, Koochiching and Cook counties. Additional details of the analysis are provided in the following sections of the report:

- Section 2.0 Analysis Boundaries;
- Section 3.0 Acid Deposition - Review
- Section 4.0 Acid Deposition and Regulation in Minnesota
- Section 5.0 Acid Deposition Trends
- Section 6.0 Local, State, and National Emissions and Trends
- Section 7.0 Acid Deposition Summary
- Section 8.0 Conclusions

## 1.3 Proposed Projects and Summary of Potential Emissions

Table 1-1 shows the estimated potential emissions of $SO_2$ and $NO_X$ from each of the proposed projects and reductions included in this analysis. Concurrent emission reductions are provided for comparison to the emissions estimated for the proposed projects. Additional details regarding each of the emission reduction projects and their status are provided in Section 6.0. Proposed projects were included only if they were not yet operating as of January 1, 2011 and reductions were only included if they occurred after January 1, 2011. This cutoff date was chosen because the monitoring data used to assess the past or existing conditions includes information through December 31, 2010. Any projects that began operating after January 1, 2011 were not included in the analysis of the existing conditions and therefore needs to be considered in the assessment of future cumulative impacts. Similarly, any reductions that occurred or will occur after January 1, 2011 are not reflected in the monitoring data and are considered in this assessment of cumulative impacts.

Concurrent emission reductions are provided for comparison to the emissions estimated for the proposed projects. As can be seen from Table 1-1, acid rain precursor emissions will be reduced significantly in northeast Minnesota due to large reductions from Minnesota Power's facilities and from reductions from mining operations. The emission increases from the proposed projects (mainly mining) will be at least partially offset by these reductions.

Northeast Minnesota is the state's most acid-sensitive region (reference (3)). Figure 1-1 shows the general locations of the proposed projects in northeast Minnesota and in relation to federal Class I areas within 250 kilometers of Minnesota's Iron Range, and existing taconite production facilities.

**Table 1-1 Maximum potential sulfur dioxide and nitrogen oxide emissions from proposed projects in the six-county project area in comparison to emission reductions.**
(Six-county project area is Carlton, Koochiching, Itasca, St. Louis, Lake, Cook counties)

| Project | Location In Minnesota | $SO_2$ (tpy) | $NO_X$ (tpy) | BACT/ MACT [16] |
|---|---|---|---|---|
| **Increases** | | | | |
| Excelsior Energy, Mesaba Energy Project [1] | Taconite or Hoyt Lakes, St. Louis or Itasca County | 1,390 | 2,872 | Yes |
| Mesabi Nugget Phase I LSDP [2] | Hoyt Lakes, St. Louis County | 417 | 955 | Yes |
| Mesabi Nugget Phase II [3] | Hoyt Lakes, St. Louis County | 7 | 298 | Yes |
| Essar Steel Minnesota LLC (formerly Minnesota Steel) [4] | Nashwauk, Itasca County | 421 | 1,505 | Yes |
| Essar Steel Minnesota LLC – Project modifications [5] | Nashwauk, Itasca County | 146 | -69 | Yes |
| Northshore Mining Company: Furnace 5 Reactivation [6] | Silver Bay, Lake County | 56 | 200 | Yes |
| PolyMet Mining, NorthMet Project [7] | Hoyt Lakes, St. Louis County | 40 | 473 | Yes |
| SAPPI Cloquet [12] | Cloquet, Carlton County | 1 | 162 | Yes |
| UPM/Blandin Paper Mill Expansion: Project Thunderhawk [8] | Grand Rapids, Itasca County | 213 | 169 | Yes |
| US Steel Keewatin, Keetac Expansion [9] | Keewatin, Itasca and St. Louis Counties | 81 | 35 | Yes |
| United Taconite Green Production Project [13] | Forbes, St. Louis County | 35 | 35 | No [13] |
| Total Increases | | 2,807 | 6,635 | |
| **Anticipated Reductions from 2009 Emissions** | | | | |
| Minnesota Power – Taconite Harbor Energy Center Unit 2, emission control modifications for $SO_2$, $NO_X$ and mercury [11] | Schroeder, Cook County | -1549 | -423 | |
| US Steel Minntac [10] | Mtn. Iron, St. Louis County | | -1,973 | |
| Northshore Mining Company: BART Reductions [11][14] | Silver Bay, Lake County | -583 | -1,159 | |
| United Taconite BART Reductions [11][14] | Forbes, St. Louis County | -1,954 | | |

| Project | Location In Minnesota | $SO_2$ (tpy) | $NO_X$ (tpy) | BACT/ MACT [16] |
|---|---|---|---|---|
| Total Reductions | | -4,086 | -3,555 | |
| Net Reduction/Increase | | -1,279 | 3,080 | |

[1] Emission estimates (Phase I and Phase II) based on emissions used in the air quality analysis in the final EIS, website: http://nepa.energy.gov/documents/EIS-0382_Mesaba_FEIS_Vol_1.pdf. Accessed on May 5, 2011.

[2] Mesabi Nugget's Proposed Large Scale Demonstration Plant (LSDP): No crushing/grinding at the site; receive concentrate from off-site. Technical Support Document for MPCA permit 13700318-003. Included in Northeast Minnesota Plan Project Tracking for MPCA SIP, version 1-20-2011.

[3] Preliminary emission estimates, Barr Engineering, as of 1/29/2011.

[4] Baseline emissions from Potential to emit from Technical Support Document for Minnesota Steel (MPCA permit #06100067-002).

[5] Project modifications preliminary emission estimates Barr Engineering, emission estimate from EI spreadsheet submitted to MPCA on 4/5/2011.

[6] Northshore Mining's Furnace 5 Project: reactivating 2 crushing lines, 9 concentrating lines, one pellet furnace (Furnace 5); new sources emissions only (MPCA permit #07500003-003). Although construction for the project was completed prior to the January 1, 2009 cutoff date for this analysis, due to plant turnaround and current demand, the furnace has not yet operated at a capacity reflecting the expected increase and is therefore included in this evaluation.

[7] PolyMet Mining's Proposed NorthMet Facility: crushing/grinding of ore, reagent and materials handling, flotation, hydrometallurgical processing, mobile emissions. Emission estimates from Barr Engineering report dated November 2008 Stationary and Mobile Source Emission Calculations for the NorthMet Project –Combined Report (RS57), submitted to MDNR and updated 4/1/1009. An updated emission inventory is being prepared to reflect the project as currently proposed. The updated emissions will tend to be lower than those reported previously.

[8] Net Emission Increase from Blandin Project Thunderhawk MPCA permit #06100001-009 No change in emissions for -010 or -011.

[9] U. S. Steel Keewatin, Keetac mine expansion and restart of taconite processing line – preliminary emission calculations, Barr Engineering. Submitted to MPCA in May 2011 permit application. $NO_X$ emission increase is from the baseline actual emissions used to determine PSD applicability. Although there will be a small increase in actual emissions, there will be a decrease in the allowable emissions.

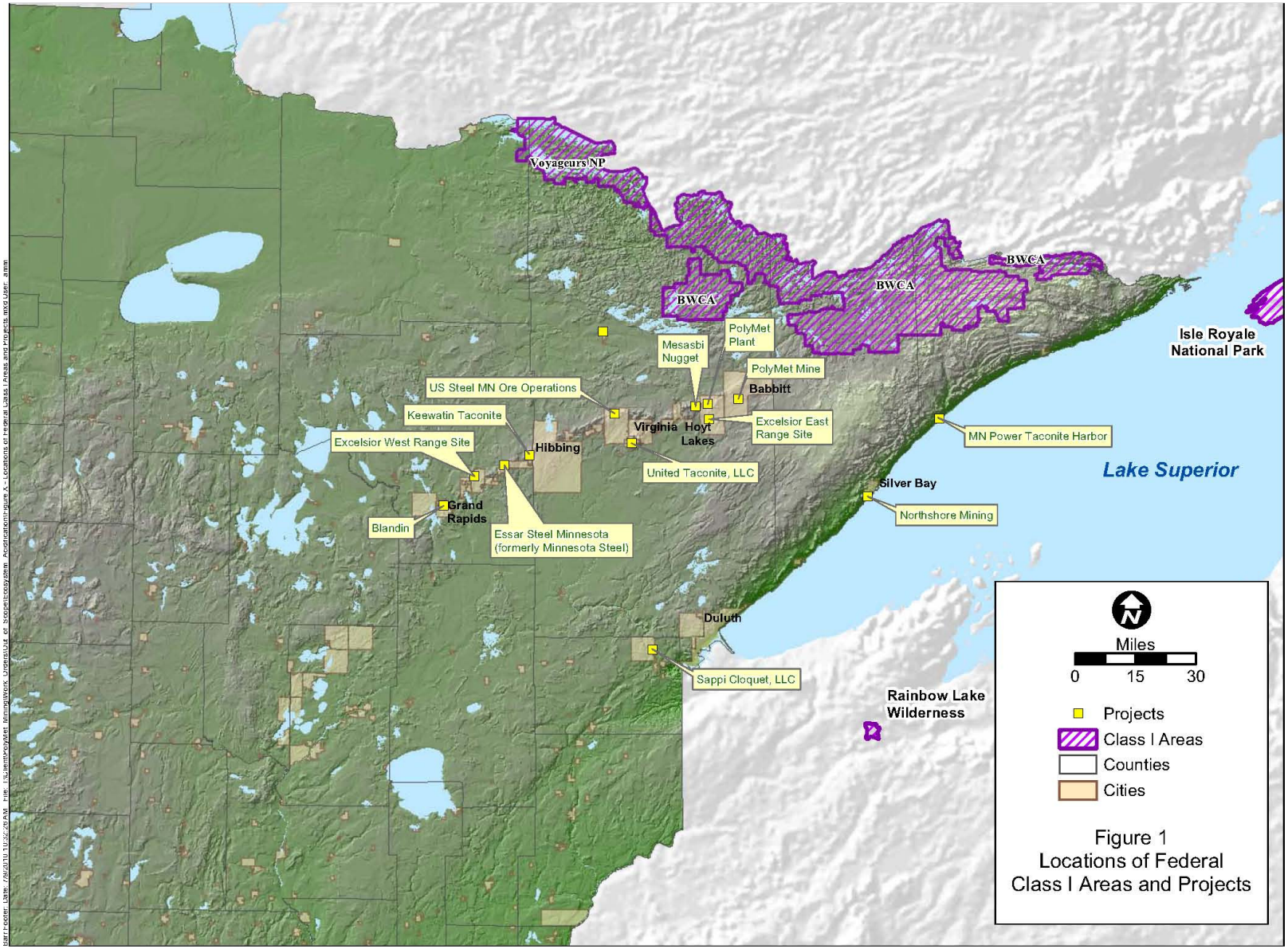
[10] Reductions calculated based on data in "US Steel Minntac Line 7 Low NOx Main Burner Final Testing Report", May 13, 2011of 3,990 ton per year goal for NOx emissions and the 2009 actual emissions provided in the MPCA "Northeast Minnesota Plan Emissions Tracking Spreadsheet" 1-20-2011.

[11] Emission estimates provided by the MPCA from the "Northeast Minnesota Plan Emission Tracking Spreadsheet" 1-20-2011

[12] Net emission change estimates from final EAW dated 5/1/2009. Plant expansion, new paper machine, new boiler.

[13] United Taconite's Green Production Project involves fuel changes and improvements to the concentrator and the Line 1 pellet plant to increase pellet production and was a Prevention of Significant Deterioration (PSD) minor project. Because it was a PSD minor project, specific considerations for BACT/MACT were not required. However, the Line 1 pellet plant has an existing wet scrubber to control particulate and $SO_2$ emissions. Emission estimates are taken from the Technical Support Document of Permit Number 13700113-005 authorizing the project on August 19, 2010.

[14] The MPCA RH SIP is still being reviewed by the EPA for approval including the recommended BART determinations for affected facilities. Actual BART requirements are pending discussions with the MPCA and have not yet been implemented.




Notes: 1) PolyMet's NorthMet project includes a Plant site and a Mine site.

2) Mesabi Nugget includes the Phase I (Direct Reduced Iron Facility) and Phase II (mining and concentrating) projects.

**Figure 1-1 Location of proposed projects in relation to Class I areas in northeast Minnesota.**

# 2.0 Analysis Boundaries

The original EIS scoping process provided some boundaries for this cumulative impact analysis, but further definition is required. The boundaries of interest are:

- The timeframe for the analysis
- Other "reasonably foreseeable" actions to be assessed in addition to the proposed project
- The geographic area that may be affected (the "zone of impact")

## 2.1 Timeframe

The timeframe for this analysis extends to the expected life of the Project, 20 years. For emission rate data, this report describes historical emission rates back to 1990 for sources in northeastern Minnesota and uses information from the MPCA's Northeast Minnesota Plan developed to assist in implementation of the Regional Haze SIP to show expected future emission rates based on likely emission caps or other regulatory emission limits. Emission inventory data is available through 2008 for each county and 2009 for the state and country. For monitoring data, acid deposition information from the NADP network is available for full calendar years from 1978 to 2010, depending on the site (see section 3.0 for more information).

## 2.2 Other Actions to be Assessed

Other "reasonably foreseeable" actions to be assessed include activities occurring in two different geographic areas:

- Other projects proceeding concurrently with the Project, including projects that will both increase and decrease emissions, within the six-county area of northeastern Minnesota (Lake, Cook, St. Louis, Carlton, Itasca and Koochiching)
- Regulatory and other major actions to be undertaken in geographic areas that could potentially impact acid deposition in the BWCA or Voyageurs

Figure 1-1, above, shows the general locations of the "reasonably foreseeable" projects to be assessed for cumulative impacts, as well as the locations of tribal lands and federally protected Class I areas. The projects selected as "reasonably foreseeable" are defined as those that are already underway and are actively moving through the environmental review process. It includes those that have started environmental review and received permits but were not yet constructed or operating in 2011, those for which a completed data portion of an environmental review document has been submitted to the MDNR or the MPCA, and those that have submitted sufficient information to the

MPCA to be able to determine potential emissions. "Reasonably foreseeable actions" in regard to potential emission reductions include those regulatory actions that have been placed on public notice by a government agency (e.g., draft rules or regulations) or there has been a submittal to a regulatory agency that provides details on a planned action being considered.

The following projects and actions are considered to be underway or "reasonably foreseeable":

- Proposed projects:
    - Excelsior Energy, Mesaba Energy Project, Coal Gasification Power Plant
    - Mesabi Nugget Company, Phase I Large Scale Demonstration Plant
    - Mesabi Nugget Company, Phase II Project
    - Essar Steel Minnesota LLC, Mining/Taconite/DRI/Steel Plant
    - Essar Steel Minnesota LLC, project modifications
    - Northshore Mining Company, Furnace 5 Reactivation Project
    - PolyMet Mining, NorthMet Project
    - SAPPI Cloquet Plant Expansion
    - UPM/Blandin Paper Mill Expansion, Project Thunderhawk
    - U. S. Steel Keetac, Expansion Project
    - United Taconite Green Production Project
- Emission Reductions
    - Minnesota Power Taconite Harbor Energy Center Unit 2, Emission Control Modifications
    - U. S. Steel Minntac BACT Reductions
    - Northshore Mining Company: BART Reductions
    - United Taconite BART Reductions
- Regulatory and other actions:
    - Implementation of the Regional Haze Rule and Best Available Retrofit Technology (BART) Rule;
    - Implementation of the Cross State Air Pollution Rule (CAIR Replacement Rule)
    - State acid rain rule and statewide $SO_2$ emissions cap
    - Title IV of the 1990 Clean Air Act Amendments.
    - On-road mobile source programs
        - Fuel blending standards

        - Tier II/Low sulfur gasoline
    - Non-road mobile source programs
        - Non-road diesel rule
        - Control of emissions from unregulated non-road engines
    - Locomotive/Marine engine reductions
    - RACT requirements under the Wisconsin and Michigan $PM_{2.5}$ and ozone SIPs
    - Potential updates and additions to the NAAQS for $SO_2$, $NO_X$, $PM/PM_{2.5}$ and ozone, including 1-hr $NO_X$ and $SO_2$ standards
    - Xcel Energy's Riverside plant re-powering project

## 2.3 Zone of Impact

The "zone of impact" is defined as the area of concern to be evaluated for potential cumulative impacts due to the above listed actions. This area depends on which cumulative impact is being studied. For ecosystem acidification the selected zone of impact is defined as northeast Minnesota and encompasses the area consisting of the following six counties: Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook which includes the two Class I areas, Boundary Waters Canoe Area Wilderness and Voyageurs National Park. The aquatic resources and terrestrial ecosystems considered the most sensitive to acidification in the state are within this six-county area. Ecosystem acidification is a region-wide issue, and is not generally site specific. It is not expected that ecosystems or lakes within a ten kilometer radius of the Project are at any greater risk than other ecosystems in the six-county region. Therefore, the zone of impact for this analysis is considered to be the area encompassed by Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook Counties.

## 2.4 Additional Factors Evaluated (synergistic, additive, assimilation capacity)

The critical assimilation capacity for acidification is the watershed buffering capacity, which is discussed further in Section 3.5 of this report.

Concerns have been expressed by investigators that an increase in sulfate to surface waters and wetlands will increase mercury methylation and result in increased fish mercury concentrations. The potential effects of additional sulfate from the proposed projects on mercury methylation are not discussed in this report. However, because the cumulative $SO_2$ emissions from the proposed projects are only a small percent of current $SO_2$ emissions and because statewide $SO_2$ emissions are expected

to continue to decline in the future, the potential $SO_2$ emissions from the proposed projects are not expected to have any significant effect on mercury methylation rates.

# 3.0 Acid Deposition - Review

## 3.1 Acid Precursors/Atmospheric Processes

Acidic deposition occurs when gaseous precursors are converted by atmospheric processes to compounds that are either acidic themselves or can be easily converted to acidic compounds by interactions with terrestrial or aquatic compounds. Oxides of sulfur (SOx) and nitrogen ($NO_X$) are probably the best-recognized acid precursors, and in some cases, ammonia, emitted primarily by livestock operations, can also be an acid precursor. $SO_2$ is the predominant oxide of sulfur species emitted. Most of the discussions in this report will focus on $SO_2$, but other forms of sulfur species are emitted and can contribute to sulfate deposition.

Acidic compounds are formed in the atmosphere by a complex group of gas- and aqueous-phase chemical reactions between acid precursors and other atmospheric compounds such as VOC, ozone, and hydrogen peroxide, often catalyzed by sunlight. At the same time, air masses can transport these compounds for long distances, in some cases thousands of kilometers, from their origin (hence the term long-range transport) (reference (14)).

One of the results from this complexity of atmospheric reactions is the strong likelihood of nonlinear responses to emission reductions (reference (15)). For example, reducing $NO_X$ emissions can increase the concentrations of the oxidant hydrogen peroxide. Increased hydrogen peroxide levels in turn can increase sulfate (sulfuric acid ion) formation. Therefore reducing $NO_X$ concentrations while $SO_2$ remains unchanged can increase acid deposition due to increased sulfate formation. Similarly, reducing $SO_2$ but not $NO_X$ could, under certain conditions, lead to increased nitrate formation. In gas-phase/aqueous-phase chemistry, ammonia preferentially neutralizes sulfate over nitrate to form ammonium sulfate aerosols. If $SO_2$ is reduced, the excess ammonia that becomes available can neutralize nitric acid and form ammonium nitrate aerosols. These aerosols absorb gas-phase nitric acid, which increases the formation of particle nitrate (reference (16)).

## 3.2 Emission Sources

There are a variety of sources of $SO_2$ and $NO_X$ emissions. For both pollutants, the proportional contribution of emissions from various source categories does not vary greatly year-to-year because most source categories are simply not amenable to rapid changes.

Using national data for the period from 1970 to 2008, electric utilities are clearly the major source of $SO_x$ (primarily as $SO_2$), contributing about two-thirds of all emissions (Table 3-1). Other major

source categories include industrial fuel use (about 14%) and metals processing (3.4%). The emissions of $SO_2$ are primarily related to the sulfur content of the fuels being burned.

In contrast, transportation sources are the major contributor of $NO_X$ emissions (~ 55%; 37.4% from highway sources plus 17.5% from off-highway), with electric utilities a smaller source of national $NO_X$ emissions (about 23%) (Table 3-1). In the case of $NO_X$ emissions the oxides arise from fixation of atmospheric nitrogen at high temperatures, and hence are more dependent on the combustion process than on the properties of the fuel (reference (17)).

**Table 3-1 Average relative contribution of major source categories to national emissions of sulfur oxides ($SO_2$) and nitrogen oxides ($NO_X$) for the period 1970 - 2008.**

[from http://www.epa.gov/ttn/chief/eiinformation.html, 1970 - 2008 Average annual emissions, all criteria pollutants in MS Excel - June 2009.]

| Source Category | % Contribution - $SO_2$ | | % Contribution – $NO_X$ | |
|---|---|---|---|---|
| | 1970-2007* | 2008 | 1970-2008* | 2008 |
| FUEL COMB. ELEC. UTIL. | 68.1% | 66.1% | 23.4% | 18.4% |
| FUEL COMB. INDUSTRIAL | 13.8% | 14.6% | 12.1% | 11.2% |
| FUEL COMB. OTHER | 3.8% | 5.1% | 4.1% | 4.4% |
| CHEMICAL & ALLIED PRODUCT MFG | 1.6% | 2.2% | 0.6% | 0.4% |
| METALS PROCESSING | 4.0% | 1.8% | 0.3% | 0.4% |
| PETROLEUM & RELATED INDUSTRIES | 2.0% | 1.8% | 0.9% | 2.1% |
| OTHER INDUSTRIAL PROCESSES | 2.3% | 2.9% | 1.7% | 2.6% |
| SOLVENT UTILIZATION | 0.0% | 0.0% | 0.0% | 0.0% |
| STORAGE & TRANSPORT | 0.0% | 0.0% | 0.0% | 0.1% |
| WASTE DISPOSAL & RECYCLING | 0.2% | 0.2% | 0.6% | 0.7% |
| HIGHWAY VEHICLES | 1.5% | 0.6% | 37.5% | 31.9% |
| OFF-HIGHWAY | 2.4% | 4.0% | 17.6% | 26.0% |
| MISCELLANEOUS | 0.3% | 0.7% | 1.2% | 1.6% |

*Average for the 1970-2008 time period.

The proportional distribution of $SO_2$ and $NO_X$ emissions from the respective source categories in Minnesota is very similar to the national distribution. In Minnesota, electric utilities contribute approximately 62% of the $SO_2$ emissions and about 19% of the $NO_X$ emissions (Figure 3-1) as compared to national emissions where electric utilities contribute approximately 68% of the $SO_2$ emissions and 23% of the $NO_X$ emissions (Table 3-1, averages for 1970-2008). The relative percentage of $SO_2$ emitted by various source categories has remained roughly the same in the 1970 to 2008 time period, both nationally and in Minnesota.

Transportation and off-highway sources contribute about 60% of the $NO_X$ emissions in Minnesota (Figure 3-1) as compared to an average of 58% on a national basis (Table 3-1). $NO_X$ emissions from highway and off-highway vehicles have continued to increase since the 1990s while emissions from point sources have tended to decrease. For $NO_X$ emissions on a national basis, transportation was the major contributing source category in 2008 (~ 58%; highway vehicle emissions of about 33% and off-highway sources 26%) (Table 3-1). In 2008, electric utilities were estimated to contribute about

18% of the national $NO_X$ emissions (Table 3-1). On a national basis, the largest contributions of $NO_x$ emissions have been highway vehicles, off-highway transportation, and electric generation units. Since 1994, the relative contribution of highway vehicles and electric generation units has been falling and off-highway transportation has risen slightly (reference (6)).

For Minnesota, the relative source category contributions of $NO_X$ emissions have changed since 1994 (reference (18)). The most noticeable changes are related to the off-road transportation category and electric utility category. For off-road transportation, that category now has a relative contribution of approximately 26% based on 2005 emissions data compared to approximately 10% in 1994 (reference (18)). Electric utilities were estimated in 2008 to contribute about 19% of Minnesota's $NO_X$ emissions (Figure 3-1) as compared to electric utility fuel contributions of 40% in 1994 (reference (18)). While this relatively recent shift in source category contributions of $NO_X$ emissions is noted in Minnesota, the overall conclusion is that source category contributions of $NO_X$ emissions in Minnesota are similar to the national pattern of source category contributions.

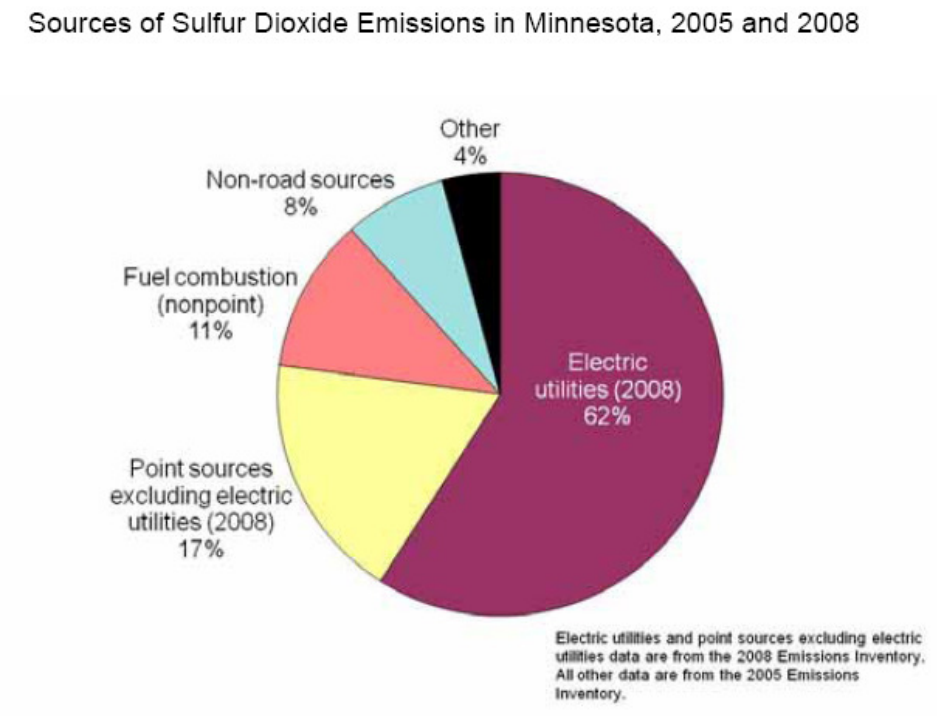



**Figure 3-1 Average relative contribution of major source categories to Minnesota emissions of sulfur oxides ($SO_2$) and nitrogen oxides ($NO_X$) for inventory years 2005 and 2008.**

## 3.3 Wet and Dry Deposition

### 3.3.1 Wet deposition

Wet deposition is formed when aerosols directly combine with droplets of water as they condense during formation of precipitation, or the aerosols can be "washed out" of the atmosphere during a rain or snow event. Deposition of acidic aerosols in this manner is referred to as "acid rain". In general, sulfate ($SO_4$) is a good proxy for deposition of acidic materials associated with $SO_2$ emissions, and nitrate ($NO_3$) is a proxy for the deposition of acidic materials associated with $NO_X$ emissions. Sulfate-associated acidity constitutes about 60% of acidic deposition, and nitrate-associated acidity about 40% (reference (19)).

### 3.3.2 Dry deposition

Some of the acidic aerosols do not fall with precipitation, but instead come directly into contact with and remain on surfaces such as tree leaves. This process is continuous; deposition is not dependent on a precipitation event. Such deposition is referred to as dry deposition or dryfall. Depending on the nature of the atmosphere, the collecting surface, and climatic conditions, dryfall can account for as much or more of the acidic materials delivered to an ecosystem as wet deposition. For example, total wet and total dry depositions are thought to be of approximately equal magnitude over eastern North America (reference (20)). Forest canopies, especially those of conifers, are very efficient at filtering these aerosols from the atmosphere and hence dry deposition is greater in forests than in more open vegetation types (reference (21)). Some fraction of the nitric acid also remains in a gaseous form, and direct uptake of that gas by plants is an important mode of dry deposition for nitrogen (reference (22)).

The distinction between wet deposition and dry deposition is obscure in the case of fog. Fog formed at low elevations and cloud-water fog at high elevations can deliver acidic materials to terrestrial ecosystems. Both wind speed and water content affect the amount of materials deposited. The pH of cloud water can be quite low (e.g., mean annual pH of 3.5 and 3.9 in high elevations in New York State - RMCC Atmospheric Sciences Subgroup 1986).

## 3.4 Source-Receptor Relationships/Models

Although it would seem that “what goes up must come down”, the qualitative or quantitative relationship between the emission of acid precursors at their source(s) and the air concentration and deposition of acidic materials at a receptor (source-receptor relationship – SRR) has considerable uncertainty (reference (23)). Probably the simplest analytical approach to SRR is an empirical analysis focusing on relationships between observations. At the most elementary level, this approach

simply compares regional emissions and deposition, with the latter measured as either mass per unit area or concentration. Another slightly more sophisticated approach is to define a source-area for emissions using a back-trajectory approach, and relate emissions from that source-area to deposition (reference (24)). Finally, the most sophisticated empirical approach uses a regional acid deposition model to quantitatively relate the deposition of acidic material at a set of receptor sites to a set of acidic precursor sources for a multi-state geographic area.

Throughout the 1980s, the scientific community dedicated significant resources to developing acid deposition modeling capabilities. The NAPAP 1990 Integrated Assessment relied primarily on a then state-of-the-art model called the Regional Acid Deposition Model (RADM). The model was designed to provide a scientific basis for estimating changes in deposition resulting from changes in sulfur and nitrogen emissions, to estimate the influence of emission sources in one region on acid deposition in other regions, and to estimate the levels of acid deposition in certain sensitive receptor regions. Updated versions of RADM are still considered by most modelers to be the highest quality acid deposition model currently available for the eastern United States (references (16) and (25)). The basic framework for acid deposition models has not changed since 1990. No major overhauls have been made; rather, the understanding of particular chemical and physical interactions has improved, improvements in emission inventories have occurred, and improvements in computing power have expanded the complexity a model can achieve (references (16) and (25)).

The results of most modeling efforts indicate that sulfur deposition at remote receptors is dominated by wet deposition, with the sulfur originating from sources at distances as far as 500 km from these receptors (reference (23)). On a national basis, for source regions aggregated by state, no one source region contributed more than about 15% to the sulfur deposition at remote receptors. Thus, sulfur deposition at remote receptors, including northeastern Minnesota, is not dominated by one or two source regions. Source regions as far away as 1,000 km contributed to the deposition, even though their relative contributions are as small as 1 to 2%. For example, one analysis indicates that only 13% of the wet sulfate deposition in the Upper Midwest region (Iowa, Michigan, Minnesota, and Wisconsin) is derived from sources within the region, with sources in Illinois, Missouri, Indiana, and Texas each contributing about 10% of the deposition (reference (9)).

## 3.5 Effects on Ecosystems

The following summary of potential acidification impacts is divided into two categories: (1) impacts on terrestrial systems and (2) impacts on aquatic systems.

### 3.5.1 Terrestrial Systems

The most important long-term impact of air pollution on terrestrial ecosystems is the potential of altering soil properties. Soils are the basic resource or substrate from which the terrestrial ecosystem derives its existence. Soils, however, are extremely resistant to change. Various natural processes tend to both buffer soil properties against change and to restore those properties toward their initial state following disturbance. Accumulation of organic matter and weathering of minerals can rebuild an eroded soil. The amount of acids added annually by atmospheric deposition, even in the worst cases, is a small portion of the total chemical buffering capacity of surface soils (reference (26)).

Impacts of air pollution on soil cannot be considered in isolation. Soil is an integral part of the ecosystem, and changes in soil properties can affect other components. In fact, the major concern of impacts of air pollutants on terrestrial ecosystems is most often centered on impacts on vegetation. It is in that context that the impacts of air pollutants on soil will be discussed, including additions and depletions of material and an increase in the concentration of toxic materials within the soil.

#### 3.5.1.1 Additions and Depletions

One of the initial effects of acidic deposition on terrestrial ecosystems is often an increase in site productivity. Both nitrogen and sulfur are essential plant nutrients, and their addition via atmospheric deposition has the potential to enhance plant growth. For example, soils in north-central Minnesota were historically deficient in sulfur, requiring its addition via fertilization to achieve optimum plant growth (reference (27)). Deposition of sulfate (acidic deposition) undoubtedly enhanced the nutrition of plants in that region (reference (28)).

Similarly, in most systems, plant growth is limited by nitrogen. If nitrate deposition exceeds ecosystem demand for nitrogen, the ecosystem should theoretically become saturated with nitrogen. Nitrogen saturation is generally defined as a condition wherein inputs of nitrogen to an ecosystem exceed the requirements of terrestrial biota and a substantial fraction of that nitrogen leaches out of the ecosystem as nitrate to groundwater and surface water. Nitrogen saturation is said to contribute to poor forest health and can lead to the presence of nitrates in waters, contributing to attendant acidification, human health problems, and estuary eutrophication (reference (29)). The issue of nitrogen retention/saturation is much more complex than that encompassed by a simple input-output balance, with myriad factors influencing nitrogen retention in forest systems. As a result, even in the northeastern United States, where nitrate loadings are much higher than in Minnesota (reference (19)), levels of nitrates in aquatic systems have not risen but instead have declined over the past two decades (references (30), (31) and (32)).

Even as nutrients are added to the soil, some can also be lost. First, changes in soil solution, such as higher ionic concentrations than normal and presence of mobile anions such as sulfate and nitrate, can occur as a result of acidic deposition. As a result of these changes, hydrogen ions in solution exchange with the base cations calcium, magnesium, and potassium on soil colloids; these cations are subsequently leached from the soil (reference (33)). The base cations are plant nutrients; where they are already in short supply this accelerated leaching may affect plant nutrition. Base cations can also be added to soil colloids by weathering, or breakdown of soil minerals to soluble forms. The critical question for nutrient status of ecosystems is the balance between the rates of weathering and of cation leaching.

A second process of nutrient depletion from a soil comes about as a consequence of the soil becoming more acidic as base cations are leached from it. This has the potential of converting soil phosphorus to insoluble forms by chemical precipitation to aluminum and iron hydroxides, so that it is no longer available to plants (reference (34)). As might be expected, this is also more likely to affect plant nutrition in soils that are initially low in phosphorus.

#### 3.5.1.2 Toxic materials

All soils contain large quantities of aluminum, primarily as insoluble forms but with some as soluble organic complexes. As soils become more acidic, inorganic aluminum compounds become more soluble (reference (35)). This is a fundamental chemical principle. Inorganic aluminum in solution is toxic to aquatic organisms. At relatively high concentrations, these ions are also toxic to tree roots (reference (36)). There are, however, relatively wide differences in tolerance among tree species. It also appears that the ratio of calcium to aluminum concentrations in solution affects toxicity (reference (37)).

#### 3.5.1.3 Vegetation

Vegetation can be affected both directly by air pollution and indirectly by feedback from its substrate, the soil. It is clear from both observations and from experimental work that there is genotypic variation among trees and other plants in terms of response to air pollution. That is, not only do species vary in their response, but individuals within a species also vary.

Direct effects of acidic deposition to vegetation involve the leaching of essential plant nutrients (reference (38)). Direct leaching of nutrients such as magnesium from leaves could further exacerbate any soil-caused deficiency. Red spruce trees at high elevations in the northeast United States have experienced periodic waves of mortality associated with winter injury. One of the contributing factors to this injury is hypothesized to be the leaching of calcium from cell membranes in spruce needles by acidic deposition (reference (39)). The loss of calcium renders the needles more

susceptible to freezing damage, thereby reducing the tolerance of trees to low temperatures and increasing the occurrence of winter injury and subsequent tree damage or death.

Two of the most widely hypothesized indirect effects of acidic deposition on vegetation (i.e., soil-related) include aluminum toxicity and a surfeit of nitrogen. As described above, inorganic aluminum compounds become more soluble as soils become more acidic. Soluble aluminum can be both damaging to root tissues, and can interfere with plant uptake of cations such as calcium. The ratio of calcium to aluminum in soil solution has been widely used as an index of risk for vegetation (reference (37)). Additions of atmospheric nitrogen may increase the productivity of certain plant species such that they gain a competitive advantage in the ecosystem, thereby potentially contributing to changes in the composition of the plant community. Over-fertilization by nitrogen in acidic deposition is also hypothesized to negatively affect vegetation. Such fertilization could upset the balance between the aboveground plant organs and roots, making the plant more susceptible to stresses such as drought. It could also alter elemental ratios within the plant, leading to deficiency of other nutrients or suppressing mycorrhizae formation. One caveat in the acceptance of this hypothesis is that commercial forest fertilization rates of nitrogen, where nitrogen is applied in amounts that are higher than the nitrogen deposited from the atmosphere, have not had the negative effects that have been attributed to atmospheric deposition of nitrogen.

#### 3.5.1.4 Aquatic Systems

Acidic deposition can affect water quality by lowering pH levels (i.e. increasing acidity); decreasing acid-neutralizing capacity (ANC); and increasing aluminum concentrations. Direct acidic deposition onto lakes can directly reduce pH, as can runoff from soils that have been acidified. The ANC of an aquatic system measures that balance between cations such as calcium and magnesium and strong acid anions (i.e., sulfate and nitrate). The same factors that can lower pH of aquatic systems therefore can also lower ANC. Finally, just as in soils, as pH drops in aquatic systems inorganic aluminum can become more available to biota.

Low pH and soluble aluminum can have deleterious effects of aquatic biota, reducing both abundance and species diversity. In some cases, although the average water quality in aquatic systems is within the range of tolerance of biota, seasonal acidification can occur. This is the periodic increase in acidity and the corresponding decrease in pH and ANC in streams and lakes caused by a sudden pulse of acids and/or a dilution of base cations (e.g. calcium, magnesium, sodium, potassium) due to spring snowmelt and large rain events (reference (40)). These short-term increases in acid inputs can reach levels that are lethal to fish and other aquatic organisms (references (41) and (42)).

In the United States, effects of acidic deposition on aquatic systems have been most prominent in acid-sensitive areas of New York and other areas of the Northeast.

#### 3.5.1.5 Watershed buffering

One of the keys to understanding the deleterious effects of acidic deposition on aquatic systems is the concept of watershed buffering. Although the focus of acidic deposition is most often on aquatic systems, in most watersheds, terrestrial systems receive most of the acidic deposition that occurs to a landscape. First, the land area is simply greater than the water surface area in most regions. In the four northeastern Minnesota counties, land covers over 90% of the surface area (only about 9% open water -- 1992 USGS National Land Cover Database). Nonetheless, there is a wide range in the ratio of watershed area to lake area. Secondly, dry deposition is usually greater on terrestrial systems than aquatic systems because of the presence of the intercepting surfaces of vegetation in the former.

Most water that reaches aquatic systems first passes through terrestrial systems. It enters aquatic systems as either outflow from groundwater aquifers that are recharged by percolating soil water or as runoff, including overland flow, precipitation that has reached the aquatic system without infiltrating into the soil surface at any point, and interflow, subsurface flow that has moved through the soil during at least part of its journey to the aquatic system (reference (43)). Although overland flow occurs in agricultural soils, roads, lawns, parking lots, areas subject to livestock trampling, and similar situations, it has not been observed or described in undisturbed humid forested areas except under unique conditions (references (44), (45), and (43)). Therefore, overland flow is not expected to be a major route to lakes or other waters in most areas in northeast Minnesota.

Any acidic deposition that enters the soil system will chemically interact with soil constituents, altering the chemistry of both. Soils are generally well-buffered, resisting change and returning toward their initial state following disturbance. Soil processes, such as mineral weathering, cation exchange, and oxidation/reduction reactions reduce the acidity of any waters that pass through soils. A valid generalization, therefore, is that waters that have long flow paths through soil before reaching aquatic systems become increasingly altered from their original composition, generally increasing in pH and gaining ANC. Soil properties also have some influence, with soils having high levels of exchangeable cations and abundant weatherable minerals being more effective at changing water quality. This alteration of acidic deposition by terrestrial processes is referred to as *watershed buffering capacity*. The buffering capacity of Minnesota lakes and watersheds is described in detail in the next section.

# 4.0 Acid Deposition and Regulation in Minnesota

## 4.1 Acid Sensitive Ecosystems and Buffering Capacity

The Minnesota Legislature passed the Acid Deposition Control Act in 1982 (Minnesota Statutes, Sections 116.42 to 116.45) which required the MPCA to carry out a number of tasks related to acidic deposition, including the identification of areas of the state containing resources sensitive to acidic deposition.

### 4.1.1 Aquatic: Sensitive Lakes in Minnesota

To identify lakes sensitive to acidic deposition, the MPCA first established an index based on acid neutralizing capacity (ANC) as the best single indicator of a lake's sensitivity to acid deposition. The sensitivity index defined lakes that were sensitive to the effects of acidic deposition as having an ANC of 0 – 100 microequivalents per liter ($\mu eq\ L^{-1}$), potentially sensitive as having an ANC of 100 - 200 $\mu eq\ L^{-1}$, and nonsensitive as having an ANC of > 200 $\mu eq\ L^{-1}$ (reference (46)).

Four areas considered to be representative of lake chemistry and bedrock and geomorphic settings in northern and central Minnesota were studied to determine if a relationship between water chemistry and some watershed descriptor could be established to map the occurrence of low ANC lake systems. The results indicated that in mapping sensitive lakes in areas characterized by shallow soils (< 1 meter, m) over bedrock (primarily the BWCA), bedrock type was the integrating watershed factor. Sensitive lakes were associated with gabbros, granite, and basalt bedrock while potentially sensitive lakes were associated with slate and greenstone bedrock. In deeper soil areas (> 1 m), surficial geology information was needed to predict the presence of low ANC lakes. Nearly all the lakes with an ANC < 200 $\mu eq\ L^{-1}$ were in terminal moraines with rolling to steep topography. Soil textures ranged from loamy sands to loams, with small inclusions of clay soils. The low ANC lakes were generally small (< 40 hectares, ha, in area), at relatively high elevations, had low conductivity (indicating limited contact with alkaline groundwater), and were typically classed as precipitation-dominated seepage systems. In contrast, high ANC lakes (> 200 $\mu eq\ L^{-1}$) were often associated with agricultural and residential land use and outwash and lacustrine plains. These lakes tended to be large (> 100 ha in area), had high conductivities, and were typically flow-through systems with large streams entering and leaving them. The relationships between low ANC lakes and specific soil types in moraine areas was sufficiently strong to provide the basis for mapping areas of sensitive lakes, and the relationship between high ANC lakes and land use was used to classify a large part of the state as containing nonsensitive lakes (Figure 4-1) (reference (46)).

This exercise demonstrated that the routing of water through a watershed and the length of time that water spends in contact with soils on its way to the lake are major determinants of lake-water chemistry and the sensitivity to acidification by atmospheric deposition (reference (46)).

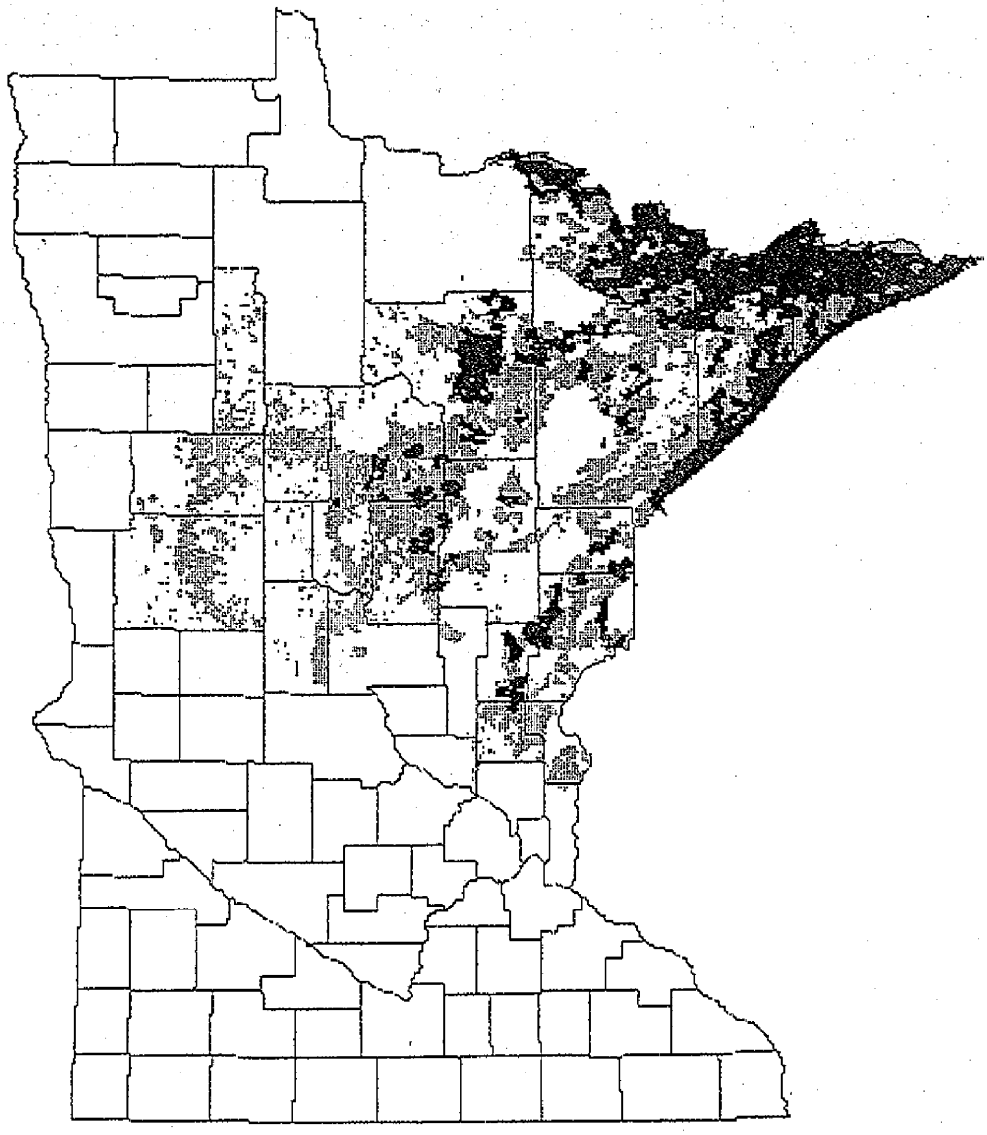



**Figure 4-1 Areas in Minnesota estimated to contain lakes considered sensitive or potentially sensitive to acidic deposition (from Twaroski et al. 1989).**

### 4.1.2 Terrestrial

The MPCA decided that cultivated agricultural soils would not be considered sensitive because of their generally high buffering capacities, enrichment with calcium carbonate, and the intensive management practices that far outweigh any effects from acid deposition (reference (47)).

For mapping of non-agricultural soils, the MPCA developed seven classes of sensitivity to acid deposition (sensitive – S, potentially sensitive – PS, and nonsensitive – NS), based on soil exchangeable bases in the surface 25 cm (in kiloequivalents per hectare; keq $ha^{-1}$), soil pH and annual precipitation:

S1 Sum of bases < 200 keq $ha^{-1}$, pH 4.5 - 7.0, 27 - 30 inches of precipitation.

S2 Sum of bases < 200 keq $ha^{-1}$, pH < 4.5, 27 - 30 inches of precipitation,

S3 Shallow soils over bedrock,

PS1 Sum of bases 200 - 500 keq $ha^{-1}$, pH 4.5 - 7.0, 27 - 30 inches of precipitation.

PS2 Sum of bases < 200 keq $ha^{-1}$, pH 4.5 - 7.0, 21 - 27 inches of precipitation.

PS3 Sum of bases 200 - 500 keq $ha^{-1}$, pH 4.5 - 7.0, 21 - 27 inches of precipitation.

NS Nonsensitive

The NS category included cultivated agricultural soils, clay, silt, or loam soils, soils with carbonates present in the surface 25 cm, soils on slopes > 12%, grassland soils, poorly drained, and frequently flooded soils.

The sensitivity classes were applied on a state-wide basis using data from the Minnesota Soil Atlas Project (1969-1981) contained in the Minnesota Land Management Information Center, currently available online at http://www.lmic.state.mn.us/chouse/metadata/soil_atlas.html. That mapping delineates the state into geomorphic regions, each of which is further subdivided into landscape units based on surface and subsurface texture, drainage, and surface organic matter. The analysis was directed at forested, pasture, and open land. Soil properties for each geomorphic region – landscape unit combination were based on data from the USDA Soil Conservation Service (SCS – renamed the Natural Resources Conservation Service – NRCS).

The most sensitive soils, S1, S2, and S3, occurred in the eastern one-third of the state, including the Arrowhead region. Soils with low buffering capacity in the western two-thirds of the state were in the PS2 and PS3 categories. The rationale for this ranking was that the western soils contain more primary minerals than soils further east. These minerals act as an additional buffer against acid

deposition. The western soils also are likely to have less base cation loss because they receive less deposition and less precipitation, so that less acidic water percolates through them (reference (47)).

Soils in the S1, S2, and S3 classes were considered to be of most concern, and they occupy 2.1% (1,128,480 acres), 0.1% (63,320 acres), and 4.2% (2,301,240 acres) of the state, respectively. The potentially-sensitive classes PS1, PS2, and PS3 occupy 3.5% (1,905,600 acres), 2.5% (1,354,200 acres), and 1.3% (683,720 acres), respectively. The majority of soils, 86.3%, were not considered to be sensitive to acidic deposition.

In the report on the potential sensitivity of soils, the MPCA stressed that even though some soils were classified as sensitive, Minnesota soils are not as susceptible to acidic deposition as are soils from the eastern United States or from central Europe (reference (47)). The large reserve of nutrients and presence of primary minerals provide an additional buffer against acidic deposition compared to those other areas. In addition, Minnesota has a drier climate than those areas so less leaching loss of soil bases has occurred to date, and less leaching of soil bases will occur in the future (reference (47)).

The MPCA also acknowledged that the data used for their mapping of sensitive soils was only accurate to about 650 acres (reference (47)). Ratings were assigned to landscape units represented by one or more specific soil series. However, not all soils within a given landscape unit have the same properties, and hence landscape units considered to be sensitive or potentially sensitive may include many soils that are not as sensitive. As an example, they describe the Sartell soil, which was considered one of the most sensitive soils in the state. The soil occurs on the Anoka Sand Plain, and its presence led to about 430,000 acres of the Sand Plain being mapped as sensitive while the Sartell soil, the basis for the ranking, only covers about 40,000 acres. It is therefore likely that the total area mapped as sensitive is considerably greater than the actual area of sensitive soils (reference (47)).

The sensitivity rating for Minnesota soils as described above was based on current soil properties. A companion dynamic approach was also used to determine soil sensitivity. In that approach, a computer model was used to estimate soil properties after 100 and 300 years of simulated average acidic deposition and average precipitation and evapotranspiration (reference (48)). Using somewhat the same approach as the MPCA, soil properties were based on representative soil series and applied to landscape units from the Soil Atlas maps. Sensitivity was based on the change in pH, sum of bases, and levels of aluminum (Al) in soil solution. After 100 years, Class 1 (most sensitive) soils dropped more than 0.5 pH units, the sum of bases was less than 10 keq $ha^{-1}$, and Al soil solution reached potentially toxic levels. Class 2 soils dropped approximately 0.2 pH units in 100 years, sum of bases after 100 years was less than 50 keq $ha^{-1}$, and potentially toxic Al levels were reached within

300 years. Class 3 soils also dropped in pH about 0.2 units, the sum of bases after 100 years was less than 100 keq $ha^{-1}$, and soil solution did not reach potentially toxic Al levels within 300 years. Finally, in Class 4 soils the sum of bases after 100 years did not drop below 100 keq $ha^{-1}$ and the soil solution did not reach potentially toxic levels of aluminum within 300 years (reference (48)).

Most of the soils classified by the MPCA (reference (47)) as potentially sensitive (PS) using current properties were judged not to be sensitive to acidic deposition based on the results of the dynamic soil modeling, and some soils classified as S1, S2, and S3 by the MPCA were only potentially sensitive. In general, however, there were no large discrepancies between the two methods in the identification of soils that were most susceptible to acidic deposition.

The dynamic soil modeling approach also suffers from the problems associated with extrapolating from data for a few soils to large areas of the state. A follow-up study was initiated to explore this in more detail by Grigal (reference (49)). This follow-up investigation focused on the Sartell soil, previously described as one of the most sensitive soils in the state. Representative Sartell soils were sampled from 13 locations on the Anoka Sand Plain and their properties determined. In the previous modeling effort, the Sartell soil had been described as having a pH of 4.6 and a sum of base cations in the upper 25 cm of 25 keq $ha^{-1}$ (reference (48)). Although the average pH of the 13 Sartell samples was 4.6, the average sum of bases was 90 keq $ha^{-1}$ and no sample had a sum as low as 25 keq $ha^{-1}$. The dynamic soil computer model was then used to evaluate the 13 samples individually, with the modeling results indicating that none of the 13 Sartell samples fell in the Class 1 sensitivity, 7 of the samples were in Class 2 sensitivity, 4 of the samples were in Class 3, and 2 samples were in Class 4 (reference (49)). In other words, the "representative soil" for that landscape unit was not truly representative, having a significantly lower buffering capacity than found in the 13 samples. In addition, such models may encompass currently available knowledge of chemistry and hydrology, but that knowledge may be wholly incomplete, leading to uncertainty.

In summary, the evaluation of the sensitivity of Minnesota soils to acidic deposition determined that some soils in Minnesota are potentially more sensitive to change due to acidic deposition than others. In addition, because of a fortuitous combination of soil properties and climate, and the lower acidic deposition received in Minnesota compared to areas further east, Minnesota currently does not have and likely will not soon have soils that are seriously affected by acidic deposition.

## 4.2 Emission Source Contributions to Minnesota Ecosystems

In 1985 the MPCA completed a sophisticated analysis of long range transport of $SO_2$ and sources of acidic deposition (concentrating on sulfate) to Minnesota for its acid rain rule (MPCA 1985). Two

Lagrangian models, Empire State Electric Energy Research Corporation (ESEERCO) Model and Environmental Research & Technology, Inc., MESOPUFF II Model were selected for use. The base year for modeling was 1980 because emissions data, meteorological data, and precipitation monitoring data were available for that year. In addition, 1982, a wetter year than 1980, was modeled.

The ESEERCO Model was used to evaluate the contributions to sulfur deposition from sources at very large distances outside Minnesota (nearly all of North America east of the Rocky Mountains). The MESOPUFF II Model was used to more carefully investigate the contributions from sources in Minnesota. In the final analysis, results from MESOPUFF II (Minnesota sources) were combined with the results from ESEERCO (sources outside Minnesota). This was done because MESOPUFF II is more sophisticated than ESEERCO in its treatment of atmospheric processes near the pollutant source.

Modeling was directed at deposition to seven receptors in Minnesota, including four that continue to be monitored in northeastern Minnesota (Hovland, Cook County; Marcell Experimental Forest, Itasca County; Fernberg Road (Ely), Lake County; and Grindstone Lake, Pine County). About 75% of the deposition to those receptors could be attributed to regional sources that each exceeded 5% of the deposition. The major sources in that category were the Midwest, including the Ohio Valley, and the South, including Missouri and Texas (about 20% each). Sources in the northeastern United States, including New England, New York, and Pennsylvania contributed about 12% of the sulfate deposition, and Canadian sources contributed an additional 10%. Sulfur dioxide emissions from Minnesota sources only contributed about 11% to sulfate deposition at the four receptors, with less contribution at Hovland (~ 5% at Hovland) (reference (2)).

These results are consistent with a more recent modeling exercise cited earlier that attributed about 13% of the wet sulfate deposition in the Upper Midwest to sources within the region (reference (9)). In summary, modeling results indicate that 85 to 90% of the wet sulfate deposition in northern Minnesota is derived from out-of-state sources, and that only 10 to 15% of the wet sulfate deposition is likely from in-state sources.

As previously discussed in the section on source-receptor relationships, the results of most modeling efforts indicate that sulfur deposition at remote receptors is dominated by wet deposition, with the sulfur originating from sources at distances as large as 500 km from these receptors (reference (23)). On a national basis, for source regions aggregated by state, no one source region contributed more than about 15% to the sulfur deposition at remote receptors. Thus, sulfur deposition at remote receptors, including northeastern Minnesota, is not dominated by one or two source regions. Source

regions as far away as 1,000 km contributed to the deposition, even though their relative contributions are as small as 1 to 2%. For example, one analysis indicates that only 13% of the wet sulfate deposition in the Upper Midwest region (Iowa, Michigan, Minnesota, and Wisconsin) is derived from sources within the region, with sources in Illinois, Missouri, Indiana, and Texas each contributing about 10% of the deposition (reference (9)).

Additionally, the available studies indicate trends showing that the amount of in-state versus out-state contributions have proportionally stayed about the same in Minnesota over the past two decades (reference (9)). This leads to the conclusion that the past proportionality of Minnesota's $SO_2$ emissions and expected small contribution to acid deposition in Minnesota (~10-15%) compared to $SO_2$ emissions from other eastern states and their contribution to acid deposition in Minnesota (~85-90%) will be similar in the future (reference (16)).

## 4.3 State Acid Deposition Standard and Control Plan

The Minnesota Legislature passed the Acid Deposition Control Act in 1982 (Minnesota Statutes, Sections 116.42 to 116.45) that required the MPCA to inventory acid sensitive resources and to establish an acid deposition standard and control plan. In 1986, the MPCA adopted a wet sulfate standard intended to protect Minnesota's most acid-sensitive lakes from cumulative long term damage. This standard is set at 11 kilograms of sulfate per hectare per year.

A three-part emissions control plan was adopted at the same time as the acid deposition standard, and included the following provisions:

- The two largest emitters of $SO_2$ in the state were required to reduce emissions by applying Reasonably Available Control Technology (RACT).
- The system-wide $SO_2$ emissions of Northern States Power (now Xcel Energy) and Minnesota Power were to be held at no more than 130% of their 1984 levels.
- Statewide $SO_2$ emissions were to be reduced to 194,000 tons/yr by January 1, 1994.

Compliance reports issued by the MPCA indicate that the acid deposition standard and control plan were both being met as of January 1, 1994 (reference (50)). Deposition monitoring data obtained from the National Atmospheric Deposition Program (NADP) for 1994 – 2010 indicates that the wet sulfate deposition standard was exceeded at the Wolf Ridge site in 1998. Current deposition monitoring data from the NADP and $SO_2$ emissions data from Minnesota sources obtained from the MPCA's website indicate that the state is in compliance with the acid deposition standard and control plan.

# 5.0 Acid Deposition Trends

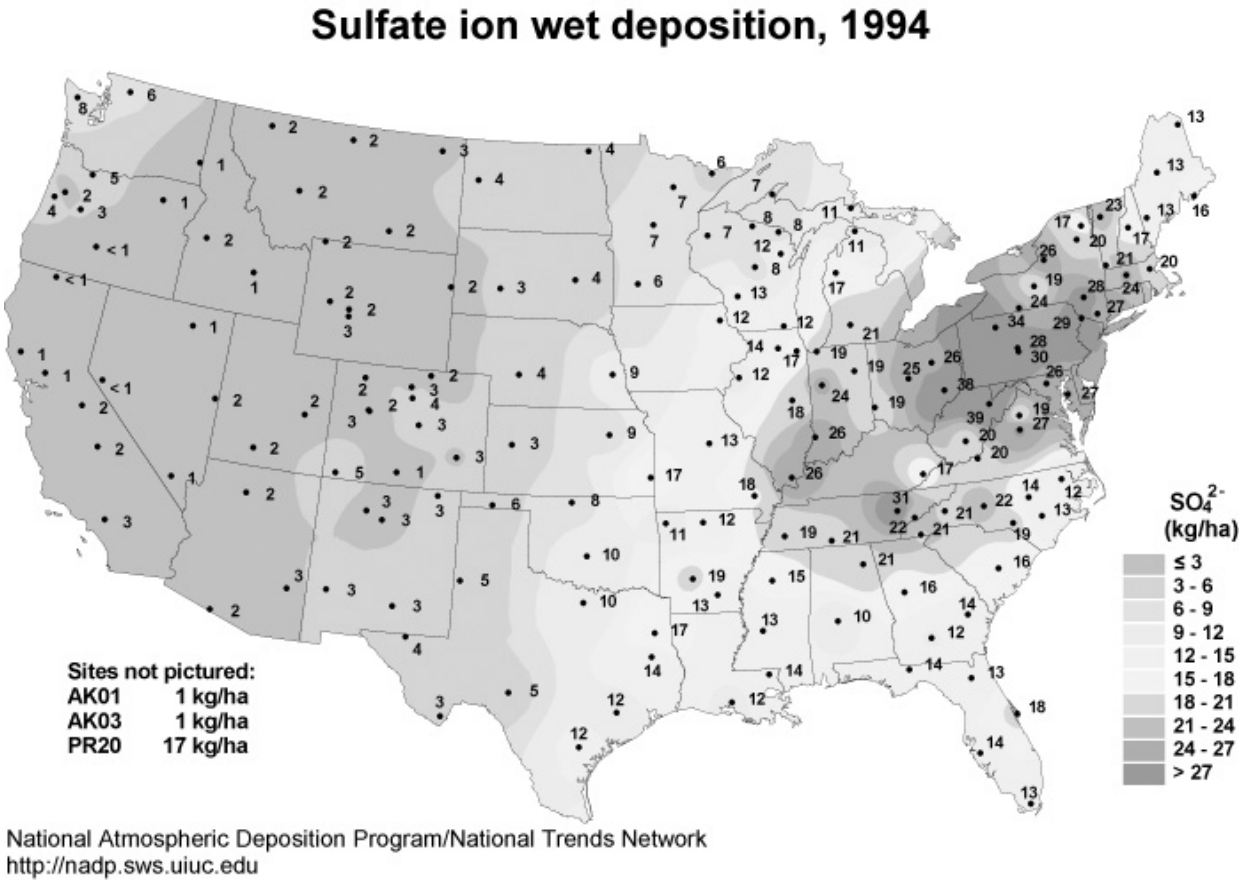
This section summarizes acid deposition trends for the United States, primarily the eastern U.S. and also for northeastern Minnesota and the upper Midwest region (Minnesota, Michigan, North Dakota and Wisconsin).

## 5.1 National Deposition Trends

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The NADP/NTN network is a cooperative effort between many different groups, including the State Agricultural Experiment Stations, U. S. Geological Survey, U. S. Department of Agriculture, and numerous other governmental and private entities. The NADP/NTN has grown from 22 stations at the end of 1978, the first year, to over 240 sites spanning the continental United States, Alaska, and Puerto Rico, and the Virgin Islands. The purpose of the network is to collect data on the chemistry of precipitation for monitoring of geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium).

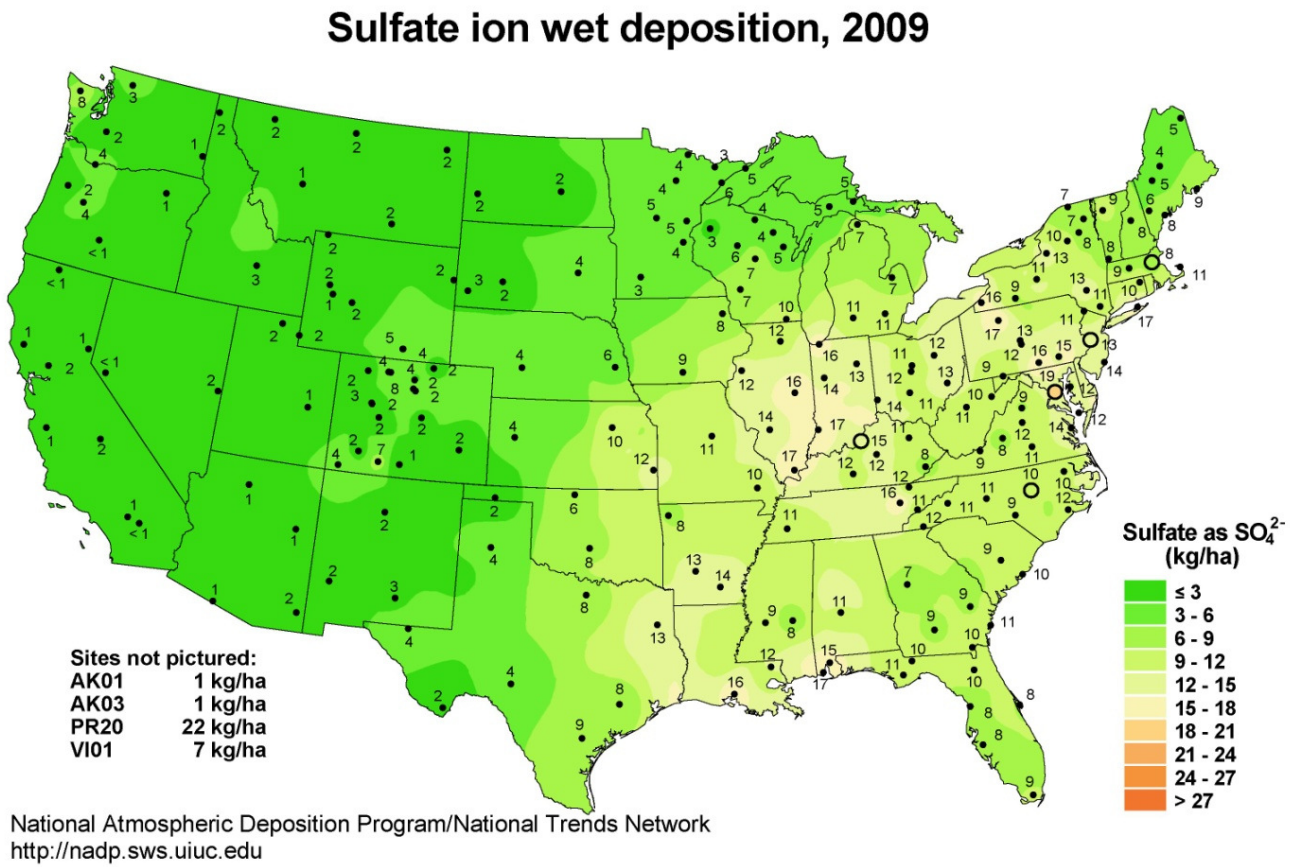
In general, acidic deposition in the United States tends to decrease from east to west, with highest levels in Pennsylvania, New York and surrounding states, and lowest levels in Nevada and Utah (reference (51)). Although geographically in the middle of the United States, Minnesota receives relatively low levels of acid deposition.

NADP isopleth maps indicate that in 1994 wet sulfate deposition in Minnesota averaged about 6.5 kg $ha^{-1}$ compared to between 20 and 30 kg $ha^{-1}$ in Pennsylvania and New York (Figure 5-1). Figure 5-2 shows 2009 wet sulfate deposition rates, which averaged about 6 kg $ha^{-1}$. The comparison of data in Figure 5-1 and Figure 5-2 indicates that wet sulfate deposition decreased nearly 50% in some portions of the eastern United States (e.g., Pennsylvania, Ohio, West Virginia) from 1994 to 2009, with smaller declines in the Upper Midwest and Minnesota (~30% decrease) during this time period (reference (52)). This decline in wet sulfate deposition since the early to mid-1990s for the eastern half of the United States is similar to that described by the EPA and NAPAP (references (53), (16), and (25)). Their analysis indicates that wet sulfate deposition in the Northeast in 2006-2008 was 33% lower than in 1989-1991, and in the Midwest was 37% lower (references (53), (16), and (25).




Map obtained from:
National Atmospheric Deposition Program (NRSP-3). 2005.
NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820

**Figure 5-1 Sulfate ion wet deposition, 1994, across the United States.**




Map obtained from:
National Atmospheric Deposition Program (NRSP-3). March 2011.
NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820

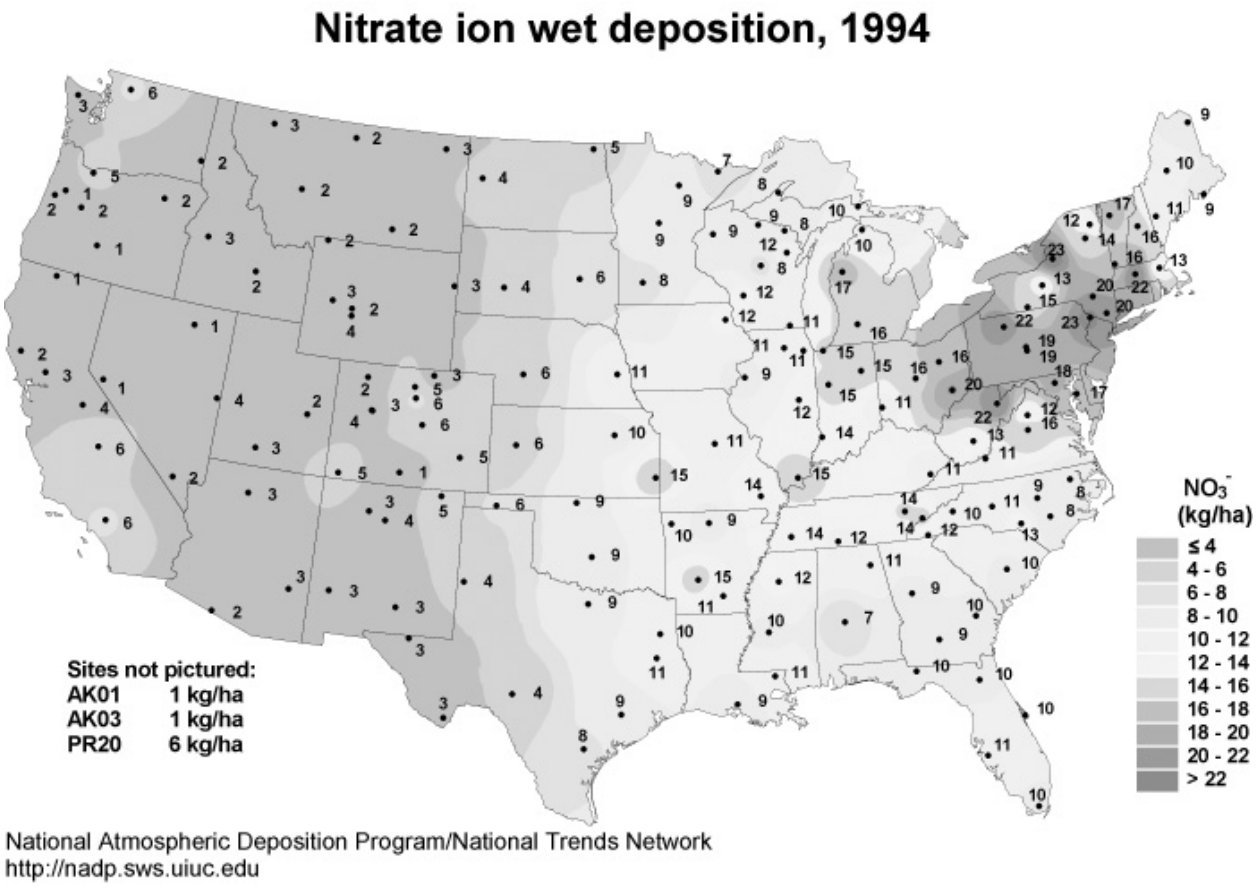
**Figure 5-2 Sulfate ion wet deposition, 2009, across the United States.**

Similar to wet sulfate deposition rates, wet nitrate deposition rates are higher in eastern states than in Minnesota. In 1994, wet nitrate deposition averaged about 8 kg $ha^{-1}$ in Minnesota compared to between 15 and 25 kg $ha^{-1}$ in Pennsylvania and New York (Figure 5-3). From 1994 to 2009 nitrate deposition had not decreased nationally as noticeably as sulfate deposition, although NAPAP indicates that average annual wet nitrate deposition in 2006-2008 was 10% to 21% lower than in 1989-1991 in the Midwest and eastern United States (references (53), (16), and (25)).

Comparison of data in Figure 5-3 (1994 deposition) and Figure 5-4 (2009 deposition) indicates that wet nitrate deposition has decreased in the Mid-Atlantic and Northeast regions between 1994 and 2009; most of the decrease occurred between 2004 and 2007 (references (54) and (55)). Deposition in some portions of the eastern United States decreased by more than 30% (e.g., West Virginia, Ohio, Tennessee). Nitrate wet deposition in Minnesota decreased between 1994 and 2009 from 8 to 6 kg $ha^{-1}$, about a 25% decrease when averaged over the entire state.

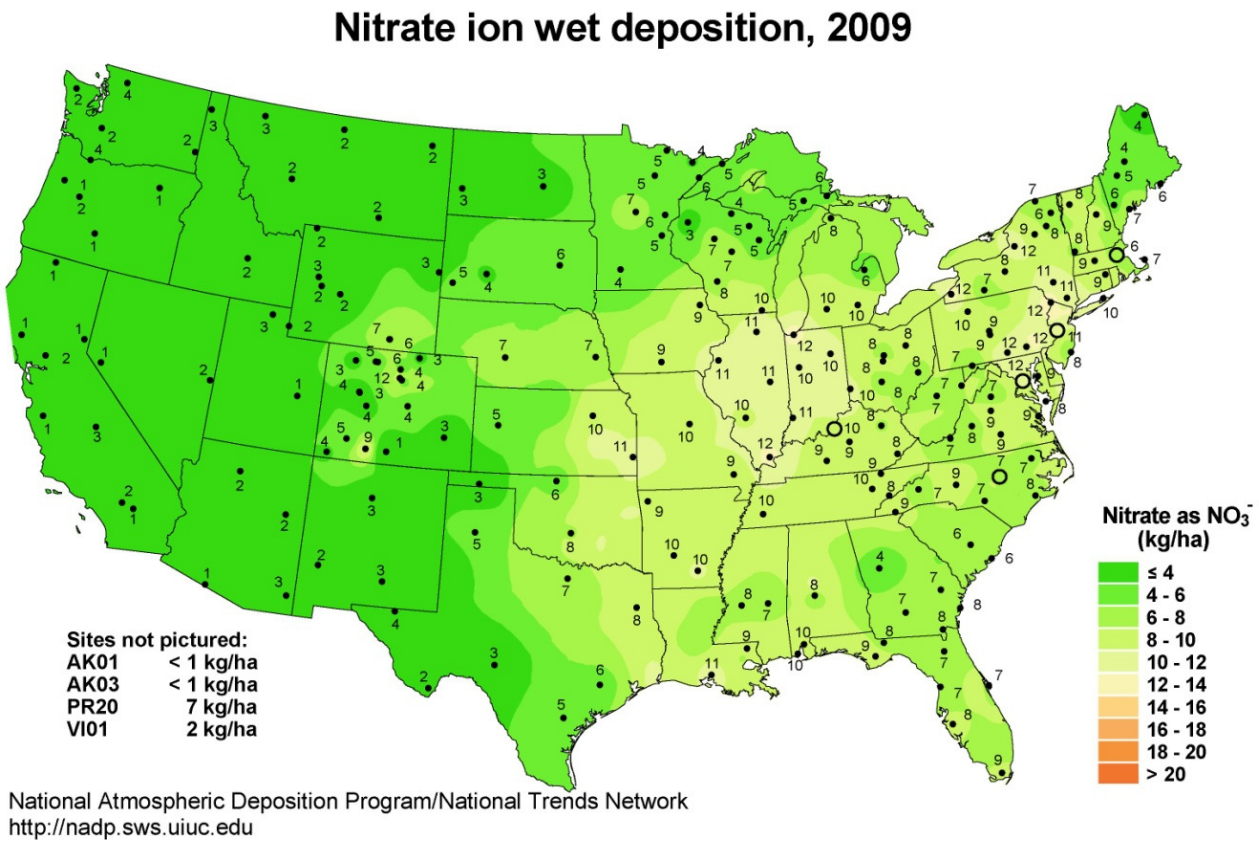
Significant $NO_X$ emission reductions occurred in the eastern half of the United States between 2002 and 2005 due to the federal regulatory action identified as the $NO_X$ State Implementation Plan (SIP) Call. Emissions from power plants were reduced by about 36 percent and mobile source emissions were reduced by approximately 13 percent from 2002 to 2004. The largest $NO_X$ emission reductions occurred within the Ohio River Valley, with additional notable reductions in southern Michigan, Illinois, Tennessee, Alabama, Georgia and the Carolinas (references (54) and (55)). Preliminary findings indicate that the reductions in $NO_X$ emissions resulted in lower nitrate concentrations in precipitation measured at numerous monitoring locations in the eastern one-half of the country in 2005 compared to 2002 (reference (55)). Monitoring locations in the Ohio River Valley, where the largest emission reductions occurred, experienced the largest decreases in nitrate concentration, on the order of 20 to 60 percent (references (54) and (55)). The respective authors concluded that the "impact from power plant reductions" had been captured in the monitoring data (references (54) and (55)).

While $NO_X$ emissions from both mobile sources and power plants were reduced because of the $NO_X$ SIP Call, both investigators focused on the reductions from power plants as being most important (references (54) and (55)). $NO_X$ emissions within the Ohio River Valley decreased by 75 percent, primarily due to reductions at power plants, accompanied by relatively large decreases in nitrate deposition at monitoring locations within the Valley, with smaller changes at more distant monitoring locations (references (54) and (55)). This suggests that power plants may have a relatively large contribution to local/regional deposition in the Ohio River Valley compared to agricultural or mobile sources. It is not clear from the data presented, however, whether the relatively close relationship between power plant emission reductions and lower concentrations of nitrate in air and precipitation occurred throughout the eastern United States or was unique to the Ohio River valley. Data analysis and interpretation are continuing (reference (55)). Overall, emissions of $NO_X$ from all sources have decreased by 36% during the period 1990 to 2008 (reference (25)).




Map obtained from:
National Atmospheric Deposition Program (NRSP-3). 2005.
NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820

**Figure 5-3 Nitrate ion wet deposition, 1994, across the United States.**




Map obtained from:
National Atmospheric Deposition Program (NRSP-3). March 2011.
NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820

**Figure 5-4 Nitrate ion wet deposition, 2009, across the United States.**

## 5.2 Minnesota and Regional Acid Deposition Trends

### 5.2.1 Monitoring Site Data

Trends analyses are typically conducted using the longest time periods for which reliable data are available. One reason for using longer time periods is that a trend analysis conducted for relatively short periods may lead to different conclusions than an analysis based on longer time periods. For assessing acid deposition trends, sufficient monitoring data are available from 1984 to 2010. Appendix A, Tables A1 and A2, show the monitoring sites and data used for the trend analyses.

Geographic trends of deposition of sulfate and nitrate across northeastern Minnesota are consistent with regional and national trends, with clear increases both from west to east and from north to south across Minnesota and the region. Analyses were conducted using data from the period of 1984-2010 for regional sites (Appendix A, Table A1) and for all northern Minnesota sites (Appendix A, Table A2).

Analyses of Variance (ANOVA) using the general linear model (GLM) procedure in SYSTAT (SYSTAT 2007) were run on the deposition data, using years 1984 to 2010. The analyses assumed that average deposition to any specific monitoring site in any given year is intrinsically different from that in any other year, because of differences in emissions, storm tracks, rates of atmospheric reactions, and other factors. Using data from all sites, the analyses then test whether or not there are gradients in deposition across sites over all years. In other words, the analyses consider "year" to be an independent categorical variable, and precipitation, latitude, longitude, and elevation to be independent continuous variables.

The analyses indicated that precipitation, latitude and longitude were significantly related to both sulfate and nitrate deposition, but elevation was only significantly related in some cases (Table 5-1). Findings from this analysis for wet sulfate and wet nitrate deposition, as summarized in Table 5-1, include:

- Sulfate:
    - Annual deposition increases:
        - ~ 0.1 kilogram per hectare per year (kg $ha^{-1}$ yr-1) with each centimeter (cm) increase in annual precipitation across Minnesota and the region.
        - ~ 0.7 kg $ha^{-1}$ yr-1 with each degree of longitude east across Minnesota, and ~ 0.2 kg $ha^{-1}$ with each degree across the region;
    - Annual deposition decreases:
        - ~ 1.0 kg $ha^{-1}$ yr-1 with each degree of latitude north across both Minnesota and the region.
        - ~ 0.5 kg $ha^{-1}$ yr-1 with each 100 m elevation increase across Minnesota.

**Table 5-1 Summary statistics showing the change in deposition of sulfate, nitrate, and inorganic nitrogen in northeast Minnesota and the adjoining Region with longitude, latitude, precipitation, and elevation (1984 – 2010 time period)**

| Area | Variable | # of Data Points (n) | Period (years) | Longitude : To east | Prob. | Latitude : To north | Prob. | Precipitation | Prob. | Elevation | Prob. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NE MN | Sulfate | 147 | 1984 –2010 | 0.748 | 0.000 | -1.046 | 0.000 | 0.123 | 0.000 | -0.005 | 0.000 |
| | Nitrate | 147 | 1984 –2010 | 0.290 | 0.002 | -0.779 | 0.000 | 0.099 | 0.000 | -0.005 | 0.000 |
| | inorganic N | 147 | 1984 –2010 | 0.045 | 0.417 | -0.554 | 0.000 | 0.047 | 0.000 | -0.003 | 0.000 |
| | | | | | | | | | | | |
| Region | Sulfate | 703 | 1984 –2010 | 0.216 | 0.000 | -1.061 | 0.000 | 0.109 | 0.000 | -0.001 | 0.226 |
| | Nitrate | 703 | 1984 –2010 | 0.119 | 0.000 | -0.704 | 0.000 | 0.111 | 0.000 | -0.001 | 0.146 |
| | inorganic N | 703 | 1984 –2010 | -0.075 | 0.000 | -0.369 | 0.000 | 0.056 | 0.000 | -0.002 | 0.000 |

Units: Change in units of kg $ha^{-1}$ $degree^{-1}$ $yr^{-1}$ for longitude and latitude; kg $ha^{-1}$ $cm^{-1}$ $yr^{-1}$ for precipitation, and kg $ha^{-1}$ $m^{-1}$ $yr^{-1}$ for elevation.

Wet sulfate deposition, wet nitrate deposition, and precipitation data from:

- NADP at http://nadp.sws.uiuc.edu/, accessed September 2011, and
- Mr. Rick Strassman, MPCA, spreadsheet received by Barr Engineering 9 February 1998.

Area

- NE MN Area includes data from northern Minnesota monitoring sites: Hovland, Cook County; Marcell Experimental Forest, Itasca County; Fernberg Road (Ely), Lake County; Grindstone Lake, Pine County; Voyageurs National Park, St. Louis County; and Wolf Ridge, Lake County.
- Region Area includes all monitoring stations from Minnesota, Michigan, North Dakota, and Wisconsin that report to the National Atmospheric Deposition Program (NADP).

Abbreviations:

Units of measure: cm = centimeter m = meter kg = kilogram ha = hectare yr = year

n = number of data points

prob. = probability

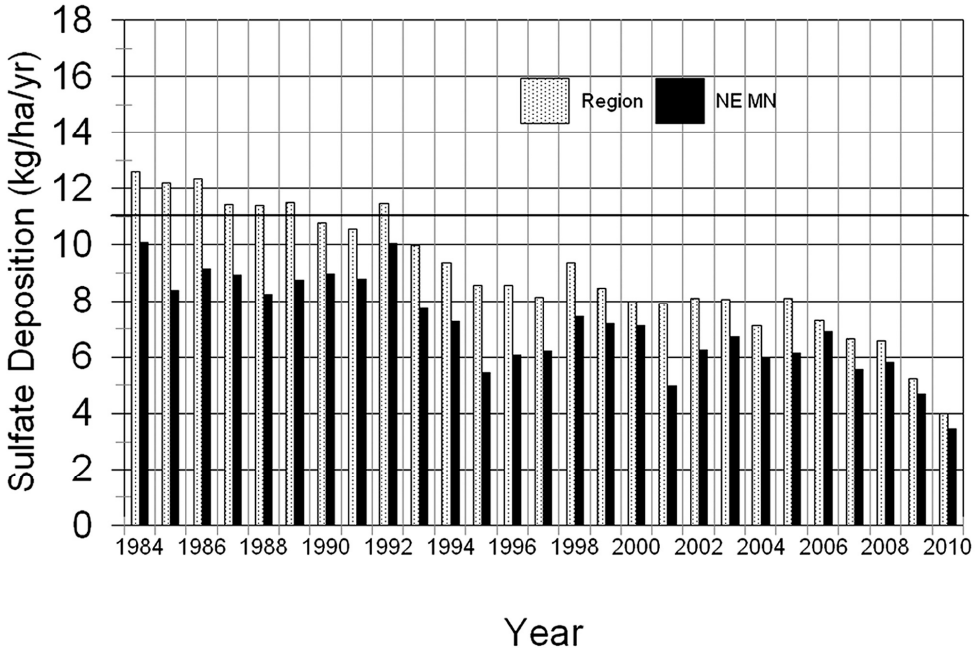
- Nitrate:
    - Annual deposition increases:
        - ~ 0.1 kg $ha^{-1}$ $yr^{-1}$ with each cm increase in annual precipitation across Minnesota and the region.
        - ~ 0.3 kg $ha^{-1}$ $yr^{-1}$ with each degree of longitude east across Minnesota;
        - ~ 0.1 kg $ha^{-1}$ $yr^{-1}$ with each degree of longitude east across the region;
    - Annual deposition decreases:
        - ~ 0.8 kg $ha^{-1}$ $yr^{-1}$ with each degree of latitude north in Minnesota and ~ 0.7 kg $ha^{-1}$ $yr^{-1}$ with each degree across the region.
        - ~ 0.5 kg $ha^{-1}$ $yr^{-1}$ with each 100 meter (m) increase in elevation in Minnesota.

The study area (Itasca, Koochiching, St. Louis, Lake, Carlton and Cook Counties) spans the longitudinal range from about 94.5º to 89.5º east and the latitudinal range from about 46.6º to 48.5º north. As a result, a difference of about 3.8 kg $ha^{-1}$ $yr^{-1}$ in sulfate deposition and 1.2 kg $ha^{-1}$ $yr^{-1}$ in nitrate deposition across the area are related to longitude and latitude, irrespective of precipitation and elevation. Because precipitation also tends to increase in Minnesota toward the east and south, deposition is further increased in southern and eastern locations. These gradients in wet sulfate deposition are very likely the effect of distance to major sources of sulfate emissions to the east (Ohio Valley) and the south (Missouri and Texas), as discussed earlier.

When the influence of precipitation, elevation, latitude and longitude are statistically isolated, wet sulfate deposition to northeastern Minnesota and the region show a decrease over the period 1984 to 2010, with much of the decrease occurring between 1992 and 1994 (Figure 5-5). The decline is statistically significant in northeastern Minnesota (-0.18 kg $ha^{-1}$ $yr^{-2}$, prob. = 0.000) (Figure 5-5). The annual wet sulfate deposition in northern Minnesota is consistently lower than the regional average (Figure 5-5), reflecting the increase in deposition to the east and south, and over the past decade is also well below the 11 kg $ha^{-1}$ $yr^{-1}$ deposition standard (Figure 5-5). These statistical findings are consistent with the previous finding of Eilers and Bernert (1997) when they assessed the available deposition data from selected monitoring sites in northern Minnesota (Birch Lake, Fernberg Road (Ely), and Marcell) (reference (11)).

A supplemental analysis of only the 1997 – 2010 wet sulfate (and nitrate) deposition data for northern Minnesota was conducted. When the influence of precipitation, elevation, latitude and longitude are statistically isolated for this shorter time period, there is a statistically significant decline in sulfate wet deposition to northeastern Minnesota (-0.18 kg $ha^{-1}$ $yr^{-2}$, prob. = 0.029) over the

period 1997 to 2010 (Figure 5-6). The average wet sulfate deposition for that period (that is, at the midpoint of the precipitation, elevation, latitude and longitude for the recording stations) is about 6.0 kg $ha^{-1}$ $yr^{-1}$ (Fig. 5.6), well below the annual 11 kg $ha^{-1}$ $yr^{-1}$ deposition standard.



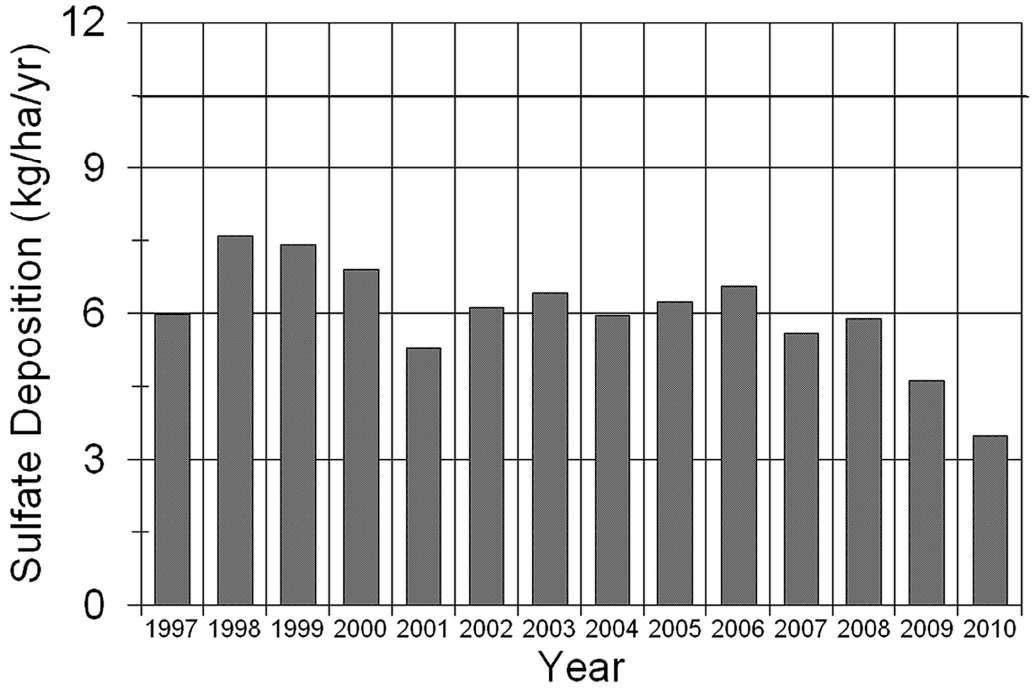

[1] Minnesota's annual wet sulfate deposition standard of 11 kg $ha^{-1}$ indicated by the dark horizontal line. Northern Minnesota acid deposition monitoring stations include:

- Hovland, Cook County;
- Marcell Experimental Forest, Itasca County;
- Fernberg Road (Ely), Lake County;
- Grindstone Lake, Pine County;
- Voyageurs National Park, St. Louis County;
- Wolf Ridge, Lake County.

[2] The Adjoining Region includes all monitoring stations from Minnesota, Michigan, North Dakota, and Wisconsin that report data to the National Atmospheric Deposition Program (NADP; http://nadp.sws.uiuc.edu/).

**Figure 5-5 Wet sulfate deposition to northern Minnesota[1] and the adjoining region[2] over the period 1984 to 2010, statistically isolating the influence of precipitation, latitude and longitude.**

(The estimate is at the midpoint of those variables for the recording stations).




Minnesota's 11 kg $ha^{-1}$ deposition standard indicated by the solid line.

[1] Data from the following monitoring stations included in the statistical analysis:

- Hovland, Cook County;
- Marcell Experimental Forest, Itasca County;
- Fernberg Road (Ely), Lake County;
- Grindstone Lake, Pine County;
- Voyageurs National Park, St. Louis Count

**Figure 5-6 Wet sulfate deposition to northeastern Minnesota[1] over the period 1997 to 2010, statistically isolating the influence of precipitation, elevation, latitude and longitude.**

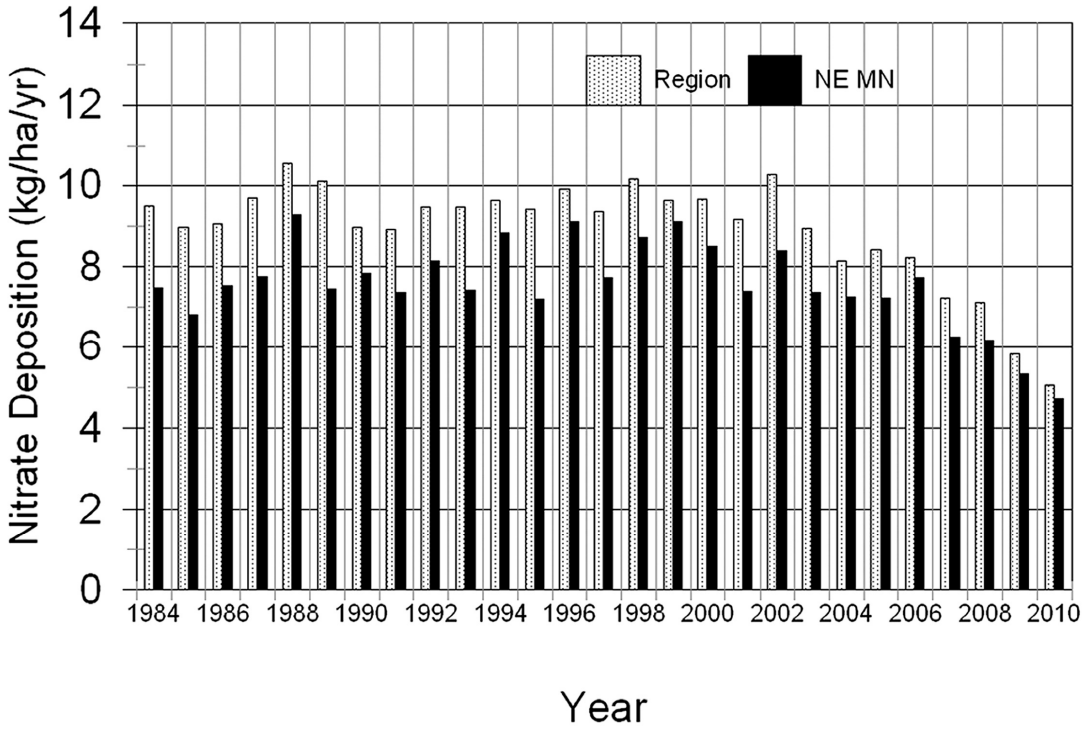
(The estimate is at the midpoint of those variables for the recording stations).

For nitrate deposition, there is a small but statistically significant decline over both the region (-0.10 kg $ha^{-1}$ $yr^{-2}$, prob. = 0.000) and northeastern Minnesota (-0.06 kg $ha^{-1}$ $yr^{-2}$, prob. = 0.010) from 1984 to 2010 (Figure 5-7). As with sulfate, nitrate deposition to northern Minnesota is consistently lower than the regional average (Figure 5-7). The supplemental analysis for the 1997 – 2010 was also conducted for wet nitrate deposition, with results provided in Figure 5-8. As with wet sulfate deposition, wet nitrate deposition had a statistically significant decrease during the 1997 – 2010 time period (-0.27 kg $ha^{-1}$ $yr^{-2}$, prob. = 0.000) (Figure 5-8). The average nitrate deposition between 1997 and 2010 was about 7.2 kg $ha^{-1}$ $yr^{-1}$ (Figure 5-8).

Inorganic nitrogen, the sum of nitrate and ammonium deposition, does not significantly change across Minnesota from west to east, and actually decreases from west to east across the region (Table 5-1). Deposition of inorganic N does not show a strong time-trend over northern Minnesota or the

region (Figure 5-9). Because of the lack of a longitudinal effect on inorganic N deposition, deposition to northern Minnesota is only slightly lower than the regional average (Figure 5-9). The difference in behavior between nitrate deposition and inorganic nitrogen deposition likely reflects the importance of western agricultural sources to ammonium emissions and deposition.

A review of deposition data for the Fernberg Road site near Ely, Minnesota, confirms that ammonium deposition increases since the late 1990s have essentially offset wet nitrate deposition decreases during the same time period (Figure 5-10). The same trend of increasing ammonium wet deposition and decreasing nitrate wet deposition since the late 1990s is also found for the Marcell site, just northeast of Grand Rapids, and to a lesser degree at the Wolf Ridge site just north and west of Silver Bay along the North Shore of Lake Superior. Nitrate wet deposition is expected to remain the same or decline in the future as additional regulations of $NO_X$ emissions from combustion sources are implemented. Ammonium wet deposition is primarily attributed to agricultural sources and there is uncertainty as to whether ammonia ($NH_3$) emissions, the precursor to ammonium, will be increasing or decreasing in the future.



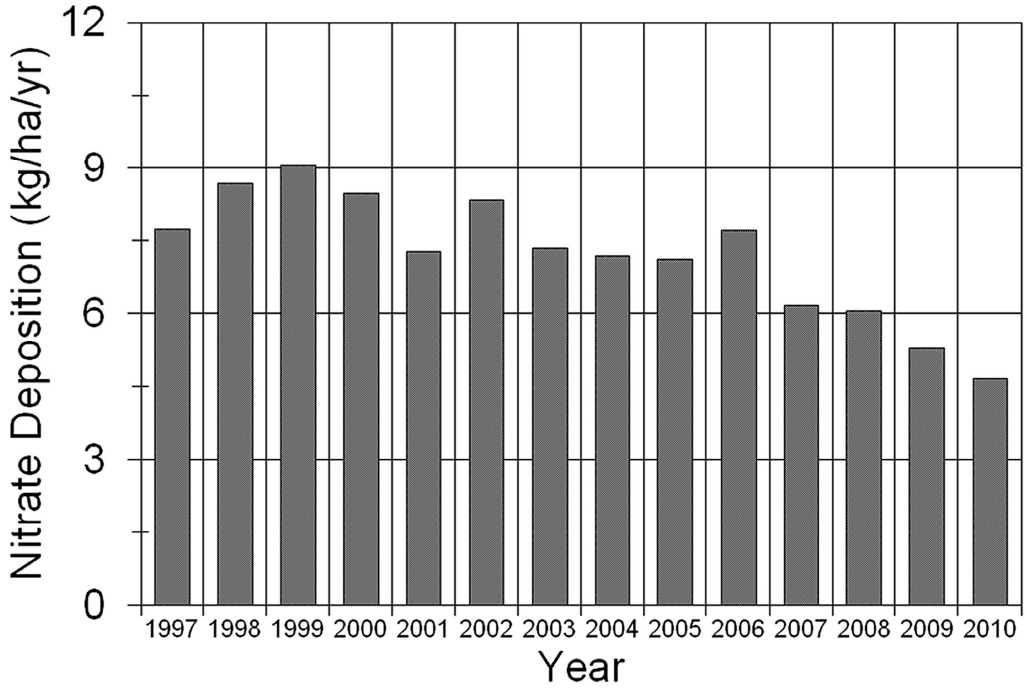

[1] Northern Minnesota acid deposition monitoring stations include:

- Hovland, Cook County;
- Marcell Experimental Forest, Itasca County;
- Fernberg Road (Ely), Lake County;
- Grindstone Lake, Pine County;
- Voyageurs National Park, St. Louis County;
- Wolf Ridge, Lake County.

[2] The Adjoining Region includes all monitoring stations from Minnesota, Michigan, North Dakota, and Wisconsin that report data to the National Atmospheric Deposition Program (NADP; http://nadp.sws.uiuc.edu/).

**Figure 5-7 Wet nitrate deposition to northern Minnesota[1] and the adjoining region[2] over the period 1984 to 2010, statistically isolating the influence of precipitation, latitude and longitude.**

(The estimate is at the midpoint of those variables for the recording stations).

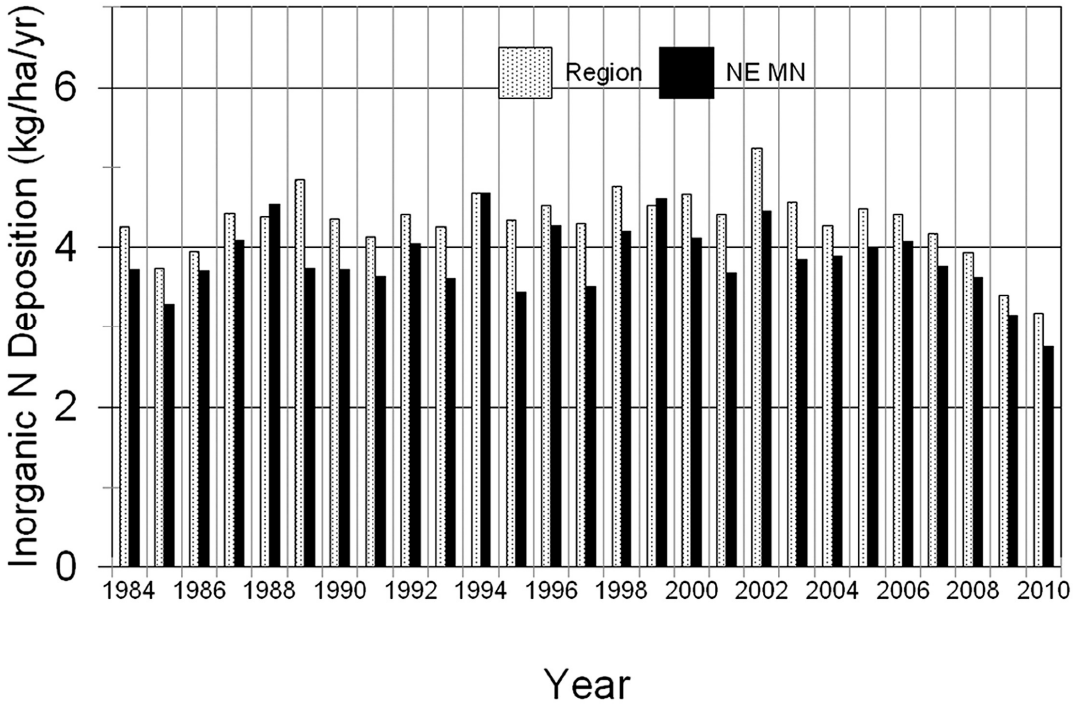



[1] Data from the following monitoring stations were included in this analysis:

- Hovland, Cook County;
- Marcell Experimental Forest, Itasca County;
- Fernberg Road (Ely), Lake County;
- Grindstone Lake, Pine County;
- Voyageurs National Park, St. Louis County;
- Wolf Ridge, Lake County.

**Figure 5-8 Wet nitrate deposition to northeastern Minnesota[1] over the period 1997 to 2010, statistically isolating the influence of precipitation, elevation, latitude and longitude.**

(The estimate is at the midpoint of those variables for the recording stations).



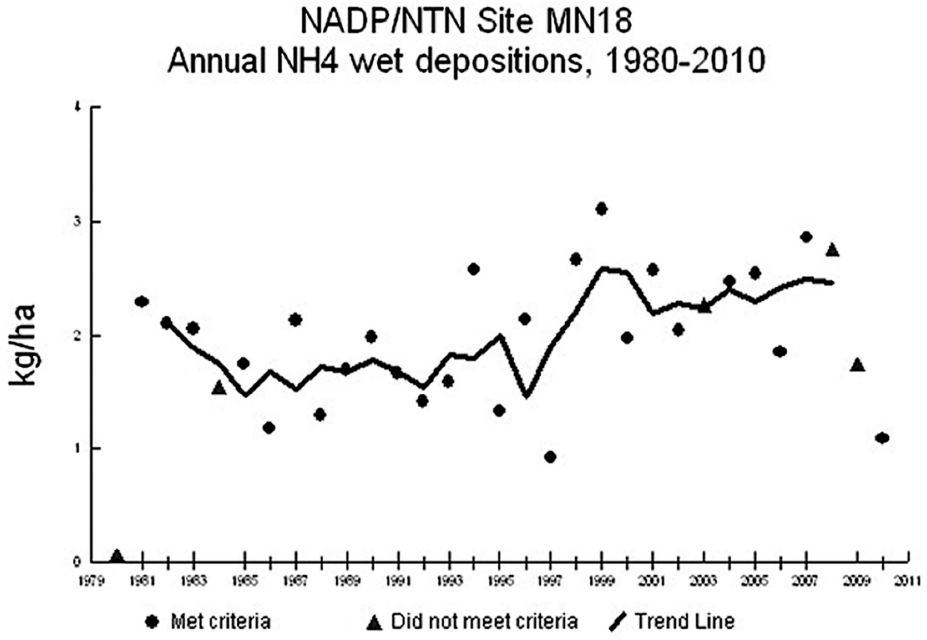

[1] Northern Minnesota acid deposition monitoring stations included:

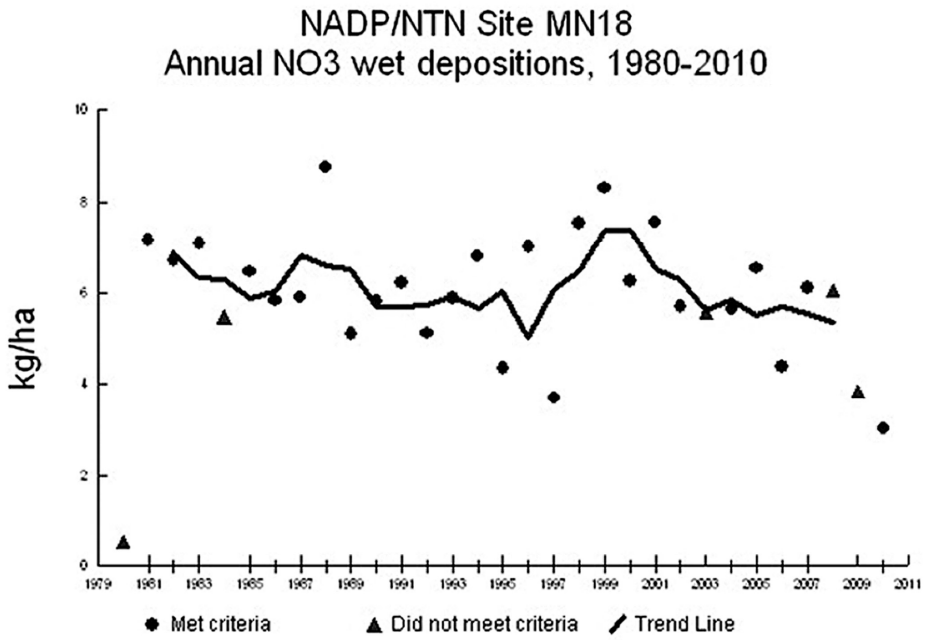
- Hovland, Cook County;
- Marcell Experimental Forest, Itasca County;
- Fernberg Road (Ely), Lake County;
- Grindstone Lake, Pine County;
- Voyageurs National Park, St. Louis County;
- Wolf Ridge, Lake County.

[2] The Adjoining Region includes all monitoring stations from Minnesota, Michigan, North Dakota, and Wisconsin that report data to the National Atmospheric Deposition Program (NADP; http://nadp.sws.uiuc.edu/).

**Figure 5-9 Inorganic wet nitrogen deposition to northern Minnesota[1] and the adjoining region[2] over the period 1984 to 2010, statistically isolating the influence of precipitation, latitude and longitude.**

(The estimate is at the midpoint of those variables for the recording stations).




Note: Trend line developed by the National Atmospheric Deposition Program (NADP)

**Figure 5-10 Trends in nitrate wet deposition (upper graph) and ammonium wet deposition (lower graph) for the Fernberg Road monitoring site near Ely, in northeast Minnesota.**

### 5.2.2 Long Term Monitoring of Lakes

To better assess the sensitivity of Minnesota lakes to acid deposition, in 1981 the MPCA initiated a long-term lake monitoring program. This program included 22 lakes that were regularly sampled from 1981 to 1986, and a then a subset of 12 lakes sampled from 1988 - 1995. Samples were usually collected in May, August, and October at multiple depths. The lakes were selected to provide adequate geographic coverage throughout the northeastern portion of the state.

Only data from the surface samples were evaluated in the time series analysis conducted by Eilers and Bernert (1997). Due to a laboratory change in 1988, only data from 11 of the 12 lakes sampled from 1988 through 1995 were used in this analysis (Table 5-2; from Eilers and Bernert 1997). Based on 1995 data, all the long term monitoring lakes would be considered sensitive to the effects of acidic deposition; acid neutralizing capacity (ANC) less than 100 $\mu eq\ L^{-1}$ (Table 5-2).

**Table 5-2 Physical characteristics of the MPCA's long term monitoring lakes. (From Eilers and Bernert 1997).**

| Lake | County | Area (ha) | Depth (m) | 1995 ANC ($\mu eq\ L^{-1}$) | Hydrologic Type | Notes/Land use |
|---|---|---|---|---|---|---|
| Sandy | Carleton | 49.8 | 6.1 | 60 | Seepage | Some pasture |
| Chester | Cook | 20.2 | 9.1 | 100 | Headwater | Forest + road + small clearcut |
| Crum | Itasca | 8.5 | 4.6 | 20 | Seepage | Forest |
| Divide | Lake | 27.9 | 6.1 | 30 | Headwater | Forest + wetland; road + picnic area |
| Kane | Lake | 43.7 | 4.6 | 100 | Seepage | Mostly forest; extensive shoreline development of seasonal homes |
| Dunnigan | Lake | 34.0 | 4.6 | 60 | Headwater | Forest and wetland |
| Tamarack | Isanti | 32.4 | 12.2 | 100 | Seepage | Mostly forest; some roads |
| Bass | Pine | 13.0 | 3.0 | 45 | Seepage | Extensive wetlands; 3 homes on lakeshore |
| Meander | St. Louis | 40.9 | 7.0 | 60 | Headwater | Forest on thin soil with bedrock exposure |
| Clearwater | St. Louis | 5.7 | 3.0 | 90 | Seepage | Adjacent paved county road receives road salt |
| Deepwater | St. Louis 69-0858 | 10.1 | 12.2 | 60 | Seepage | Mostly forest; some wetland |

Eilers and Bernert (1997) found that a trend analysis for the lake chemistry data from 1988-1995 showed the following:

- Six of the eleven lakes experienced decreases in sulfate ion $SO_4^{-2}$;
- Two of the eleven lakes showed increases in $SO_4^{-2}$;

- Of the two lakes that increased in $SO_4^{-2}$, one decreased in pH and the other decreased in ANC.
- None of the eleven lakes increased in pH;
- Three of the eleven lakes decreased in pH.
- Of the lakes that showed decreases in $SO_4^{-2}$, three increased in ANC, two increased in organic anions, and three decreased in base cations.
- Six of the lakes increased in one or more base cations.

The diversity of observed changes in water chemistry for the 11 study lakes suggest that several factors are contributing to changes in the lakes. These factors include, for example, land use practices (agriculture, forestry, lakeshore development) and wetland changes (possibly caused by expanding/contracting beaver populations or agricultural drainage practices).

Eilers and Bernert (reference (11)) also investigated the potential linkage between lake sulfate concentrations and sulfate deposition. Their assessment of the available data from several monitoring sites in northeast Minnesota (Birch Lake, Fernberg Road (Ely), and Marcell) identified that wet sulfate deposition had decreased significantly during the period under study (1988 – 1995). Eilers and Bernert (1997) stated that "… The decrease in lake $SO_4^{-2}$ appears to be highly correlated with the decline in $SO_4^{-2}$ deposition for the period from 1980 – 1995. …".

In summary, while the individual lake changes over time are not uniform and the factors affecting those changes relatively complex, it is noted that the decreasing concentrations of $SO_4^{-2}$ in several of the lakes are consistent with decreases in $SO_2$ emissions and $SO_4^{-2}$ deposition in northern Minnesota (reference (11)).

### 5.2.3 Assessment of Other Lake Survey Results

Eilers and Bernert (1997) also assessed water chemistry data collected from three other lake surveys:

- Cyprus Study: Included 8 lakes in the vicinity of Silver Bay, Minnesota. Sampling conducted in 1993.
- LTVSMC Study: Included 12 lakes in Lake and Cook Counties; samples collected in 1992, 1994, and 1995.
- MPCA Survey: Included 83 lakes in the Superior Highlands; sampling conducted in 1991.
- The combined results from the evaluation of this additional lake survey data indicate that:
- The study lakes were circum-neutral to high in pH and were dominated by high ANC and high base cations.

- For lakes in the North Shore study area, the data suggest that the patterns in sulfate concentrations are more strongly influenced by various watershed sources of sulfur than by atmospheric deposition.
- Most Minnesota lakes in areas considered to be most sensitive to acid deposition have moderate to high ANC, high base cation production, high organic acid production, and substantial watershed sources of sulfur.
- The North Shore survey results indicated that the lake resources are not highly sensitive, even for those lakes with alkalinity < 25 µeq/L.
- The North Shore lake survey data, when combined with results from other studies in Minnesota, show that North Shore lakes are at low risk of acidification from atmospheric deposition.

When assessing lakes on a statewide basis, Eilers and Bernert (1997) draw the following conclusions:

- The high concentrations of base cations and organic anions provide considerable buffering and neutralization capacity.
- For the most sensitive lakes in the state, it would only be possible to acidify any of these lakes from atmospheric sources under the most extreme conditions.

### 5.2.4 Summary of Ecosystem Acidification Potential in Minnesota

In addition to the long-term lake monitoring program, a number of other projects have examined lake chemistry and its trends across northern Minnesota. Based on an examination of all those data, researchers have concluded that "There is no need to conduct additional surveys of lakes in Minnesota for the sole purpose of investigating the effects of acidic deposition." (reference (11) Inputs of both base cations and organic acid anions to Minnesota lakes provide pH buffering in the event of increased sulfur or nitrogen deposition. "The acidification threat to Minnesota lakes from atmospheric sources is very low." (reference (11)) With regard to potential impacts of acid deposition on stream resources, the MPCA found that streams along the North Shore of Lake Superior were not susceptible to episodic acidification from nitrate and sulfate additions during spring snowmelt events (reference (19)).

In summary, Minnesota's lakes and watersheds are at low risk of acidification at current levels of acid deposition. Likewise, based on the information in the following section regarding past and future acid-precursor emission trends, Minnesota's lakes will remain at low risk of acidification for the foreseeable future even if all the proposed projects are constructed as planned.

# 6.0 Local, State, and National Emissions and Trends

The air pollutants from the proposed projects in northeast Minnesota (see Table 1-1) that are being assessed for potential cumulative effects that may affect ecosystem acidification in the Class I areas are $SO_2$ and $NO_X$. As was mentioned in the previous section, acid deposition in remote Class I areas such as the BWCA and Voyageurs is affected not only by the emission increases and decreases in the area nearest the Class I areas, but also regional and national emission increases and decreases. To give perspective on these emissions, this section compares local, state, and national emission trends, and is divided into the following four subsections:

Section 6.1 Local (Six-County Zone of Interest) Emissions and Trends

Section 6.2 Statewide Emissions and Trends

Section 6.3 National Emission and Trends

Section 6.4 Foreseeable Regulatory and Other Actions and Expected Emission Reductions

Data by county from the MPCA Criteria Pollutant Emission inventory is complete and available for point sources through 2008. State-wide emission estimates, including, point, nonpoint and mobile sources, is available through 2009. Estimated national emission data from the EPA's National Emission Inventory (NEI) are available through 2008.

## 6.1 Local (Six-County Zone of Interest) Emissions and Trends

In this section, we compare the potential new emissions (potential to emit basis) of $SO_2$ and $NO_X$ from the proposed projects to actual emissions from existing facilities in the zone of interest (six county area that includes Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook Counties).

Table 1-1 in Section 1.0 of this report, provides estimated emissions of $SO_2$ and $NO_X$ from the proposed projects on a "potential to emit" basis. New major sources and modifications will incorporate the best available control technology into their design which will minimize both their potential and actual emissions. Actual emissions from the proposed projects may be lower than these potential emissions. Because the regulatory permitting programs require that emissions for new sources be based on potential to emit or maximum controlled emissions, actual emissions for the proposed projects are not available at this time. Therefore, potential emissions from the proposed projects will be compared to the estimates of actual emissions from existing facilities for previous and future years.

### 6.1.1 Sulfur Dioxide ($SO_2$)

Table 6-1 compares the estimated cumulative potential $SO_2$ emissions from the proposed projects to the existing facility emissions in the six-county area since 1990. The year 2015 is selected as the comparison year due to the assumption that the proposed projects and reductions are likely to be in full operation by that time. The estimated 2015 emissions for existing facilities do not take into consideration any reductions due to foreseeable regulatory actions, but do include voluntary reductions from Minnesota Power's Taconite Harbor facility along with reductions required under BART for United Taconite and Northshore Mining. Additionally, emission reduction projects completed in 2010 at Minnesota Power's Boswell and Laskin Energy Center were considered in the 2015 emission estimation.

Table 6-1 indicates that the cumulative potential emissions from the proposed projects will potentially increase the local emissions in the six-county area by a relatively small amount (2,807 tons per year – see Table 1-1). This represents an approximate 7% increase above 2008 $SO_2$ emissions of 40,115 tons in the six-county area if all projects reach their potential to emit. However, when decreases in $SO_2$ from the proposed projects are included (see Table 1-1, "Reductions"), the emissions will decrease by 34% compared to the 2008 levels. Proposed and in-progress concurrent voluntary emission reductions in the six-county area are summarized below in 6.1.3. Additional local emission reductions due to ongoing regulatory requirements are likely, as summarized in Section 6.4.

**Table 6-1 Annual and projected sulfur dioxide ($SO_2$) emissions for existing major emission sources in the six-county "zone of interest" in northeast Minnesota.**
(Six-county project area: Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook).

| | Actual and Projected $SO_2$ Emissions (tons per year) [1] | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Itasca County | St. Louis County | Cook County | Lake County | Koochiching County | Carlton County | Total 6-County Area |
| **1990** | 21,612 | 6,443 | 0 | 689 | 604 | 1,315 | 30663 |
| **1991** | 14,275 | 4,949 | 337 | 1,082 | 199 | 931 | 21772 |
| **1992** | 12,622 | 5,131 | 3,899 | 705 | 118 | 1,426 | 23902 |
| **1993** | 15,479 | 5,153 | 2,210 | 1,441 | 81 | 1,158 | 25522 |
| **1994** | 20,228 | 6,028 | 2,685 | 1,881 | 86 | 1,447 | 32355 |
| **1995** | 19,129 | 4,887 | 1,865 | 1,071 | 81 | 1,413 | 28446 |
| **1996** | 15,054 | 8,782 | 1,184 | 1,466 | 68 | 1,520 | 28074 |
| **1997** | 14,409 | 8,836 | 1,992 | 1,294 | 71 | 1,871 | 28472 |
| **1998** | 16,327 | 7,835 | 3,278 | 1,516 | 93 | 1,767 | 30815 |
| **1999** | 17,374 | 8,910 | 2,961 | 1,872 | 99 | 1,536 | 32752 |
| **2000** | 15,212 | 10,860 | 3,255 | 2,062 | 60 | 1,324 | 32773 |
| **2001** | 18,740 | 9,250 | 91 | 1,857 | 72 | 446 | 30457 |
| **2002** | 21,215 | 9,646 | 3,113 | 2,292 | 68 | 214 | 36549 |
| **2003** | 20,027 | 7,598 | 5,503 | 2,371 | 80 | 222 | 35800 |

| | Actual and Projected $SO_2$ Emissions (tons per year) [1] | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Itasca County | St. Louis County | Cook County | Lake County | Koochiching County | Carlton County | Total 6-County Area |
| **2004** | 19,843 | 9,338 | 5,575 | 2,881 | 71 | 475 | 38184 |
| **2005** | 20,036 | 9,493 | 5,237 | 2,673 | 83 | 393 | 37914 |
| **2006** | 20,477 | 8,921 | 5,388 | 2,781 | 51 | 218 | 37836 |
| **2007** | 21,722 | 10,293 | 5,064 | 2,936 | 97 | 274 | 40,386 |
| **2008** | 21,643 | 11,164 | 4,722 | 2,312 | 86 | 188 | 40,115 |
| **2015[2]** | 11,207 | 10,159 | 3,173 | 1,785 | 86 | 189 | 26,598 |

[1] Historical data obtained from http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded in June 2010, and http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-and-monitoring/criteria-air-pollutant-emission-inventory/facility-actual-emissions-data.html; downloaded in May 2011.

[2] 2015 emission estimates for existing facilities is the 2008 emissions summed with reductions and increases for the proposed projects for each county in NE Minnesota as described in Table 1-1 using 2008 instead of 2009 as a baseline year. In addition, the emission reductions from Minnesota Power's AREA improvements that were completed in 2010 for Boswell and Laskin Energy were accounted for in the 2015 emissions projections as determined by comparing 2008 and 2012 emissions and the expected decrease from 2002 emissions as shown on the MPCA NE MN Plan Tracking Spreadsheet. This estimate does not account for potential emission reductions due to foreseeable regulatory actions. Emissions from projects located in two counties were split evenly between the two counties.

### 6.1.2 Nitrogen Oxides ($NO_X$)

Table 6-2 provides historical emissions from existing major emission sources in the six-county project area (Carlton, Koochiching, Itasca, St. Louis, Lake, and Cook counties). The cumulative potential $NO_X$ emissions from the proposed projects are compared to the existing facility emissions in this six-county "zone of interest". The year 2015 is selected as the comparison year due to the assumption that the proposed projects and reductions are likely to be in full operation by that time. The estimated 2015 emissions for existing facilities do not take into consideration any reductions due to foreseeable regulatory actions, but do include reductions from Minnesota Power's Taconite Harbor facility, US Steel Minntac, and Northshore Mining. Additionally, emission reduction projects completed in 2010 at Minnesota Power's Boswell and Laskin Energy Center were considered in the 2015 emission estimation.

Table 6-2 indicates that the cumulative potential emissions from the proposed projects will be an increase in the local emissions in the six-county area of Itasca, St. Louis, Lake, and Cook by a relatively small amount (6,635 tons). This represents a maximum potential increase of about 12% compared to 2008 local $NO_X$ emissions of 54,350 tons. However, when decreases in $NO_X$ from the proposed projects are included (see Table 1-1, "Reductions"), the emissions will decrease by about 25% compared to the 2008 levels. Proposed and in-progress concurrent voluntary emission reductions in the six-county area are summarized below in Section 6.1.3. Additional local emission reductions due to ongoing regulatory requirements are likely, as summarized in Section 6.4.

**Table 6-2 Annual nitrogen oxide ($NO_X$) emissions trends for existing major emission sources in the six-county area of interest in northeast Minnesota.**

(Six counties of interest: Carlton, Koochiching, Itasca, St. Louis, Lake, Cook)

| Actual and Projected $NO_X$ Emissions (tons per year) [1] | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Itasca County | St. Louis County | Cook County | Lake County | Koochiching County | Carlton County | Total 6-County Area |
| **1990** | 20,061 | 25,601 | 0 | 6,037 | 1,416 | 1,860 | 54974 |
| **1991** | 17,816 | 24,588 | 540 | 1,350 | 1,333 | 1,801 | 47429 |
| **1992** | 15,845 | 21,377 | 4,318 | 2,086 | 943 | 1,634 | 46203 |
| **1993** | 16,967 | 22,470 | 2,106 | 6,313 | 900 | 1,652 | 50408 |
| **1994** | 13,977 | 14,597 | 2,717 | 6,912 | 1,141 | 1,412 | 40756 |
| **1995** | 14,650 | 16,020 | 1,709 | 5,717 | 956 | 1,370 | 40421 |
| **1996** | 13,563 | 34,016 | 984 | 3,695 | 1,012 | 1,645 | 54914 |
| **1997** | 13,587 | 40,723 | 1,498 | 3,848 | 952 | 1,361 | 61968 |
| **1998** | 13,857 | 37,618 | 1,925 | 3,029 | 904 | 1,065 | 58399 |
| **1999** | 12,411 | 33,824 | 2,670 | 3,294 | 842 | 1,264 | 54307 |
| **2000** | 13,167 | 34,232 | 2,796 | 3,869 | 683 | 1,616 | 56362 |
| **2001** | 14,190 | 28,651 | 104 | 3,175 | 699 | 1,520 | 48337 |
| **2002** | 15,049 | 35,850 | 2,321 | 3,950 | 880 | 1,563 | 59613 |
| **2003** | 15,443 | 27,912 | 3,381 | 4,092 | 971 | 1,471 | 53270 |
| **2004** | 13,210 | 34,116 | 3,388 | 4,120 | 925 | 1,652 | 57411 |
| **2005** | 14,851 | 14,851 | 3,242 | 4,242 | 894 | 1,356 | 39437 |
| **2006** | 13,996 | 28,469 | 3,241 | 3,767 | 964 | 1,414 | 51851 |
| **2007** | 15,031 | 28,685 | 3,017 | 3,931 | 900 | 1,526 | 53090 |
| **2008** | 16,034 | 29,838 | 2,374 | 3,681 | 911 | 1,512 | 54350 |
| **2015 [2]** | 9,410 | 24,680 | 1,264 | 2,772 | 911 | 1,674 | 40,660 |

[1] Historical data obtained from http://www.pca.state.mn.us/data/edaAir/index.cfm; downloaded in June 2010, and http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-and-monitoring/criteria-air-pollutant-emission-inventory/facility-actual-emissions-data.html; downloaded in May 2011.

[2] 2015 emission estimates for existing facilities is the 2008 emissions summed with reductions and increases for the proposed projects for each county in NE Minnesota as described in Table 1 using 2008 instead of 2009 as a baseline year. In addition, the emission reductions from Minnesota Power's AREA improvements that were completed in 2010 for Boswell and Laskin Energy were accounted for in the 2015 emissions projections as determined by comparing 2008 and 2012 emissions and the expected decrease from 2002 emissions as shown on the MPCA NE MN Plan Tracking Spreadsheet. This estimate does not account for potential emission reductions due to foreseeable regulatory actions. Emissions from projects located in two counties were split evenly between the two counties.

### 6.1.3 Emission Reductions in Northeastern Minnesota

There are several emission reductions occurring in northeastern Minnesota that will significantly reduce emissions of precursors to acid deposition, $SO_2$ and $NO_X$. These emission reductions are included in Table 1-1. As part of the Arrowhead Regional Emission Abatement Plan (AREA) the Minnesota Power Taconite Harbor Energy Center is reducing emissions. U. S. Steel Minntac is also proposing projects that will reduce emissions and BART emission reductions are expected from Northshore Mining Company and United Taconite. In addition two projects which were completed in 2010 are not included in Table 1-1 because the effect of these reductions is included in the NADP deposition data. However, the effect of these emissions reductions are not reflected in the 2008 emissions data for NE MN. These projects are at Minnesota Power's Laskin Energy Center in Hoyt Lakes as part of AREA and at Boswell Energy Center in Cohasset, MN.

Work began on the Minnesota Power Laskin Energy Center in Hoyt Lakes in October and November 2006. The project entails replacing existing coal burners with low $NO_X$ burners and overfire air systems on both Laskin coal-fired generating units. Overfire air systems feature additional air ports as well as software that tracks combustion conditions and automatically modifies fuel/air input to more completely burn fuel. These improvements reduce $NO_X$ emissions from coal-burning. This work has been completed and although actual emission reductions are not yet available, the estimated emission reductions are 110 tons per year of $NO_X$ compared to 2008 emissions (reference (5)).

Work is currently in progress at the Taconite Harbor Energy Center in Schroeder and includes installing Mobotec multi-pollutant control technology on each of the three 75 MW coal-fired units. The company will install equipment within the combustion chamber of each boiler to modify combustion conditions and inject reagents to reduce $NO_X$, $SO_2$, and mercury emissions. Expected emission reductions will be 423 tons per year $NO_X$ and 1,549 tons per year $SO_2$ compared to 2009 emissions (reference (5)).

Minnesota Power also broke ground on an emission reduction project at the Boswell Energy Center in May 2007, completed installation by the end of 2009 and completed all work and testing early 2010. The project decreases emissions of $NO_X$ and $SO_2$ by replacing an existing wet scrubber on Unit 3 with a selective catalytic reduction system, activated carbon injection, a fabric filter and a wet flue gas desulfurization scrubber (reference (56)). Although actual emission reductions are not yet available, the expected emissions reductions are 9,683 tons per year of $NO_X$ and 11,952 tons per year of $SO_2$ compared to 2008 emissions (reference (5)).

In addition to these projects at power plants, two taconite facilities are proposing emission reductions, United Taconite and U. S. Steel Minntac. The United Taconite reductions are related to BART requirements and will be implemented at the Fairlane plant in Forbes. Emission reductions are expected to be 1,954 tons per year of $SO_2$ compared to 2009 emissions (reference (5)).

The U. S. Steel project at Minntac is a reduction in $NO_X$ emissions due to a backwards looking PSD analysis that resulted in permit conditions to conduct pilot testing to prove a $NO_X$ control technology. The goal is a $NO_X$ reduction of 1,973 tons per year compared to 2009 emissions. Finally, BART requirements for Northshore Mining's facility in Silver Bay, Lake County are expected to result in reductions of 583 tons per year and 1,159 tons per year of $SO_2$ and $NO_X$, respectively, compared to 2009 emissions.

### 6.1.4 Summary of Local (Six-county Project Area) Emissions

As shown above, if all proposed projects included in this analysis move forward to construction as planned, they would potentially increase point source emissions from 2008 levels in the six-county area of interest by approximately 7% for $SO_2$ and 12% for $NO_X$. These potential increases do not take into account the proposed reductions associated with the voluntary emission reduction actions described above or the additional likely reductions required by foreseeable future regulatory and other actions summarized in Section 6.4. When reductions from various projects including Minnesota Power facilities and BART requirements are included, the emissions of $SO_2$ in the six-county area will be reduced from 2008 levels by 13,517 tons per year or 34% and the emissions of $NO_X$ by 13,690 tons per year or 25%. This information is summarized in Table 6-3.

**Table 6-3 Summary of Local Emissions and Proposed Changes in Emissions.**

| | 2008 Six-County Emissions TPY | Proposed Project Emissions TPY | Proposed Net Emission Change, Increases Plus Reductions, TPY[1] | Proposed Net Emission Change, Increases Plus Reductions, %[1] |
|---|---|---|---|---|
| **$SO_2$** | 40,115 | 2,807 | -13,517 | -34 |
| **$NO_X$** | 54,350 | 6,635 | -13,690 | -25 |

[1] Reductions included are those by Minnesota Power facilities in the six-county area, US Steel Minntac, and the required BART reductions.

When comparing the potential emissions from the proposed projects and reductions with historical and existing emissions in the six-county project area the following can be concluded:

- $SO_2$: projected emissions for 2015, calculated from actual 2008emission data and including existing sources with reductions from Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities along with reductions required under BART for United Taconite and Northshore Mining and the potential change in emissions from the proposed projects, are lower than historical emissions (see Figure 6-1).
- $NO_X$: projected emissions for 2015, which include existing sources with reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, and Northshore Mining, the potential change in emissions from the proposed projects are lower than historical emissions (see Figure 6-2).

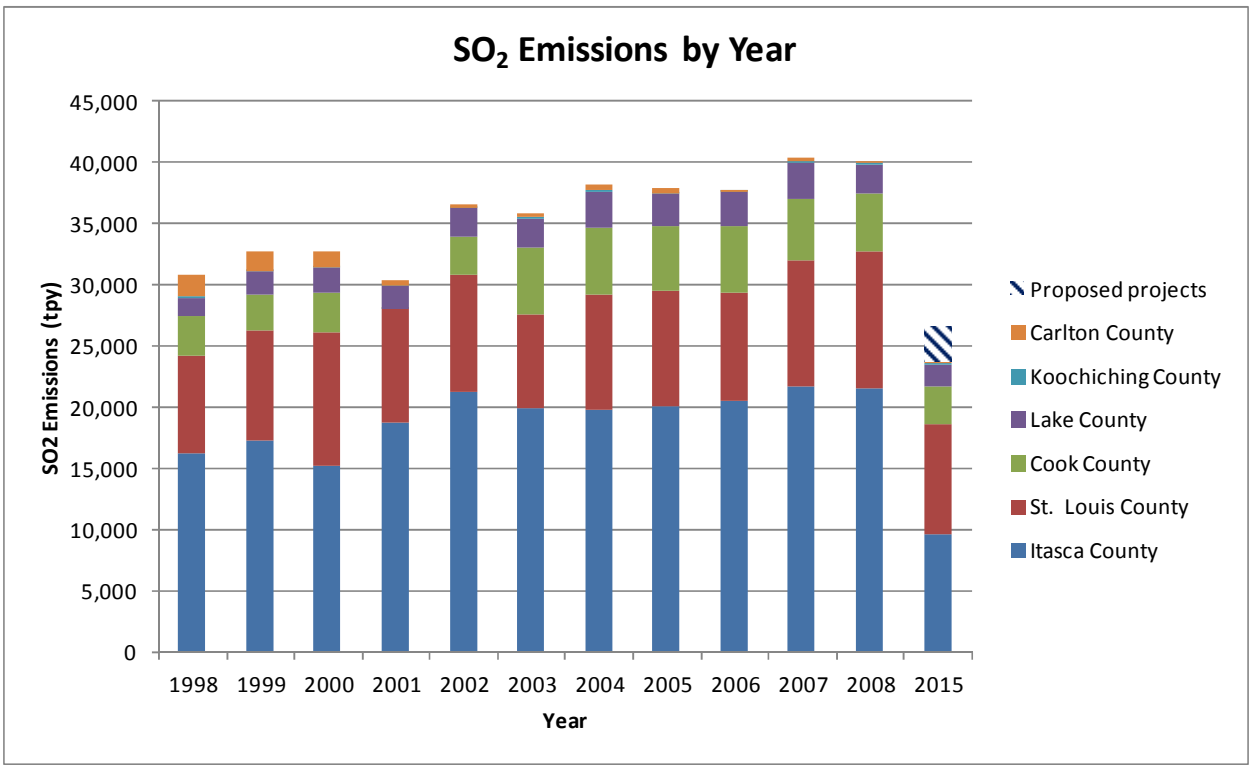



**Figure 6-1 Sulfur Dioxide ($SO_2$) Emissions in Northeast Minnesota**

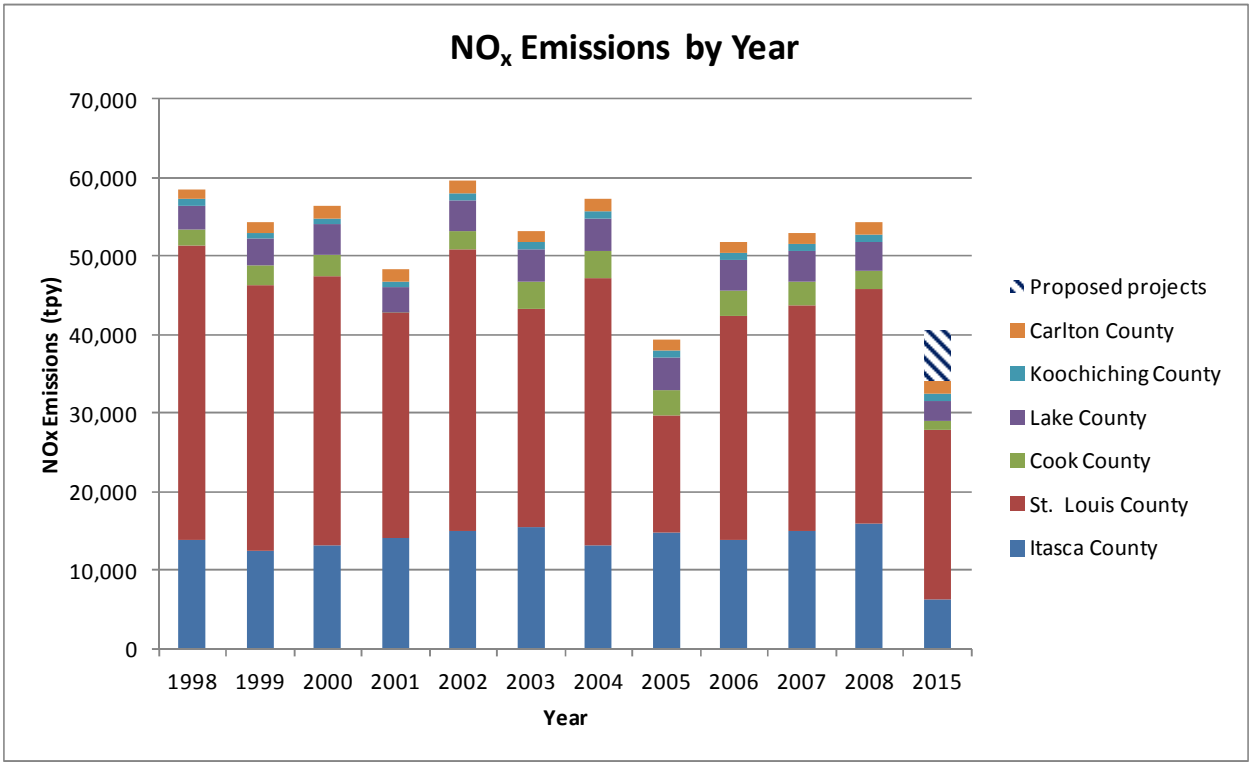


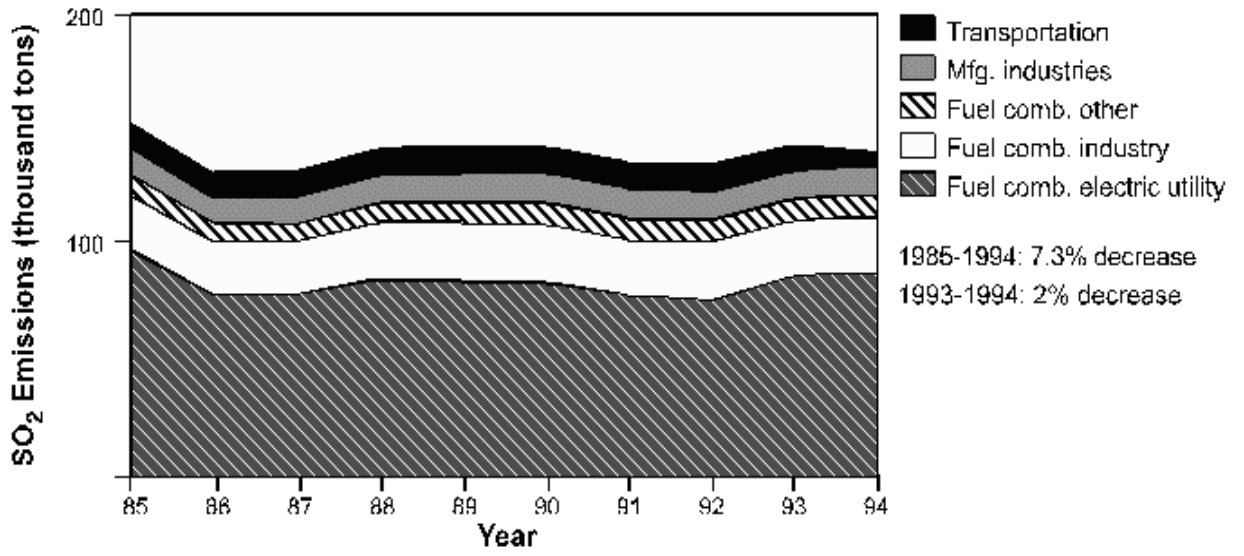

**Figure 6-2 Nitrogen Oxides ($NO_X$) Emissions in Northeast Minnesota.**

## 6.2 Statewide Emissions and Trends

This section summarizes statewide emission trends for $SO_2$ and $NO_X$ through 2008.

### 6.2.1 Sulfur Dioxide ($SO_2$)

Eilers and Bernert (reference (11)) reported that state $SO_2$ emissions decreased from almost 600,000 tons/yr in 1968 to 250,000 tons/yr by 1980. This decline includes large reductions in emissions from the electric utility sector between 1980 and 1985 (reference (3)). Between 1985 and 1994 emission reductions were more modest, consistent with information assessed by Eilers and Bernert. By 1994, total statewide emissions were slightly more than 140,000 tons/yr (Figure 6-3). Detailed historical data (from 1985 through 1994) for both $SO_2$ and $NO_X$ are included in the 1997 MPCA "Air Trends" Report available at http://www.pca.state.mn.us/air/ aqemissions-trends.html.



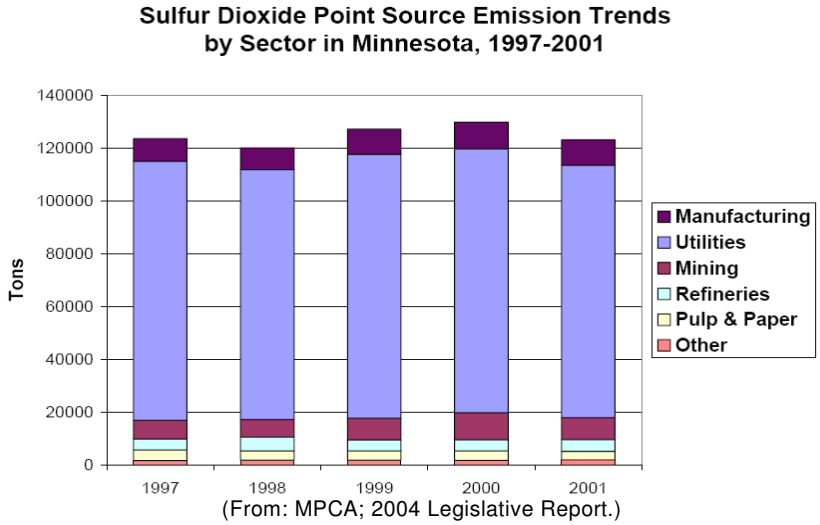

(from: http://www.pca.state.mn.us/air/emissions/so2.html)

**Figure 6-3 Sulfur dioxide ($SO_2$) emission trends in Minnesota: 1985-1994.**

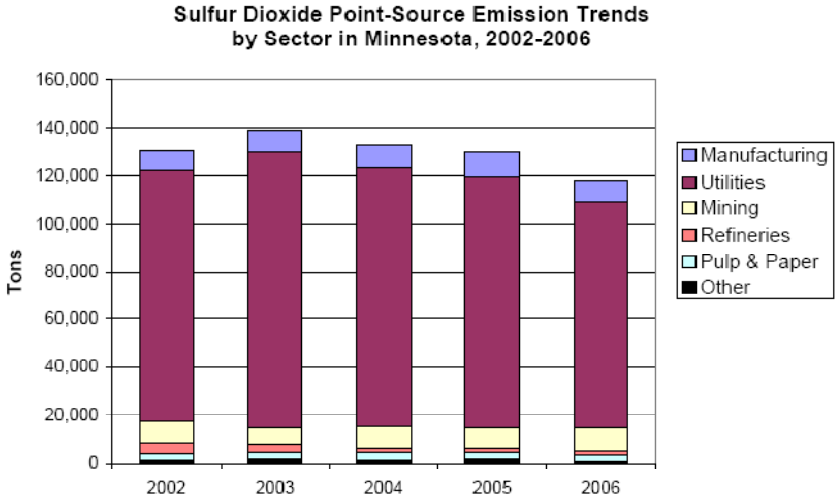
Since 1994, statewide $SO_2$ emissions have decreased to about 101,000 tons/yr (reference (4)). Stationary source emissions make up approximately 71% of the statewide $SO_2$ emissions (reference (4)). Stationary source emissions are estimated to be approximately 72,000 tons/year in 2009. The potential $SO_2$ emissions from the proposed projects (2,807 tons), compared to total statewide actual emissions of approximately 101,000 tons/yr, represent an approximate increase of about 2.8% on a statewide basis. When the potential $SO_2$ emissions from the projects are compared to stationary source $SO_2$ emissions only (~72,000 tpy), the potential increase is approximately 4%. As can be seen from Figure 6-4, the potential $SO_2$ emissions added by the proposed projects are within the annual variability of statewide stationary source emissions from 1997 to 2009. This comparison indicates

that on a statewide level the potential increase in $SO_2$ emissions from the proposed projects will be small.

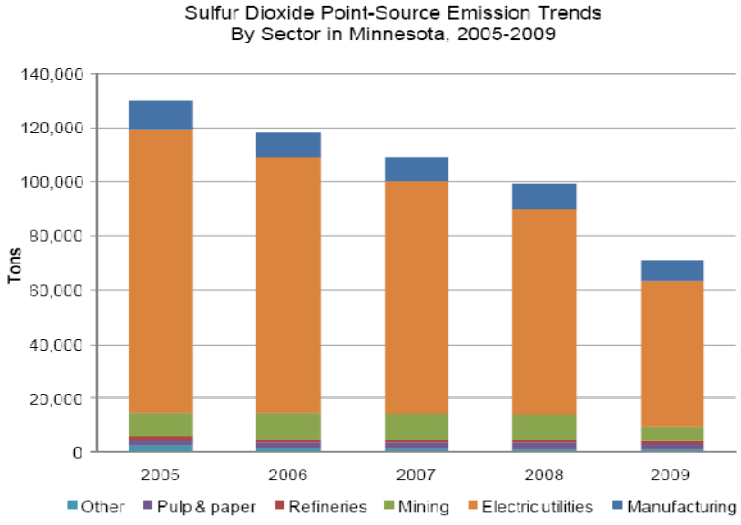
The $SO_2$ emissions from the proposed projects (2,807 tpy) do not take into account the expected emission reductions from Minnesota Power's Taconite Harbor facility, United Taconite and Northshore Mining or the emission reductions in 2010 from projects at Minnesota Power's Laskin and Boswell Energy Centers. When emission reductions are included, the emission change will be a reduction of 8,310 tons per year, which is a reduction of 17% in stationary source emissions compared to 2009. It should be noted that 2009 was a unique year for emissions in northeastern Minnesota because much of the mining industry was idled in response to economic conditions. Compared to more typical years of mining activity the emissions from all proposed projects are a smaller percentage of statewide emissions than stated above.




(From: MPCA; 2004 Legislative Report.)




(From: MPCA Annual Pollution Report to the Legislature. April 2008.)

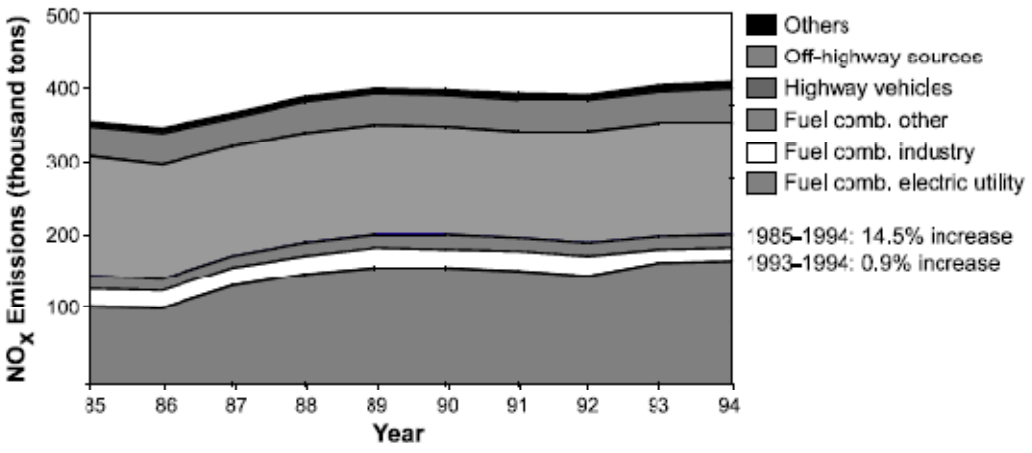



(From: MPCA Annual Pollution Report to the Legislature. April 2011.)

**Figure 6-4 Statewide stationary source sulfur dioxide ($SO_2$) emission trends, 1997 – 2009.**

### 6.2.2 Nitrogen Oxides ($NO_X$)

Figure 6-5 summarizes Minnesota $NO_X$ emission trends between 1985 and 1994, which is the last detailed analysis that is publicly available from the MPCA (1997). These data show that statewide $NO_X$ emissions increased gradually from 1985 to 1994, reaching about 416,000 tons/yr in 1994 (reference (50)).




From: MPCA 1997

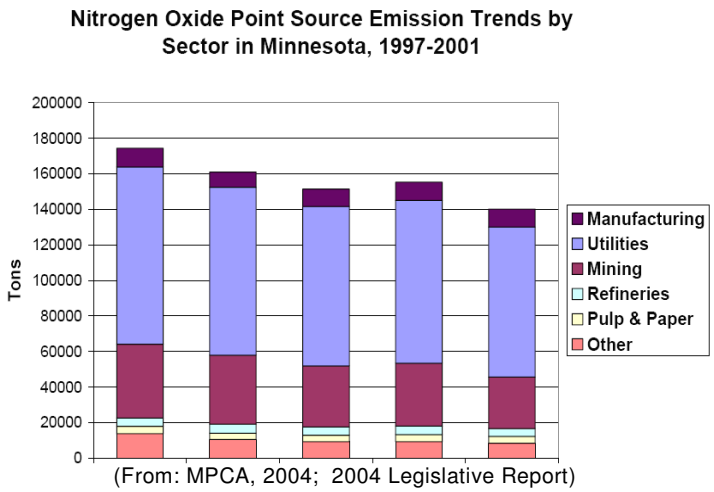
**Figure 6-5 Sources of nitrogen oxide emissions in Minnesota, 1985 – 1994.**

MPCA has recently estimated that since 1994, $NO_X$ emissions have decreased to about 353,000 tons (reference (4)). As identified by the MPCA, stationary source emissions account for approximately 22% of the statewide $NO_X$ emissions while gasoline and diesel sources account for approximately 40% of $NO_X$ emissions and non-road sources, including off-road transportation, contribute approximately 29% of $NO_X$ emissions. Figure 6-6 provides stationary-source emissions of $NO_X$ in Minnesota for the 1997 to 2009 time period, broken down by industrial sector (references (4) and (57)). Figure 6-6 indicates that $NO_X$ emissions gradually declined from stationary sources in Minnesota from 1997 to 2001, but have remained relatively steady from 2002 to 2005 with a decrease in 2006 through 2009. These reductions were mainly due to the mining and utility sectors (references (18) (4)).

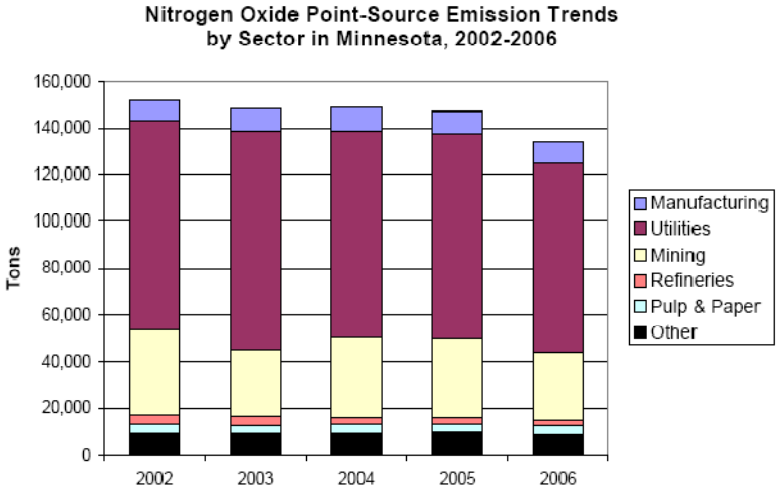
In comparison to statewide $NO_X$ emissions of 353,000 tons/year in 2009, the potential increase in $NO_X$ emissions from the proposed projects is small (6,635 tons/year), an approximately 2% increase. When the potential emissions increase from the proposed projects is compared to stationary source emissions only (78,000 tpy), the potential increase is approximately 8.5%. Based on the relatively small amount of $NO_X$ estimated to be emitted from the proposed projects, it is concluded that the

$NO_X$ emissions from the proposed projects is within the variability exhibited by statewide $NO_X$ emissions since 1997 (Figure 6-6).

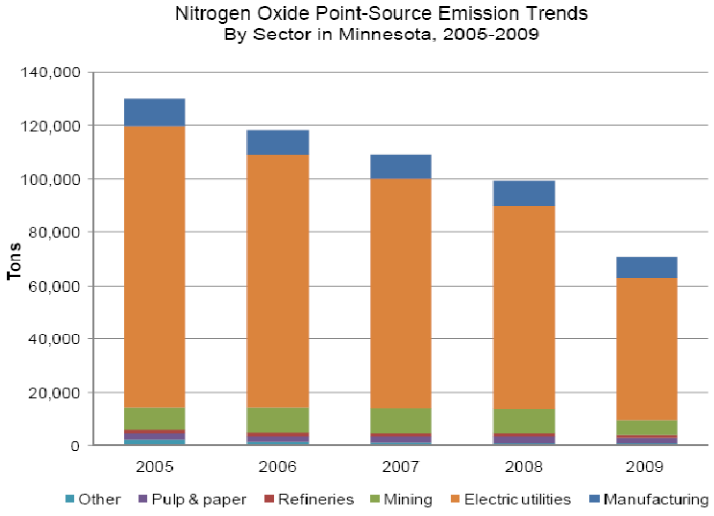
The $NO_X$ emissions from the proposed projects (6,635 tpy) do not take into account the expected emission reductions from Minnesota Power's Taconite Harbor facility, US Steel Minntac, and Northshore Mining or the emission reductions in 2010 from projects at Minnesota Power's Laskin and Boswell Energy Centers. See Section 4.4 for details of these reductions. When emission reductions are included, the emission change will be a reduction of 13,690 tons per year, which is a reduction of approximately 18 percent in stationary source emissions compared to 2009. It should be noted that 2009 was a unique year for emissions in northeastern Minnesota because much of the mining industry was idled in response to economic conditions, which also impacted the power industry. Compared to more typical years of mining activity the emissions from all proposed projects are a smaller percentage of statewide emissions than stated above.




(From: MPCA, 2004; 2004 Legislative Report)




(From: MPCA Annual Pollution Report to the Legislature. April 2008)




(From: MPCA Annual Pollution Report to the Legislature. April 2011)

**Figure 6-6 Nitrogen oxide stationary source emission trends in MN by sector, 1997-2009.**

### 6.2.3 Statewide Emission Trend Summary

As shown above, if all proposed projects included in this analysis move forward to construction as planned, when combined with reductions from Minnesota Power's Taconite Harbor facility, US Steel Minntac, and United Taconite, Northshore Mining, and 2010 reductions at Minnesota Power's Laskin and Boswell facilities they would potentially change stationary source emissions in the state by approximately -17% for $SO_2$, and -18% for $NO_X$, compared to 2009 emissions. These potential increases and decreases do not take into account the likely reductions required by foreseeable regulatory and other actions (see Section 6.4).

When comparing the potential emissions from the proposed projects with statewide emissions, the following can be concluded:

- For $SO_2$: the potential change in emissions from the proposed projects combined with the reductions from Minnesota Power's Boswell, Laskin Energy Center and Taconite Harbor facilities, United Taconite and Northshore Mining will be a 17% reduction in stationary source emissions from 2009, or approximately 13,517 tons per year. The resulting total stationary source annual emissions would be approximately 66,000 tons per year. This is approximately half that in 2000-2005, when emissions ranged from approximately 120,000 to 140,000 tons per year (Figure 6-4).
- For $NO_X$: the potential change in emissions from the proposed projects combined with the reductions from Minnesota Power's Laskin, Boswell and Taconite Harbor facilities, US Steel Minntac, Hill Wood Products and Northshore Mining will be an 18% reduction in stationary source emissions from 2009, or approximately 3,690 tons per year. Total stationary source annual emission including these changes would be approximately 64,000 tons per year which is less than historical emissions which have ranged from approximately 130,000 to 170,000 tons per year (Figure 6-6).

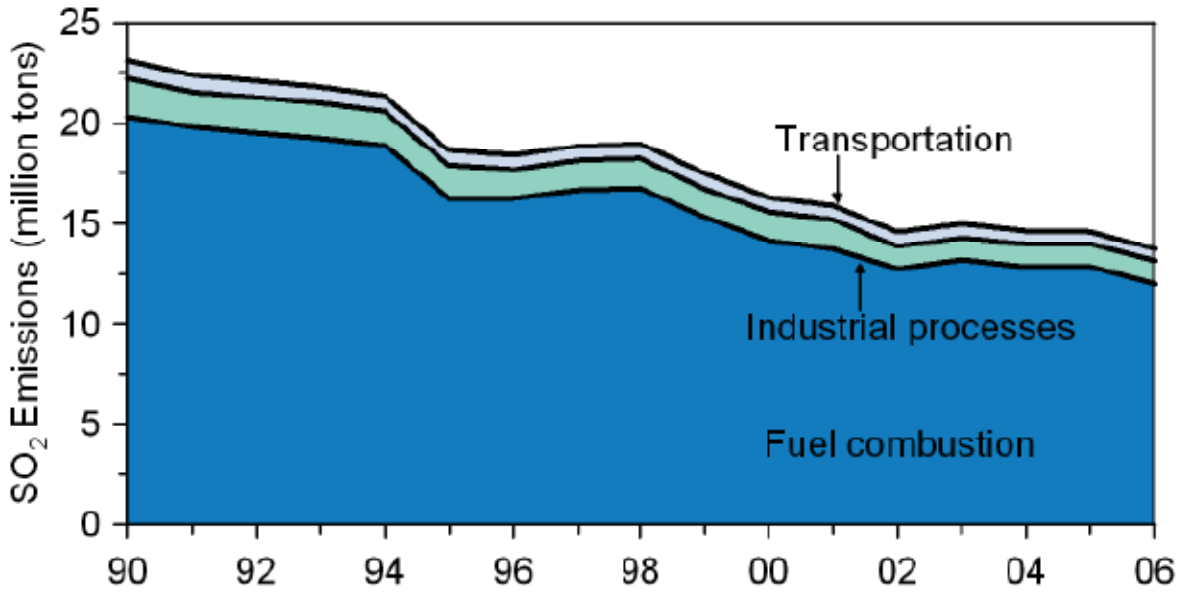
## 6.3 National Emission and Trends

National emission trends are also important to the acid deposition in federal Class I areas in Minnesota. As described in Section 3.4, out-of-state emissions contribute a major portion acid deposition in northeastern Minnesota. Therefore, the trends in national emissions are expected to be reflected in the deposition trends in Voyageurs and the BWCA. Due to the long-range transport of pollutants and their importance in federal Class I area deposition, national emissions of $SO_2$ and $NO_X$, are discussed below.

### 6.3.1 Sulfur Dioxide ($SO_2$)

Nationally, total $SO_2$ emissions (including mobile sources) have decreased by about 50% from 1990 to 2008 (reference (6)). Total $SO_2$ emissions in the U.S. in 2008 were about 11.4 million tons/yr. EPA data on historic $SO_2$ emission trends through 2006 is summarized below in Figure 6-7. More detailed historical criteria pollutant emission trends are available through EPA's web site:

- http://www.epa.gov/ttnchie1/trends/
- http://www.epa.gov/airtrends/sulfur.html.



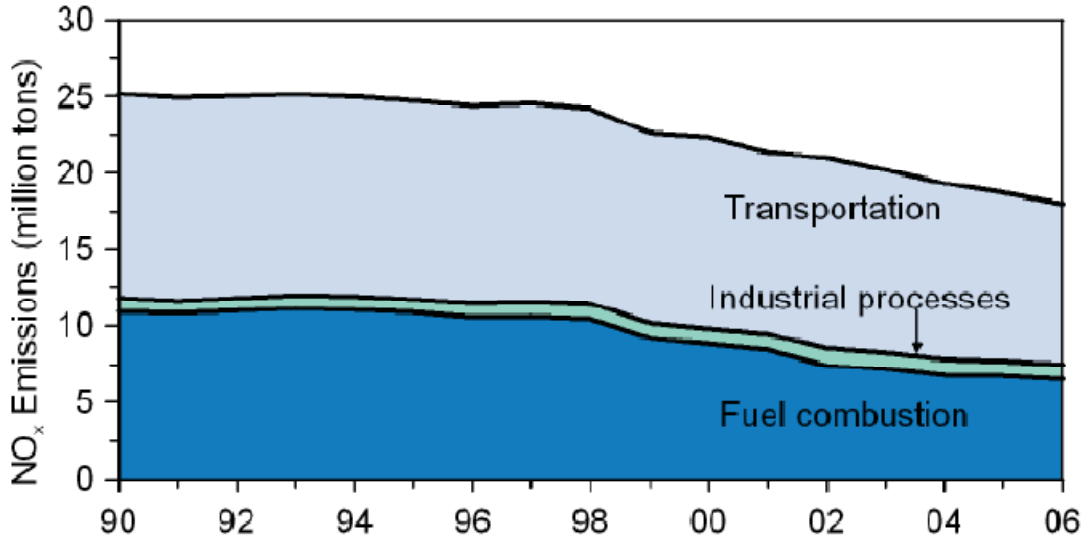

From http://www.epa.gov/airtrends/sulfur.html

**Figure 6-7 National sulfur dioxide emission trends from 1990 to 2006.**

In 2010, national $SO_2$ emission allowances from electric generation units were anticipated to level off at 8.7 million tons annually. Actual emissions were almost at this level in 2007, but could increase due to the use of previously banked emission allowances. In addition, the Cross State Air Pollution Rule (CSAPR), which replaced CAIR, requires reductions of $SO_2$ and $NO_X$ in eastern and southern states. CSAPR takes effect Jan 1, 2012 and requires 27 states to reduce emissions that contribute to ozone and fine particulate pollution in other states. CSAPR sets emission budgets that are expected to reduce $SO_2$ emissions by 6.4 million tons per year compared to base case 2005 emissions (reference (7)).

### 6.3.2 Nitrogen Oxides ($NO_X$)

Nationally, total $NO_X$ emissions (mobile plus stationary sources) have declined about 36% since 1990, with the biggest decline starting in about 1999 (Figure 6-8). Stationary source $NO_X$ emissions have declined about 43% from 1990 to 2008 and are currently approximately 6.9 million tons/year. The decline in national $NO_X$ emissions is expected to continue due to regulatory actions. CSAPR, which takes effect Jan 1, 2012, sets emission budgets anticipated to reduce $NO_x$ emissions by 1.4 million tons per year compared to base case 2005 emissions (reference (7)).




From http://www.epa.gov/airtrends/nitrogen.html

**Figure 6-8 National nitrogen oxide emission trends from 1990 to 2006.**

### 6.3.3 Summary of National Emissions and Trends

Nationally, there is a declining trend in $NO_X$ and $SO_2$ emissions over the time period from approximately 1990-2008 (reference (6)). Specifically:

$SO_2$: Between 1990 and 2008, total $SO_2$ emissions have declined by approximately 50%

$NO_X$: Between 1990 and 2008, total $NO_X$ emissions have declined approximately 35%

EPA and the states have put in place a number of control programs that will continue to reduce $SO_2$ and $NO_X$. These future declines in emissions are expected to result in a continued downward trend in emissions nationally and a decrease in acid deposition in Voyageurs and the BWCA.

## 6.4 Foreseeable Regulatory and Other Actions and Expected Emission Reductions

Estimating the exact schedule or scale that existing sources in Minnesota will reduce $SO_2$ and $NO_X$, emissions over the next ten to fifteen years is outside the scope of this report. However, there are several "on the books" or "on the way" regulatory programs that are likely to reduce or constrain emissions from both existing taconite facilities and existing coal-fired power plants. These include at least the following initiatives that have been or will be implemented in Minnesota or throughout the country:

- Minnesota's Acid Rain Rule (Minn. Rule parts 7021.0010-7021.0050);
- EPA Acid Rain Program (Title IV of the 1999 Clean Air Act Amendments); Phase II began implementation in 2000.
- The Cross State Air Pollution Rule (CSAPR), modifying 40 CFR Parts 51, 72, 73, 74, 77, 78, 96
- Regional Haze Rule, including Best Available Retrofit Technologies (BART) requirements for certain sources. On July 6, 2005, the EPA published final amendments to its 1999 regional haze rule in the Federal Register, including Appendix Y, the final guidance for Best Available Retrofit Technology (BART) determinations (70 FR 39104-39172).
- National Ambient Air Quality Standards including 1-hr standards for $NO_X$ and $SO_2$, reconsiderations of the 2008 Ozone standards, and additional changes to the standards for $SO_2$, $NO_X$ and PM.
- Mobile source reductions
- Wisconsin and Michigan ozone and $PM_{2.5}$ SIPs

How these programs will work together, which units will be affected, and on what schedule are yet to be determined. Therefore, a detailed assessment of the potential emission reductions due to these regulations is outside the scope of this report. Nevertheless, while the timing of each of these regulatory initiatives is different, each could affect emissions of pollutants that could result in acid deposition from existing sources in northeastern Minnesota and throughout the state.

### 6.4.1 Minnesota's Acid Rain Rule

Minnesota's Acid Rain Rule was established in July 1986 and includes the following provisions:

- A deposition standard that allows no more than 11 kilograms per hectare of wet sulfate to be deposited within the designated sensitive resource areas of Minnesota during any 52-week period (reference (50)).

- An emissions control plan that caps statewide $SO_2$ emissions at 194,000 tons/year.
- System-wide $SO_2$ emission limit of 93,500 tons/year for Northern States Power Company (now known as Xcel Energy).
- System-wide $SO_2$ emission limit of 40,390 tons/year for Minnesota Power.

As of 2009, statewide $SO_2$ emissions are estimated at 101,000 tons/year (reference (4)). Under Minnesota's Acid Rain Rule, $SO_2$ emissions would be allowed to increase and as such will not require any further reductions. The MN Acid Rain Rule, however, does constrain emissions with the goal of protecting resources sensitive to ecosystem acidification. In addition, current federal regulatory actions (e.g., the EPA acid rain program), foreseeable future actions, and voluntary actions (Minnesota Power's AREA Project; Xcel Energy's MERP) will continue to keep the statewide emissions below the 194,000 tons/year emissions cap.

### 6.4.2 EPA's Acid Rain Program

The goal of EPA's Acid Rain Program is to improve public health and the environment by reducing emissions of $SO_2$ and $NO_X$. The program was implemented in two phases: Phase I for $SO_2$ began in 1995 and targeted the largest and highest emitting coal-fired power plants. Phase I for $NO_X$ began in 1996. Phase II for both pollutants began in 2000 and sets restrictions on Phase I plants as well as smaller coal-, gas-, and oil-fired plants. Approximately 3000 emission units are now affected by the Acid Rain Program (see http://www.epa.gov/airtrends/ acidrain.html). The EPA Acid Rain Program has been completely phased in by 2010 and serves to constrain $SO_2$ emissions under a permanent cap.

The Acid Rain Program anticipated that by 2010 annual $SO_2$ emissions would be reduced to half of 1980 levels. The program sets a permanent cap of 8.95 million tons on the total amount of $SO_2$ that may be emitted by power plants nationwide (reference (59)). It employs an emissions trading program to achieve emission reductions more efficiently and cost-effectively. Sources are allocated allowances each year (one allowance equals 1 ton of $SO_2$ emissions), which can be bought or sold or banked for future use. This approach gives sources the flexibility and incentive to reduce emissions at the lowest cost and the cap ensures that emission reductions are maintained over time.

The $NO_X$ component of the Acid Rain Program limits the emission rate for all affected utilities, resulting in a 2 million ton $NO_X$ reduction from 1990 levels by 2001.There is no cap on total $NO_X$ emissions, but under this program a source can choose to over-control at units where it is technically easier to control emissions, average these emissions with those at their other units, and thereby achieve overall emissions reductions at lower cost.

Minnesota's electric utilities are subject to EPA's Acid Rain Program. As discussed below, additional emission reductions for $SO_2$ and $NO_X$ may not be expected from Minnesota's sources.

### 6.4.3 Cross State Air Pollution Rule (CSAPR)

The Cross State Air Pollution Rule (CSAPR) was developed to replace CAIR, which was vacated by the D.C. Circuit Court of Appeals in July of 2008 and remanded in December 2008 to the EPA for rewriting to address the flaws identified in the court's July findings. CSAPR takes effect Jan 1, 2012.

CSAPR requires 27 states to reduce emissions that contribute to ozone and fine particle pollution in other states. The reductions in this rule were developed to assist states in meeting the 1997 ozone and 2006 $PM_{2.5}$ standards. An additional supplemental notice of proposed rulemaking related to CSPAR would require summertime $NO_x$ reductions under the CSPAR ozone season control program and bring the number of states covered by CSAPR to 28. This proposed rulemaking is expected to be finalized sometime in 2011. CSPAR sets an emissions budget for each state and allows limited interstate trading among power plants within the emission ceiling of each state. CSAPR sets emissions budgets that are expected to reduce $NO_X$ emissions by 1.4 million tons and $SO_2$ emissions by 6.4 million tons per year by 2014 compared to 2005 base levels (reference (7)).

Various bills regarding the implementation of CSAPR have been introduced in the US House of Representatives that would either delay or negate this rule. However, it is uncertain if any of these bills will be passed into law. At the current time there is no change to the timing of the implementation CSAPR.

Minnesota is included in CSPAR and will have annual budgets of 29,572 tons of $NO_x$ and 41,981 tons $SO_2$ starting in 2012 for facilities generating electrical power for sale. Voluntary reductions by Minnesota sources such as that by Xcel Energy under the Metropolitan Emission Reduction Program (MERP) and other efforts may meet or exceed the emission reductions that will be required under CSAPR to meet these budgets so it is uncertain if additional reductions will take place in Minnesota as a result of CSAPR. In addition to the MERP Project, Minnesota Power has completed or is proceeding with voluntary projects to reduce emissions at the Laskin Energy Center in Hoyt Lakes, the Taconite Harbor facility on Lake Superior (Lake County) and the Boswell station in Cohasset.

### 6.4.4 Industrial Boiler Maximum Achievable Control Technology (MACT) Standards

The Industrial, Commercial, and Institutional Boilers and Process Heaters (Boiler) MACT (Subpart DDDDD) has been re-proposed and was finalized February, 2011. Affected emission units under the

Boiler MACT are boilers and indirect-fired process heaters, characterized by 11 sub-categories of units.

### 6.4.5 Utility Boiler Maximum Achievable Control Technology (MACT) Standards

On March 16, 2011, the Environmental Protection Agency (EPA) also issued a new proposed rule that would reduce emissions of toxic air pollutants from power plants. Specifically, the proposal would reduce emissions from new and existing coal- and oil-fired electric utility steam generating units (EGUs). Under a court-imposed consent decree, the EPA must issue the final rule `by November 16, 2011. Although this proposed rule is directed primarily at reducing emissions of mercury and other metallic pollutants from electric power plants, it could drive additional reductions in $SO_2$ and $NO_X$ emissions at some plants (see http://www.epa.gov/airquality/powerplanttoxics/actions.html). Various bills regarding the Utility Boiler MACT have been introduced in the US House of Representatives that would either delay or negate the Utility Boiler MACT. However, it is uncertain if any of these bills will be passed into law. At the current time there is no change to the timing of the implementation of the Utility Boiler MACT.

### 6.4.6 Best Available Retrofit Technology (BART) and Regional Haze

BART requirements are part of the EPA effort to improve visibility in federal Class I areas, such as Voyageur's National Park and the Boundary Waters Canoe Area. The MPCA Regional Haze SIP includes a summary of sources with units subject to BART in Minnesota, which includes six taconite facilities and seven electric generating units in Minnesota. BART will require $SO_2$ and $NO_X$ reductions from three generating plants in the area: Minnesota Power's Boswell Energy Center Unit 3 and Taconite Harbor Unit 3 and Northshore Power Unit 2. In addition, electric generating units in other parts of the state will also be required to implement BART including Rochester Public Utilities Silver Lake Units 3 and 4 and Xcel Energy's Sherco plant. Several of these facilities have already implemented appropriate emissions reduction measures.

In late 2009, Minnesota submitted its Regional Haze State Implementation Plan to EPA and it is currently under review to verify that the plan complies with all of the rule requirements. The plan, as submitted, proposes emission limits on several sources which would result in the goal reduction of 30% in the six-county northeastern Minnesota region by 2018. Additional $SO_2$ and $NO_X$ reductions may be required in Minnesota as part of the Regional Haze SIP requirements to meet national visibility goals.

### 6.4.7 Other Actions

There are several other actions that will help either directly or incidentally to reduce $SO_2$ and $NO_X$. These have been implemented since 2009 or will be implemented in the next several years and include:

- Heavy Duty engine standards
- Low sulfur fuel standards
- Federal control programs for nonroad mobile emissions
- Control of emissions from unregulated non-road engines
- $PM_{2.5}$ and Ozone SIPs for Wisconsin and Michigan
- Ozone NAAQS Reconsideration anticipated in 2013
- Primary and Secondary NAAQS Standards for $SO_2$ and $NO_X$
- PM NAAQS Review
- Inclusion of $PM_{2.5}$ in the PSD rule, including increments, Significant Impact Levels and Significant Monitoring Concentrations

# 7.0 Acid Deposition Summary

During the 1980's, part of the scientific debate surrounding acid rain was whether there was a direct relationship between $SO_2$ emissions and acid deposition rates. This question has for the most part been answered. The 2005 National Acid Precipitation Program Assessment Program Report (reference (16)) concludes that the reductions in acid precursor emissions mandated by the Clean Air Act Amendments of 1990 are in fact reducing acid deposition throughout the United States. Wet sulfate deposition in the Upper Midwest has in general declined by 35% since 1990. In some areas on the eastern seaboard, acid concentrations in precipitation and acid deposition rates are dropping at an approximately one-to-one ratio with national emission trends (reference (16)).

Based on data from monitoring sites in Minnesota, acid deposition has declined across Minnesota since 1984. Additional national $SO_2$ emission reductions will likely result in continued steady but slow reductions in acid deposition rates in northeastern Minnesota. For example, as part of the CAIR, now CSAPR, the EPA modeled the extent to which mandated $SO_2$ emission reductions would reduce sulfur deposition rates across the United States. To do this, EPA used a comprehensive three-dimensional grid based Eulerian air quality model called the Community Multiscale Air Quality Model (CMAQ) (reference (60)). The CMAQ model is designed to estimate deposition over large areas. The results of this modeling show that CAIR, if implemented as planned, would have reduced sulfur deposition throughout Minnesota by 5% to 10% beyond what would already occur under existing Clean Air Act programs, such as the Title IV acid rain program (reference (61)). It is expected that CSAPR will accomplish the same reductions.

Nitrate deposition currently averages about 6 kilograms per hectare per year in Minnesota, about a 25% decrease since 1994. This current deposition in Minnesota is about 50% of the estimated 10 to 16 kilograms per hectare per year currently received by ecosystems in the Ohio River valley and parts of the northeastern United States (reference (52)), and about 16% of historic nitrate deposition where nitrogen saturation has been reported to contribute to watershed acidification. The relatively small $NO_X$ emissions from the proposed projects and likely reductions in state and local $NO_X$ emissions from electric generation units due to CSAPR (as CAIR was originally proposed) and from mining sources due to the BART rule, indicate that nitrate and total nitrogen deposition in northeastern Minnesota is likely to slightly decrease further in the area over the next 15 years.

# 8.0 Conclusions

The proposed projects are located near aquatic and terrestrial ecosystems identified as sensitive or potentially sensitive to acid deposition. However, the following factors need to be taken into account when evaluating the potential cumulative impacts from the proposed projects with regard to ecosystem acidification:

- Annual wet sulfate deposition in northeast Minnesota currently ranges from 3-7 kg/ha$^{-1}$ (in 2010) and is below the state's acid deposition standard of 11 kg ha$^{-1}$ yr$^{-1}$, which is set at a level to protect the most sensitive aquatic ecosystems from acidification (reference (10)).
- The annual average pH of rainfall in all parts of Minnesota is above 4.7, the threshold associated with acid lakes in the eastern United States and in Europe (reference (10)).
- Minnesota's ecosystems are less sensitive to acid deposition than had originally been thought (i.e., have more acid neutralizing capacity, ANC), particularly in the North Shore area (reference (11)).
- Modeling results (MPCA 1985; Shannon 1999) indicate that emission sources in Minnesota contribute approximately 10% - 15% of the acid deposition that falls in the state; therefore, the potential contribution of the proposed projects to acid deposition in the state is expected to be small, if it can be measured at all. In turn, the potential contribution of the proposed projects to acid deposition falling in other states is expected to also be small due to the small potential emissions of $SO_2$ and $NO_X$ from the projects and the atmospheric mixing and dilution that occurs as the pollutants travel downwind.
- The proposed emission reductions from Minnesota Power facilities as part of the AREA project, United Taconite, and U. S. Steel Minntac, and other facilities, offset some of the potential emissions from the proposed projects.
- The potential increase in emissions from the proposed projects will likely be offset by concurrent local and statewide emission reductions by Minnesota electric utility generators due to foreseeable regulatory actions.

In summary, the proposed projects will emit $SO_2$ and $NO_X$; however, the proposed projects are not expected to have any measurable effect on ecosystem acidification in northeastern Minnesota.

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# Appendices

# Appendix A1

## Regional Acid Deposition Monitoring Data

**Regional (Michigan. Minnesota, North Dakota. Wisconsin)**
**acidic deposition monitoring sites and data**
**from initiation of site through 2010**
**Data from NADP**
**(at http://nadp.sws.uiuc.edu/, accessed September 2011)**

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MI09 | 1980 | 2.44 | 12 | 4.61 | 17.49 | 57.66 | 238 | 45.5608 | -84.6783 |
| MI09 | 1981 | 2.11 | 10.16 | 3.94 | 18.11 | 65.95 | 238 | 45.5608 | -84.6783 |
| MI09 | 1982 | 3.25 | 15.17 | 5.95 | 20.7 | 87.52 | 238 | 45.5608 | -84.6783 |
| MI09 | 1983 | 2.41 | 13.05 | 4.82 | 16.99 | 89.42 | 238 | 45.5608 | -84.6783 |
| MI09 | 1984 | 3.04 | 14.43 | 5.62 | 20.5 | 87.3 | 238 | 45.5608 | -84.6783 |
| MI09 | 1985 | 3.41 | 17.16 | 6.53 | 21.34 | 106.57 | 238 | 45.5608 | -84.6783 |
| MI09 | 1986 | 1.88 | 11.26 | 4.01 | 14.72 | 72.89 | 238 | 45.5608 | -84.6783 |
| MI09 | 1987 | 2.69 | 10.68 | 4.5 | 14.76 | 75.51 | 238 | 45.5608 | -84.6783 |
| MI09 | 1988 | 2.54 | 14.19 | 5.18 | 14.45 | 77.98 | 238 | 45.5608 | -84.6783 |
| MI09 | 1989 | 2.96 | 13.29 | 5.3 | 15.38 | 65.19 | 238 | 45.5608 | -84.6783 |
| MI09 | 1990 | 3.2 | 11.86 | 5.17 | 17.01 | 90.11 | 238 | 45.5608 | -84.6783 |
| MI09 | 1991 | 2.73 | 13.7 | 5.22 | 14.14 | 79.62 | 238 | 45.5608 | -84.6783 |
| MI09 | 1992 | 2.12 | 11.18 | 4.18 | 11.99 | 78.08 | 238 | 45.5608 | -84.6783 |
| MI09 | 1993 | 2.72 | 13.33 | 5.12 | 14.29 | 82.57 | 238 | 45.5608 | -84.6783 |
| MI09 | 1994 | 2.15 | 10.29 | 3.99 | 11.03 | 76.49 | 238 | 45.5608 | -84.6783 |
| MI09 | 1995 | 3.92 | 16.95 | 6.87 | 15.58 | 96 | 238 | 45.5608 | -84.6783 |
| MI09 | 1996 | 2.85 | 14.29 | 5.45 | 12.23 | 84.92 | 238 | 45.5608 | -84.6783 |
| MI09 | 1997 | 2.08 | 10.07 | 3.89 | 9.24 | 62.02 | 238 | 45.5608 | -84.6783 |
| MI09 | 1998 | 3.14 | 12.59 | 5.29 | 11.43 | 80.42 | 238 | 45.5608 | -84.6783 |
| MI09 | 1999 | 2.97 | 13.17 | 5.28 | 12.92 | 77.23 | 238 | 45.5608 | -84.6783 |
| MI09 | 2000 | 2.26 | 11.31 | 4.31 | 8.57 | 56.73 | 238 | 45.5608 | -84.6783 |
| MI09 | 2001 | 3.18 | 14.08 | 5.65 | 13.99 | 97.62 | 238 | 45.5608 | -84.6783 |
| MI09 | 2002 | 3.88 | 14.89 | 6.38 | 12.67 | 92.84 | 238 | 45.5608 | -84.6783 |
| MI09 | 2003 | 3 | 11.97 | 5.03 | 11.12 | 86.34 | 238 | 45.5608 | -84.6783 |
| MI09 | 2004 | 3.24 | 12.15 | 5.26 | 10.97 | 96.74 | 238 | 45.5608 | -84.6783 |
| MI09 | 2005 | 2.79 | 11.25 | 4.71 | 10.94 | 77.38 | 238 | 45.5608 | -84.6783 |
| MI09 | 2006 | 2.89 | 10.6 | 4.64 | 9.96 | 90.24 | 238 | 45.5608 | -84.6783 |
| MI09 | 2007 | 2.94 | 9.01 | 4.33 | 8.37 | 73.8 | 238 | 45.5608 | -84.6783 |
| MI09 | 2008 | 3.1 | 10.37 | 4.75 | 9.09 | 86.07 | 238 | 45.5608 | -84.6783 |
| MI09 | 2009 | 2.64 | 7.58 | 3.76 | 6.54 | 81.86 | 238 | 45.5608 | -84.6783 |
| MI09 | 2010 | 3.07 | 7.59 | 4.1 | 6.93 | 86.03 | 238 | 45.5608 | -84.6783 |
| MI22 | 1981 | 1.55 | 7.4 | 2.87 | 8.28 | 41.25 | 193 | 47.2269 | -88.6308 |
| MI22 | 1982 | 1.41 | 7.04 | 2.69 | 9.2 | 53.88 | 193 | 47.2269 | -88.6308 |
| MI25 | 1981 | 0.55 | 2.07 | 0.9 | 4.8 | 24.48 | 216 | 47.9153 | -89.1525 |
| MI25 | 1982 | 1.27 | 3.72 | 1.83 | 6.29 | 33.56 | 216 | 47.9153 | -89.1525 |
| MI25 | 1983 | 1.55 | 4.35 | 2.19 | 6.45 | 53.21 | 216 | 47.9153 | -89.1525 |
| MI26 | 1980 | 4.19 | 19.24 | 7.6 | 30.87 | 84.4 | 288 | 42.4103 | -85.3928 |
| MI26 | 1981 | 3.71 | 15.35 | 6.35 | 27.55 | 84.1 | 288 | 42.4103 | -85.3928 |
| MI26 | 1982 | 3.33 | 16.53 | 6.32 | 25.48 | 86.46 | 288 | 42.4103 | -85.3928 |
| MI26 | 1983 | 4.04 | 19.91 | 7.64 | 26.5 | 94.49 | 288 | 42.4103 | -85.3928 |
| MI26 | 1984 | 3.23 | 15.04 | 5.91 | 22.09 | 86.56 | 288 | 42.4103 | -85.3928 |
| MI26 | 1985 | 4.63 | 20.37 | 8.2 | 33.01 | 116.44 | 288 | 42.4103 | -85.3928 |
| MI26 | 1986 | 5.36 | 21.08 | 8.93 | 34.14 | 124.46 | 288 | 42.4103 | -85.3928 |
| MI26 | 1987 | 3.93 | 18.47 | 7.23 | 26.83 | 84.21 | 288 | 42.4103 | -85.3928 |
| MI26 | 1988 | 4.55 | 20.72 | 8.22 | 30.17 | 114.72 | 288 | 42.4103 | -85.3928 |
| MI26 | 1989 | 5.8 | 20.8 | 9.21 | 31.32 | 101.87 | 288 | 42.4103 | -85.3928 |
| MI26 | 1990 | 5.27 | 21.05 | 8.85 | 31.07 | 121.52 | 288 | 42.4103 | -85.3928 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MI26 | 1991 | 4.09 | 16.23 | 6.85 | 22.84 | 107.47 | 288 | 42.4103 | -85.3928 |
| MI26 | 1992 | 3.26 | 15.02 | 5.93 | 19.15 | 90.22 | 288 | 42.4103 | -85.3928 |
| MI26 | 1993 | 3.53 | 16.27 | 6.42 | 19.99 | 87.76 | 288 | 42.4103 | -85.3928 |
| MI26 | 1994 | 3.78 | 15.64 | 6.47 | 20.83 | 96.06 | 288 | 42.4103 | -85.3928 |
| MI26 | 1995 | 3.89 | 15.06 | 6.43 | 16.44 | 80.71 | 288 | 42.4103 | -85.3928 |
| MI26 | 1996 | 3.65 | 14.05 | 6.01 | 16.79 | 74.57 | 288 | 42.4103 | -85.3928 |
| MI26 | 1997 | 4.56 | 17.03 | 7.39 | 18.06 | 91.69 | 288 | 42.4103 | -85.3928 |
| MI26 | 1998 | 4.14 | 16.04 | 6.84 | 18.07 | 78.74 | 288 | 42.4103 | -85.3928 |
| MI26 | 1999 | 2.69 | 11.56 | 4.7 | 12.5 | 61.35 | 288 | 42.4103 | -85.3928 |
| MI26 | 2000 | 1.87 | 7.31 | 3.11 | 7.67 | 45.08 | 288 | 42.4103 | -85.3928 |
| MI26 | 2001 | 3.77 | 13.63 | 6.01 | 14.75 | 85.54 | 288 | 42.4103 | -85.3928 |
| MI26 | 2002 | 3.52 | 12.49 | 5.56 | 12.91 | 79.53 | 288 | 42.4103 | -85.3928 |
| MI26 | 2003 | 5.41 | 15.6 | 7.73 | 16.23 | 88.86 | 288 | 42.4103 | -85.3928 |
| MI26 | 2004 | 5.04 | 15.23 | 7.36 | 17.56 | 97.76 | 288 | 42.4103 | -85.3928 |
| MI26 | 2005 | 3.8 | 12.2 | 5.71 | 14.34 | 75.62 | 288 | 42.4103 | -85.3928 |
| MI26 | 2006 | 4.62 | 14.27 | 6.81 | 14.86 | 109.13 | 288 | 42.4103 | -85.3928 |
| MI26 | 2007 | 3.8 | 10.44 | 5.32 | 12.13 | 76.54 | 288 | 42.4103 | -85.3928 |
| MI26 | 2008 | 3.49 | 10.57 | 5.1 | 12.55 | 107.82 | 288 | 42.4103 | -85.3928 |
| MI26 | 2009 | 3.91 | 9.68 | 5.23 | 10.78 | 100.84 | 288 | 42.4103 | -85.3928 |
| MI26 | 2010 | 4.21 | 10.54 | 5.65 | 10.68 | 97.8 | 288 | 42.4103 | -85.3928 |
| MI29 | 2002 | 3.04 | 11.57 | 4.98 | 8.94 | 63.04 | 209 | 45.0289 | -85.6292 |
| MI29 | 2003 | 3.76 | 14.19 | 6.13 | 12.49 | 85.1 | 209 | 45.0289 | -85.6292 |
| MI29 | 2004 | 4.12 | 14.7 | 6.52 | 13.3 | 103.5 | 209 | 45.0289 | -85.6292 |
| MI29 | 2005 | 2.93 | 11.56 | 4.89 | 10.93 | 75.69 | 209 | 45.0289 | -85.6292 |
| MI29 | 2006 | 3.28 | 11.13 | 5.06 | 10.46 | 86.13 | 209 | 45.0289 | -85.6292 |
| MI29 | 2007 | 3.34 | 9.98 | 4.85 | 8.63 | 71.99 | 209 | 45.0289 | -85.6292 |
| MI29 | 2008 | 3.5 | 11.7 | 5.36 | 10.2 | 70.96 | 209 | 45.0289 | -85.6292 |
| MI48 | 2000 | 0.05 | 0.72 | 0.2 | 0.24 | 3.56 | 216 | 46.2875 | -85.9541 |
| MI48 | 2001 | 3.05 | 12.85 | 5.27 | 11.07 | 94.09 | 216 | 46.2875 | -85.9541 |
| MI48 | 2002 | 4.01 | 14.44 | 6.38 | 11.79 | 95.81 | 216 | 46.2875 | -85.9541 |
| MI48 | 2003 | 2.91 | 10.47 | 4.63 | 10.32 | 80.03 | 216 | 46.2875 | -85.9541 |
| MI48 | 2004 | 3.19 | 11.31 | 5.04 | 10.94 | 99.06 | 216 | 46.2875 | -85.9541 |
| MI48 | 2005 | 2.74 | 9.34 | 4.24 | 9.68 | 74.45 | 216 | 46.2875 | -85.9541 |
| MI48 | 2006 | 2.43 | 7.68 | 3.62 | 6.37 | 68.84 | 216 | 46.2875 | -85.9541 |
| MI48 | 2007 | 2.41 | 7.21 | 3.5 | 5.7 | 64.22 | 216 | 46.2875 | -85.9541 |
| MI48 | 2008 | 2.15 | 7.51 | 3.37 | 6.57 | 65.72 | 216 | 46.2875 | -85.9541 |
| MI48 | 2009 | 1.69 | 5.04 | 2.45 | 4.72 | 70.31 | 216 | 46.2875 | -85.9541 |
| MI48 | 2010 | 2.56 | 5.41 | 3.22 | 5.36 | 87.22 | 216 | 46.2875 | -85.9541 |
| MI51 | 1999 | 2.37 | 9.67 | 4.03 | 11.14 | 52.67 | 201 | 43.6135 | -83.3599 |
| MI51 | 2000 | 3.46 | 14.8 | 6.03 | 15.53 | 73.21 | 201 | 43.6135 | -83.3599 |
| MI51 | 2001 | 3.44 | 13.12 | 5.64 | 13.53 | 69.32 | 201 | 43.6135 | -83.3599 |
| MI51 | 2002 | 3.69 | 13.23 | 5.86 | 12.23 | 59.3 | 201 | 43.6135 | -83.3599 |
| MI51 | 2003 | 3.22 | 10.61 | 4.9 | 12.38 | 60.43 | 201 | 43.6135 | -83.3599 |
| MI51 | 2004 | 2.57 | 8.27 | 3.87 | 8.53 | 59.95 | 201 | 43.6135 | -83.3599 |
| MI51 | 2005 | 2.73 | 8.24 | 3.99 | 10.8 | 60.24 | 201 | 43.6135 | -83.3599 |
| MI51 | 2006 | 3.1 | 9.78 | 4.62 | 11.86 | 76.28 | 201 | 43.6135 | -83.3599 |
| MI51 | 2007 | 3.33 | 8.92 | 4.61 | 10.19 | 66.7 | 201 | 43.6135 | -83.3599 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MI51 | 2008 | 2.82 | 8.09 | 4.02 | 9.41 | 72.92 | 201 | 43.6135 | -83.3599 |
| MI51 | 2009 | 2.29 | 5.52 | 3.03 | 7.11 | 62.99 | 201 | 43.6135 | -83.3599 |
| MI51 | 2010 | 2.83 | 7.09 | 3.81 | 7.89 | 64.85 | 201 | 43.6135 | -83.3599 |
| MI52 | 1999 | 2.67 | 13.39 | 5.1 | 13.85 | 66.86 | 267 | 42.4164 | -83.9019 |
| MI52 | 2000 | 4.3 | 17.54 | 7.31 | 19.32 | 112.35 | 267 | 42.4164 | -83.9019 |
| MI52 | 2001 | 3.95 | 15.93 | 6.67 | 18.1 | 96.92 | 267 | 42.4164 | -83.9019 |
| MI52 | 2002 | 2.88 | 10.23 | 4.55 | 10.35 | 61.56 | 267 | 42.4164 | -83.9019 |
| MI52 | 2003 | 4.02 | 13.64 | 6.21 | 14.13 | 83.24 | 267 | 42.4164 | -83.9019 |
| MI52 | 2004 | 3.76 | 14.14 | 6.11 | 14.5 | 91.86 | 267 | 42.4164 | -83.9019 |
| MI52 | 2005 | 2.98 | 11.61 | 4.94 | 14.01 | 81.04 | 267 | 42.4164 | -83.9019 |
| MI52 | 2006 | 4.48 | 15.62 | 7.01 | 17.56 | 108.02 | 267 | 42.4164 | -83.9019 |
| MI52 | 2007 | 4.31 | 11.94 | 6.05 | 15.52 | 99.67 | 267 | 42.4164 | -83.9019 |
| MI52 | 2008 | 4.29 | 11.53 | 5.94 | 13.19 | 104.98 | 267 | 42.4164 | -83.9019 |
| MI52 | 2009 | 3.6 | 9.9 | 5.03 | 11.45 | 96.91 | 267 | 42.4164 | -83.9019 |
| MI52 | 2010 | 2.41 | 8.32 | 3.75 | 8.08 | 78.32 | 267 | 42.4164 | -83.9019 |
| MI53 | 1979 | 2.98 | 17.14 | 6.19 | 23.34 | 74.99 | 292 | 44.2242 | -85.8186 |
| MI53 | 1980 | 3.62 | 16.9 | 6.63 | 23.24 | 83.05 | 292 | 44.2242 | -85.8186 |
| MI53 | 1981 | 3.17 | 15.87 | 6.05 | 21.05 | 77.72 | 292 | 44.2242 | -85.8186 |
| MI53 | 1982 | 4.47 | 17.84 | 7.51 | 22.45 | 101 | 292 | 44.2242 | -85.8186 |
| MI53 | 1983 | 3.43 | 17.3 | 6.58 | 21.98 | 97 | 292 | 44.2242 | -85.8186 |
| MI53 | 1984 | 4.62 | 22.06 | 8.57 | 28 | 111.23 | 292 | 44.2242 | -85.8186 |
| MI53 | 1985 | 4.28 | 21.81 | 8.25 | 26.25 | 129.69 | 292 | 44.2242 | -85.8186 |
| MI53 | 1986 | 3.91 | 19.3 | 7.4 | 26.75 | 106.15 | 292 | 44.2242 | -85.8186 |
| MI53 | 1987 | 3.03 | 14.71 | 5.68 | 19.25 | 92.94 | 292 | 44.2242 | -85.8186 |
| MI53 | 1988 | 2.45 | 16.43 | 5.62 | 16.92 | 96.92 | 292 | 44.2242 | -85.8186 |
| MI53 | 1989 | 3.78 | 17.33 | 6.85 | 16.5 | 81.06 | 292 | 44.2242 | -85.8186 |
| MI53 | 1990 | 4.73 | 18.28 | 7.81 | 22.58 | 122.03 | 292 | 44.2242 | -85.8186 |
| MI53 | 1991 | 3.47 | 16.2 | 6.36 | 19.42 | 107.23 | 292 | 44.2242 | -85.8186 |
| MI53 | 1992 | 4.27 | 17.35 | 7.24 | 20.38 | 102.15 | 292 | 44.2242 | -85.8186 |
| MI53 | 1993 | 4.4 | 20.29 | 8 | 23.64 | 103.71 | 292 | 44.2242 | -85.8186 |
| MI53 | 1994 | 3.89 | 16.62 | 6.78 | 17.44 | 85.98 | 292 | 44.2242 | -85.8186 |
| MI53 | 1995 | 3.53 | 15.86 | 6.33 | 13.78 | 88.09 | 292 | 44.2242 | -85.8186 |
| MI53 | 1996 | 3.64 | 17.64 | 6.81 | 15.87 | 92.39 | 292 | 44.2242 | -85.8186 |
| MI53 | 1997 | 3.39 | 15.2 | 6.07 | 13.35 | 82.31 | 292 | 44.2242 | -85.8186 |
| MI53 | 1998 | 3.12 | 15.1 | 5.84 | 15.11 | 83.2 | 292 | 44.2242 | -85.8186 |
| MI53 | 1999 | 3.09 | 14.85 | 5.75 | 13.28 | 95.53 | 292 | 44.2242 | -85.8186 |
| MI53 | 2000 | 3.77 | 16.32 | 6.62 | 13.18 | 85.2 | 292 | 44.2242 | -85.8186 |
| MI53 | 2001 | 4.27 | 17.73 | 7.32 | 14.88 | 98.76 | 292 | 44.2242 | -85.8186 |
| MI53 | 2002 | 3.82 | 14.47 | 6.24 | 12.56 | 77.89 | 292 | 44.2242 | -85.8186 |
| MI53 | 2003 | 4.9 | 17.23 | 7.7 | 15.99 | 105.12 | 292 | 44.2242 | -85.8186 |
| MI53 | 2004 | 4.5 | 15.82 | 7.07 | 14.17 | 105.77 | 292 | 44.2242 | -85.8186 |
| MI53 | 2005 | 3.86 | 13.47 | 6.04 | 15.14 | 90.62 | 292 | 44.2242 | -85.8186 |
| MI53 | 2006 | 4.63 | 13.69 | 6.69 | 14.18 | 112.6 | 292 | 44.2242 | -85.8186 |
| MI53 | 2007 | 3.45 | 11.12 | 5.2 | 8.75 | 73.49 | 292 | 44.2242 | -85.8186 |
| MI53 | 2008 | 4.35 | 14.35 | 6.62 | 12.98 | 120.15 | 292 | 44.2242 | -85.8186 |
| MI53 | 2009 | 3.25 | 9.36 | 4.64 | 8.69 | 85.02 | 292 | 44.2242 | -85.8186 |
| MI53 | 2010 | 2.46 | 7.19 | 3.53 | 6.81 | 73.33 | 292 | 44.2242 | -85.8186 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MI97 | 1986 | 0.46 | 3.04 | 1.04 | 4.13 | 35.81 | 201 | 48.0575 | -88.6342 |
| MI97 | 1987 | -- | -- | -- | -- | 3.89 | 201 | 48.0575 | -88.6342 |
| MI97 | 1988 | 0.76 | 3.34 | 1.34 | 4.14 | 31.12 | 201 | 48.0575 | -88.6342 |
| MI97 | 1989 | 1.12 | 2.98 | 1.54 | 4.19 | 31.14 | 201 | 48.0575 | -88.6342 |
| MI97 | 1990 | 1.02 | 2.51 | 1.36 | 3.29 | 23.08 | 201 | 48.0575 | -88.6342 |
| MI97 | 1991 | 0.91 | 3 | 1.39 | 4.11 | 39 | 201 | 48.0575 | -88.6342 |
| MI97 | 1992 | 1.11 | 4.47 | 1.88 | 7.02 | 38.11 | 201 | 48.0575 | -88.6342 |
| MI97 | 1993 | 0.65 | 2.26 | 1.02 | 2.78 | 26.52 | 201 | 48.0575 | -88.6342 |
| MI97 | 1994 | 1.48 | 4.52 | 2.17 | 5.31 | 37.26 | 201 | 48.0575 | -88.6342 |
| MI97 | 1995 | 1.96 | 5.36 | 2.73 | 5.34 | 38.49 | 201 | 48.0575 | -88.6342 |
| MI97 | 1996 | 1.02 | 3.4 | 1.56 | 3.39 | 37.33 | 201 | 48.0575 | -88.6342 |
| MI97 | 1997 | 0.6 | 2.59 | 1.05 | 2.67 | 28.7 | 201 | 48.0575 | -88.6342 |
| MI97 | 1999 | 1.36 | 4.81 | 2.15 | 4.21 | 49.32 | 201 | 48.0575 | -88.6342 |
| MI97 | 2001 | 1.13 | 3.43 | 1.65 | 3.13 | 40.27 | 201 | 48.0575 | -88.6342 |
| MI97 | 2003 | 0.89 | 2.28 | 1.21 | 2.65 | 25.43 | 201 | 48.0575 | -88.6342 |
| MI97 | 2004 | 1.18 | 2.95 | 1.58 | 3.58 | 38.09 | 201 | 48.0575 | -88.6342 |
| MI97 | 2005 | 2.32 | 5.01 | 2.93 | 5.33 | 43.04 | 201 | 48.0575 | -88.6342 |
| MI98 | 1985 | 2.42 | 14.09 | 5.06 | 16.94 | 96.67 | 262 | 46.3722 | -84.7434 |
| MI98 | 1986 | 2.29 | 12.38 | 4.58 | 16.92 | 82.98 | 262 | 46.3722 | -84.7434 |
| MI98 | 1987 | 2.54 | 11.98 | 4.68 | 13.68 | 79.6 | 262 | 46.3722 | -84.7434 |
| MI98 | 1988 | 3.84 | 20.02 | 7.51 | 18.81 | 101.11 | 262 | 46.3722 | -84.7434 |
| MI98 | 1989 | 2.88 | 12.6 | 5.08 | 13.55 | 64.34 | 262 | 46.3722 | -84.7434 |
| MI98 | 1990 | 3.54 | 13.31 | 5.76 | 15.39 | 94.53 | 262 | 46.3722 | -84.7434 |
| MI98 | 1991 | 2.54 | 11.17 | 4.5 | 12.64 | 83.33 | 262 | 46.3722 | -84.7434 |
| MI98 | 1992 | 3.08 | 11.99 | 5.11 | 15.71 | 83.83 | 262 | 46.3722 | -84.7434 |
| MI98 | 1993 | 3.41 | 14.9 | 6.02 | 14.86 | 92.73 | 262 | 46.3722 | -84.7434 |
| MI98 | 1994 | 2.52 | 10.12 | 4.24 | 11.02 | 72.92 | 262 | 46.3722 | -84.7434 |
| MI98 | 1995 | 3.16 | 13.02 | 5.4 | 12.69 | 95.69 | 262 | 46.3722 | -84.7434 |
| MI98 | 1996 | 2.67 | 12.19 | 4.83 | 13.6 | 94.94 | 262 | 46.3722 | -84.7434 |
| MI98 | 1997 | 1.79 | 8.98 | 3.42 | 7.91 | 52.57 | 262 | 46.3722 | -84.7434 |
| MI98 | 1998 | 2.92 | 11.56 | 4.88 | 10.85 | 74.19 | 262 | 46.3722 | -84.7434 |
| MI98 | 1999 | 2.88 | 12.79 | 5.13 | 11.49 | 76.9 | 262 | 46.3722 | -84.7434 |
| MI98 | 2000 | 1.62 | 7.14 | 2.87 | 5.99 | 53.07 | 262 | 46.3722 | -84.7434 |
| MI98 | 2001 | 3.15 | 13.58 | 5.52 | 12.23 | 100.43 | 262 | 46.3722 | -84.7434 |
| MI98 | 2002 | 2.69 | 10.2 | 4.4 | 8.57 | 74.85 | 262 | 46.3722 | -84.7434 |
| MI98 | 2003 | 2.77 | 10.04 | 4.42 | 10.34 | 79.58 | 262 | 46.3722 | -84.7434 |
| MI98 | 2004 | 2.85 | 9.41 | 4.34 | 11.05 | 83.91 | 262 | 46.3722 | -84.7434 |
| MI98 | 2005 | 3.09 | 9.44 | 4.54 | 9.91 | 71.43 | 262 | 46.3722 | -84.7434 |
| MI98 | 2006 | 2.48 | 8.55 | 3.86 | 7.25 | 69.76 | 262 | 46.3722 | -84.7434 |
| MI98 | 2007 | 2.45 | 7.55 | 3.61 | 7.61 | 70.62 | 262 | 46.3722 | -84.7434 |
| MI98 | 2008 | 2.32 | 8.34 | 3.69 | 7.64 | 82.22 | 262 | 46.3722 | -84.7434 |
| MI98 | 2009 | 1.77 | 5.8 | 2.69 | 4.74 | 64.69 | 262 | 46.3722 | -84.7434 |
| MI98 | 2010 | 2 | 4.97 | 2.68 | 5 | 82.09 | 262 | 46.3722 | -84.7434 |
| MI99 | 1984 | 2.15 | 8.43 | 3.57 | 9.78 | 74.06 | 277 | 47.1047 | -88.5514 |
| MI99 | 1985 | 3.24 | 11.49 | 5.12 | 15.74 | 110.62 | 277 | 47.1047 | -88.5514 |
| MI99 | 1986 | 1.62 | 7.44 | 2.94 | 11.29 | 76.15 | 277 | 47.1047 | -88.5514 |
| MI99 | 1987 | 0.36 | 2.37 | 0.82 | 2.48 | 25.84 | 277 | 47.1047 | -88.5514 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MI99 | 1988 | 1.77 | 10.83 | 3.82 | 10.42 | 89 | 277 | 47.1047 | -88.5514 |
| MI99 | 1989 | 1.57 | 7.22 | 2.85 | 7.67 | 64.49 | 277 | 47.1047 | -88.5514 |
| MI99 | 1990 | 2.8 | 8.41 | 4.08 | 10.48 | 81.38 | 277 | 47.1047 | -88.5514 |
| MI99 | 1991 | 2.24 | 9.42 | 3.87 | 10.95 | 89.21 | 277 | 47.1047 | -88.5514 |
| MI99 | 1992 | 2.03 | 7.95 | 3.38 | 10.13 | 70.65 | 277 | 47.1047 | -88.5514 |
| MI99 | 1993 | 1.86 | 7.44 | 3.13 | 7.82 | 72.77 | 277 | 47.1047 | -88.5514 |
| MI99 | 1994 | 2.09 | 8.04 | 3.44 | 6.92 | 67.49 | 277 | 47.1047 | -88.5514 |
| MI99 | 1995 | 2.78 | 10.07 | 4.44 | 8.87 | 88.07 | 277 | 47.1047 | -88.5514 |
| MI99 | 1996 | 2.29 | 9.59 | 3.95 | 7.78 | 88.06 | 277 | 47.1047 | -88.5514 |
| MI99 | 1997 | 1.69 | 7.31 | 2.96 | 5.35 | 67.7 | 277 | 47.1047 | -88.5514 |
| MI99 | 1998 | 2.09 | 7.55 | 3.33 | 6.46 | 71.04 | 277 | 47.1047 | -88.5514 |
| MI99 | 1999 | 2.29 | 9.57 | 3.94 | 7.98 | 86.65 | 277 | 47.1047 | -88.5514 |
| MI99 | 2000 | 2.08 | 7.5 | 3.31 | 5.67 | 64.13 | 277 | 47.1047 | -88.5514 |
| MI99 | 2001 | 3.35 | 9.87 | 4.83 | 9.34 | 91.45 | 277 | 47.1047 | -88.5514 |
| MI99 | 2002 | 3.12 | 9.92 | 4.66 | 8.53 | 92.74 | 277 | 47.1047 | -88.5514 |
| MI99 | 2003 | 2.11 | 7.74 | 3.39 | 6.92 | 82.56 | 277 | 47.1047 | -88.5514 |
| MI99 | 2004 | 2.49 | 8.55 | 3.86 | 7.34 | 90.44 | 277 | 47.1047 | -88.5514 |
| MI99 | 2005 | 3.35 | 11.08 | 5.11 | 10.04 | 84.25 | 277 | 47.1047 | -88.5514 |
| MI99 | 2006 | 2.18 | 5.72 | 2.98 | 4.43 | 69.71 | 277 | 47.1047 | -88.5514 |
| MI99 | 2007 | 3.64 | 8.68 | 4.79 | 7.89 | 99.71 | 277 | 47.1047 | -88.5514 |
| MI99 | 2008 | 2.44 | 6.82 | 3.44 | 6.26 | 64.9 | 277 | 47.1047 | -88.5514 |
| MI99 | 2009 | 1.86 | 5.94 | 2.79 | 4.62 | 79.77 | 277 | 47.1047 | -88.5514 |
| MI99 | 2010 | 1.59 | 4.74 | 2.3 | 3.65 | 69.56 | 277 | 47.1047 | -88.5514 |
| MN01 | 1997 | 3.21 | 8.44 | 4.4 | 6.92 | 67.66 | 280 | 45.4017 | -93.2031 |
| MN01 | 1998 | 4.6 | 11.14 | 6.1 | 9.73 | 66.99 | 280 | 45.4017 | -93.2031 |
| MN01 | 1999 | 4.16 | 10.57 | 5.63 | 9.33 | 70.92 | 280 | 45.4017 | -93.2031 |
| MN01 | 2000 | 3.36 | 8.76 | 4.59 | 6.64 | 62.39 | 280 | 45.4017 | -93.2031 |
| MN01 | 2001 | 4.27 | 9.9 | 5.56 | 7.65 | 79.87 | 280 | 45.4017 | -93.2031 |
| MN01 | 2002 | 7.22 | 15.65 | 9.15 | 11.51 | 96.95 | 280 | 45.4017 | -93.2031 |
| MN01 | 2003 | 3.12 | 7.13 | 4.04 | 6.24 | 60.67 | 280 | 45.4017 | -93.2031 |
| MN01 | 2004 | 4.69 | 9.85 | 5.87 | 8.2 | 87.61 | 280 | 45.4017 | -93.2031 |
| MN01 | 2005 | 5.35 | 11.28 | 6.71 | 10.75 | 87.55 | 280 | 45.4017 | -93.2031 |
| MN01 | 2006 | 3.98 | 7.46 | 4.78 | 6.65 | 61.47 | 280 | 45.4017 | -93.2031 |
| MN01 | 2007 | 4.2 | 8.49 | 5.18 | 7.36 | 71.32 | 280 | 45.4017 | -93.2031 |
| MN01 | 2008 | 3.38 | 6.09 | 4.01 | 5.32 | 61.88 | 280 | 45.4017 | -93.2031 |
| MN01 | 2009 | 2.94 | 5 | 3.42 | 4.36 | 63.71 | 280 | 45.4017 | -93.2031 |
| MN01 | 2010 | 4.08 | 7.39 | 4.84 | 5.28 | 87.04 | 280 | 45.4017 | -93.2031 |
| MN05 | 1996 | 0.07 | 0.75 | 0.22 | 0.25 | 5.47 | 390 | 46.7131 | -92.5108 |
| MN05 | 1997 | 1.48 | 5.35 | 2.36 | 3.85 | 61.74 | 390 | 46.7131 | -92.5108 |
| MN05 | 1998 | 2.37 | 8.21 | 3.7 | 6.58 | 77.06 | 390 | 46.7131 | -92.5108 |
| MN05 | 1999 | 3.16 | 8.77 | 4.44 | 7.41 | 87.43 | 390 | 46.7131 | -92.5108 |
| MN05 | 2000 | 3.17 | 8.58 | 4.4 | 7.33 | 74.4 | 390 | 46.7131 | -92.5108 |
| MN05 | 2001 | 2.81 | 8.53 | 4.11 | 6.55 | 73.97 | 390 | 46.7131 | -92.5108 |
| MN05 | 2002 | 3.36 | 7.91 | 4.4 | 6.46 | 78.75 | 390 | 46.7131 | -92.5108 |
| MN05 | 2003 | 2.39 | 6.45 | 3.32 | 6.07 | 62.32 | 390 | 46.7131 | -92.5108 |
| MN05 | 2004 | 2.79 | 6.89 | 3.73 | 5.71 | 63.6 | 390 | 46.7131 | -92.5108 |
| MN05 | 2005 | 0.3 | 1.09 | 0.48 | 0.61 | 9.63 | 390 | 46.7131 | -92.5108 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN08 | 1991 | 2.9592 | 8.7931 | 4.29542 | 12.43 | 81.8 | 224 | 47.8472 | -89.9625 |
| MN08 | 1992 | 3.1889 | 9.2303 | 4.573417 | 13.26 | 69.7 | 224 | 47.8472 | -89.9625 |
| MN08 | 1993 | 2.1406 | 6.3935 | 3.114566 | 7.51 | 62.4 | 224 | 47.8472 | -89.9625 |
| MN08 | 1994 | 3.3784 | 9.202 | 4.714833 | 8.25 | 63.1 | 224 | 47.8472 | -89.9625 |
| MN08 | 1995 | 2.7759 | 8.4158 | 4.067203 | 7.23 | 75.3237 | 224 | 47.8472 | -89.9625 |
| MN08 | 1996 | 3.6355 | 12.502 | 5.661077 | 10.36 | 93.9673 | 224 | 47.8472 | -89.9625 |
| MN08 | 1997 | 2.37 | 8.4 | 3.74 | 5.9 | 53.69 | 224 | 47.8472 | -89.9625 |
| MN08 | 1998 | 3.16 | 10.52 | 4.83 | 10.2 | 76.1 | 224 | 47.8472 | -89.9625 |
| MN08 | 1999 | 3.17 | 9.56 | 4.62 | 8.37 | 64.22 | 224 | 47.8472 | -89.9625 |
| MN08 | 2000 | 3.13 | 9.77 | 4.64 | 8.43 | 60.86 | 224 | 47.8472 | -89.9625 |
| MN08 | 2001 | 3.14 | 9.7 | 4.64 | 8.22 | 86.6 | 224 | 47.8472 | -89.9625 |
| MN08 | 2002 | 2.15 | 5.92 | 3.01 | 4.2 | 51 | 224 | 47.8472 | -89.9625 |
| MN08 | 2003 | 2.16 | 5.98 | 3.03 | 5.57 | 50.62 | 224 | 47.8472 | -89.9625 |
| MN08 | 2004 | 2.66 | 7.47 | 3.75 | 6.7 | 65.45 | 224 | 47.8472 | -89.9625 |
| MN08 | 2005 | 3.28 | 8.36 | 4.44 | 8 | 76.88 | 224 | 47.8472 | -89.9625 |
| MN08 | 2006 | 2.02 | 7.03 | 3.16 | 5.74 | 51.68 | 224 | 47.8472 | -89.9625 |
| MN08 | 2007 | 2.86 | 6.4 | 3.67 | 6.23 | 69.03 | 224 | 47.8472 | -89.9625 |
| MN08 | 2008 | 3.39 | 8.33 | 4.52 | 9.14 | 76.45 | 224 | 47.8472 | -89.9625 |
| MN08 | 2009 | 2.22 | 4.64 | 2.77 | 4.52 | 57.67 | 224 | 47.8472 | -89.9625 |
| MN08 | 2010 | 1.75 | 4.59 | 2.4 | 3.73 | 59.71 | 224 | 47.8472 | -89.9625 |
| MN16 | 1979 | 3.56 | 11.88 | 5.45 | 15.28 | 77.52 | 431 | 47.5311 | -93.4686 |
| MN16 | 1980 | 2.34 | 8.31 | 3.69 | 8.66 | 64.9 | 431 | 47.5311 | -93.4686 |
| MN16 | 1981 | 2.62 | 8.49 | 3.95 | 10.24 | 77.65 | 431 | 47.5311 | -93.4686 |
| MN16 | 1982 | 2.53 | 7.81 | 3.74 | 10.42 | 81.74 | 431 | 47.5311 | -93.4686 |
| MN16 | 1983 | 2.7 | 8.19 | 3.95 | 9.48 | 70.04 | 431 | 47.5311 | -93.4686 |
| MN16 | 1984 | 2.82 | 7.81 | 3.96 | 9.94 | 75.43 | 431 | 47.5311 | -93.4686 |
| MN16 | 1985 | 2.36 | 7.7 | 3.58 | 9.43 | 91.91 | 431 | 47.5311 | -93.4686 |
| MN16 | 1986 | 2.58 | 7.84 | 3.78 | 8.86 | 76.75 | 431 | 47.5311 | -93.4686 |
| MN16 | 1987 | 2.66 | 8.02 | 3.88 | 8.67 | 78.52 | 431 | 47.5311 | -93.4686 |
| MN16 | 1988 | 1.93 | 9.05 | 3.54 | 8.26 | 92.74 | 431 | 47.5311 | -93.4686 |
| MN16 | 1989 | 3.66 | 8.81 | 4.84 | 9.05 | 76.16 | 431 | 47.5311 | -93.4686 |
| MN16 | 1990 | 2.14 | 6.38 | 3.11 | 5.5 | 56.15 | 431 | 47.5311 | -93.4686 |
| MN16 | 1991 | 2.04 | 6.98 | 3.16 | 6.96 | 69.35 | 431 | 47.5311 | -93.4686 |
| MN16 | 1992 | 2.78 | 8.05 | 3.98 | 8.05 | 82.88 | 431 | 47.5311 | -93.4686 |
| MN16 | 1993 | 2.15 | 7.26 | 3.31 | 6.44 | 73.61 | 431 | 47.5311 | -93.4686 |
| MN16 | 1994 | 3.38 | 9.2 | 4.71 | 6.71 | 83.94 | 431 | 47.5311 | -93.4686 |
| MN16 | 1995 | 2.42 | 7.66 | 3.61 | 5.78 | 89.31 | 431 | 47.5311 | -93.4686 |
| MN16 | 1996 | 1.9 | 8.01 | 3.29 | 5.6 | 78.83 | 431 | 47.5311 | -93.4686 |
| MN16 | 1997 | 1.72 | 6.81 | 2.88 | 4.49 | 74.88 | 431 | 47.5311 | -93.4686 |
| MN16 | 1998 | 3.09 | 7.93 | 4.2 | 6.72 | 79.67 | 431 | 47.5311 | -93.4686 |
| MN16 | 1999 | 3.64 | 9.82 | 5.05 | 7.74 | 90.65 | 431 | 47.5311 | -93.4686 |
| MN16 | 2000 | 2.76 | 8.1 | 3.98 | 5.76 | 73.27 | 431 | 47.5311 | -93.4686 |
| MN16 | 2001 | 2.19 | 6.73 | 3.22 | 4.77 | 81.36 | 431 | 47.5311 | -93.4686 |
| MN16 | 2002 | 3.44 | 7.9 | 4.46 | 5.91 | 73.09 | 431 | 47.5311 | -93.4686 |
| MN16 | 2003 | 2.61 | 6.16 | 3.42 | 4.52 | 62.46 | 431 | 47.5311 | -93.4686 |
| MN16 | 2004 | 3.26 | 7.3 | 4.18 | 5.89 | 76.51 | 431 | 47.5311 | -93.4686 |
| MN16 | 2005 | 2.91 | 7.21 | 3.89 | 5.87 | 72.56 | 431 | 47.5311 | -93.4686 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN16 | 2006 | 2.51 | 5.85 | 3.27 | 4.59 | 55.02 | 431 | 47.5311 | -93.4686 |
| MN16 | 2007 | 3.41 | 6.62 | 4.15 | 5.54 | 72.08 | 431 | 47.5311 | -93.4686 |
| MN16 | 2008 | 3.13 | 6.28 | 3.85 | 5.29 | 70.76 | 431 | 47.5311 | -93.4686 |
| MN16 | 2009 | 2.22 | 4.59 | 2.76 | 3.81 | 64.74 | 431 | 47.5311 | -93.4686 |
| MN16 | 2010 | 2.37 | 5.01 | 2.98 | 3.68 | 78.85 | 431 | 47.5311 | -93.4686 |
| MN18 | 1981 | 2.29 | 7.16 | 3.39 | 10.38 | 67.02 | 524 | 47.9464 | -91.4961 |
| MN18 | 1982 | 2.11 | 6.71 | 3.15 | 10.2 | 78.84 | 524 | 47.9464 | -91.4961 |
| MN18 | 1983 | 2.06 | 7.09 | 3.2 | 8.38 | 88.81 | 524 | 47.9464 | -91.4961 |
| MN18 | 1984 | 1.55 | 5.48 | 2.44 | 6.8 | 56.88 | 524 | 47.9464 | -91.4961 |
| MN18 | 1985 | 1.75 | 6.46 | 2.82 | 8.19 | 74.38 | 524 | 47.9464 | -91.4961 |
| MN18 | 1986 | 1.18 | 5.84 | 2.24 | 6.72 | 66.77 | 524 | 47.9464 | -91.4961 |
| MN18 | 1987 | 2.13 | 5.91 | 2.99 | 6.2 | 62.28 | 524 | 47.9464 | -91.4961 |
| MN18 | 1988 | 1.29 | 8.76 | 2.98 | 7.75 | 85.56 | 524 | 47.9464 | -91.4961 |
| MN18 | 1989 | 1.7 | 5.11 | 2.47 | 4.99 | 52.5 | 524 | 47.9464 | -91.4961 |
| MN18 | 1990 | 1.98 | 5.82 | 2.85 | 5.63 | 65.52 | 524 | 47.9464 | -91.4961 |
| MN18 | 1991 | 1.67 | 6.22 | 2.7 | 5.93 | 68.02 | 524 | 47.9464 | -91.4961 |
| MN18 | 1992 | 1.41 | 5.13 | 2.25 | 5.93 | 61.61 | 524 | 47.9464 | -91.4961 |
| MN18 | 1993 | 1.59 | 5.89 | 2.57 | 5.57 | 69.25 | 524 | 47.9464 | -91.4961 |
| MN18 | 1994 | 2.57 | 6.81 | 3.54 | 5.55 | 69.15 | 524 | 47.9464 | -91.4961 |
| MN18 | 1995 | 1.33 | 4.36 | 2.02 | 3.47 | 57.31 | 524 | 47.9464 | -91.4961 |
| MN18 | 1996 | 2.14 | 7.02 | 3.25 | 5 | 71.28 | 524 | 47.9464 | -91.4961 |
| MN18 | 1997 | 0.92 | 3.69 | 1.55 | 2.74 | 42.7 | 524 | 47.9464 | -91.4961 |
| MN18 | 1998 | 2.66 | 7.53 | 3.77 | 6.25 | 62.4 | 524 | 47.9464 | -91.4961 |
| MN18 | 1999 | 3.11 | 8.31 | 4.29 | 6.93 | 76.19 | 524 | 47.9464 | -91.4961 |
| MN18 | 2000 | 1.98 | 6.27 | 2.95 | 5.05 | 64.62 | 524 | 47.9464 | -91.4961 |
| MN18 | 2001 | 2.56 | 7.56 | 3.7 | 5.55 | 75.87 | 524 | 47.9464 | -91.4961 |
| MN18 | 2002 | 2.04 | 5.71 | 2.88 | 4.03 | 56.05 | 524 | 47.9464 | -91.4961 |
| MN18 | 2003 | 2.27 | 5.6 | 3.03 | 5.58 | 58.64 | 524 | 47.9464 | -91.4961 |
| MN18 | 2004 | 2.47 | 5.65 | 3.2 | 4.32 | 68.79 | 524 | 47.9464 | -91.4961 |
| MN18 | 2005 | 2.53 | 6.54 | 3.45 | 5.41 | 72.39 | 524 | 47.9464 | -91.4961 |
| MN18 | 2006 | 1.85 | 4.39 | 2.43 | 3.47 | 52.95 | 524 | 47.9464 | -91.4961 |
| MN18 | 2007 | 2.86 | 6.12 | 3.6 | 5.26 | 76.81 | 524 | 47.9464 | -91.4961 |
| MN18 | 2008 | 2.76 | 6.06 | 3.51 | 5.55 | 79.68 | 524 | 47.9464 | -91.4961 |
| MN18 | 2009 | 1.75 | 3.85 | 2.23 | 3.36 | 59.23 | 524 | 47.9464 | -91.4961 |
| MN18 | 2010 | 1.09 | 3.02 | 1.53 | 2.05 | 51.04 | 524 | 47.9464 | -91.4961 |
| MN23 | 1984 | 2.32 | 5.86 | 3.13 | 6.9 | 66.54 | 410 | 46.2494 | -94.4972 |
| MN23 | 1985 | 1.48 | 5.88 | 2.48 | 6.5 | 70.71 | 410 | 46.2494 | -94.4972 |
| MN23 | 1986 | 2.46 | 7.87 | 3.69 | 8.98 | 88.18 | 410 | 46.2494 | -94.4972 |
| MN23 | 1987 | 2 | 5.13 | 2.71 | 4.62 | 42.07 | 410 | 46.2494 | -94.4972 |
| MN23 | 1988 | 2.59 | 8.51 | 3.94 | 8.38 | 70.29 | 410 | 46.2494 | -94.4972 |
| MN23 | 1989 | 3.36 | 7.5 | 4.31 | 6.79 | 63.36 | 410 | 46.2494 | -94.4972 |
| MN23 | 1990 | 3.41 | 7.11 | 4.26 | 5.91 | 66.51 | 410 | 46.2494 | -94.4972 |
| MN23 | 1991 | 3.18 | 7.9 | 4.26 | 7.36 | 79.53 | 410 | 46.2494 | -94.4972 |
| MN23 | 1992 | 3.86 | 8.05 | 4.82 | 8.63 | 57.93 | 410 | 46.2494 | -94.4972 |
| MN23 | 1993 | 2.83 | 8.46 | 4.11 | 6.7 | 88.73 | 410 | 46.2494 | -94.4972 |
| MN23 | 1994 | 4.01 | 9.32 | 5.23 | 6.94 | 80.58 | 410 | 46.2494 | -94.4972 |
| MN23 | 1995 | 3.09 | 9.18 | 4.47 | 6.42 | 82.95 | 410 | 46.2494 | -94.4972 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN23 | 1996 | 3.27 | 8.16 | 4.39 | 5.58 | 65.45 | 410 | 46.2494 | -94.4972 |
| MN23 | 1997 | 2.76 | 7 | 3.73 | 4.45 | 59.04 | 410 | 46.2494 | -94.4972 |
| MN23 | 1998 | 4.39 | 10.14 | 5.7 | 8.4 | 69.34 | 410 | 46.2494 | -94.4972 |
| MN23 | 1999 | 4.28 | 10.35 | 5.67 | 8.39 | 74.49 | 410 | 46.2494 | -94.4972 |
| MN23 | 2000 | 3.25 | 8.09 | 4.35 | 5.85 | 72.13 | 410 | 46.2494 | -94.4972 |
| MN23 | 2001 | 3.94 | 9 | 5.1 | 6.25 | 88.8 | 410 | 46.2494 | -94.4972 |
| MN23 | 2002 | 4.55 | 9.66 | 5.72 | 6.47 | 76.94 | 410 | 46.2494 | -94.4972 |
| MN23 | 2003 | 3.63 | 7.39 | 4.49 | 5.67 | 66.94 | 410 | 46.2494 | -94.4972 |
| MN23 | 2004 | 3.46 | 6.23 | 4.1 | 5.11 | 66.75 | 410 | 46.2494 | -94.4972 |
| MN23 | 2005 | 4.48 | 9.67 | 5.67 | 7.58 | 75.83 | 410 | 46.2494 | -94.4972 |
| MN23 | 2006 | 3.22 | 6.71 | 4.02 | 4.81 | 61.33 | 410 | 46.2494 | -94.4972 |
| MN23 | 2007 | 3.45 | 7.14 | 4.3 | 5.83 | 69.05 | 410 | 46.2494 | -94.4972 |
| MN23 | 2008 | 3.61 | 6.28 | 4.23 | 5.25 | 69.02 | 410 | 46.2494 | -94.4972 |
| MN23 | 2009 | 3.95 | 6.76 | 4.6 | 5.26 | 76.78 | 410 | 46.2494 | -94.4972 |
| MN23 | 2010 | 4.36 | 7.15 | 5.01 | 4.83 | 88.86 | 410 | 46.2494 | -94.4972 |
| MN27 | 1979 | 5.31 | 12.22 | 6.89 | 17.7 | 77.92 | 343 | 44.2369 | -95.301 |
| MN27 | 1980 | 3.69 | 8.71 | 4.84 | 10.75 | 47.32 | 343 | 44.2369 | -95.301 |
| MN27 | 1981 | 4.29 | 9.62 | 5.51 | 10.99 | 54.32 | 343 | 44.2369 | -95.301 |
| MN27 | 1982 | 4.09 | 8.66 | 5.13 | 10.76 | 77.37 | 343 | 44.2369 | -95.301 |
| MN27 | 1983 | 5.52 | 10.96 | 6.77 | 12.73 | 63.51 | 343 | 44.2369 | -95.301 |
| MN27 | 1984 | 4.58 | 10.33 | 5.9 | 11.98 | 75.39 | 343 | 44.2369 | -95.301 |
| MN27 | 1985 | 3.3 | 7.96 | 4.36 | 9.36 | 78.87 | 343 | 44.2369 | -95.301 |
| MN27 | 1986 | 5.36 | 11.44 | 6.75 | 12.47 | 88.89 | 343 | 44.2369 | -95.301 |
| MN27 | 1987 | 3.3 | 8 | 4.37 | 8.84 | 51.5 | 343 | 44.2369 | -95.301 |
| MN27 | 1988 | 2.1 | 6.19 | 3.03 | 6.42 | 40.22 | 343 | 44.2369 | -95.301 |
| MN27 | 1989 | 3.28 | 6.64 | 4.05 | 6.31 | 45.24 | 343 | 44.2369 | -95.301 |
| MN27 | 1990 | 3.83 | 7.39 | 4.64 | 6.04 | 61.8 | 343 | 44.2369 | -95.301 |
| MN27 | 1991 | 4.54 | 9.23 | 5.61 | 8.56 | 73.8 | 343 | 44.2369 | -95.301 |
| MN27 | 1992 | 4.66 | 8.89 | 5.63 | 9.25 | 66.99 | 343 | 44.2369 | -95.301 |
| MN27 | 1993 | 5.93 | 12.05 | 7.33 | 10.63 | 95.19 | 343 | 44.2369 | -95.301 |
| MN27 | 1994 | 3.81 | 7.8 | 4.73 | 6.04 | 59.26 | 343 | 44.2369 | -95.301 |
| MN27 | 1995 | 4.07 | 9.84 | 5.39 | 6.95 | 68.3 | 343 | 44.2369 | -95.301 |
| MN27 | 1996 | 4.67 | 9.5 | 5.77 | 7.19 | 83.17 | 343 | 44.2369 | -95.301 |
| MN27 | 1997 | 3.77 | 9.19 | 5.01 | 5.59 | 60.38 | 343 | 44.2369 | -95.301 |
| MN27 | 1998 | 4.85 | 9.06 | 5.82 | 8.13 | 60.24 | 343 | 44.2369 | -95.301 |
| MN27 | 1999 | 3.34 | 6.54 | 4.07 | 4.63 | 50.31 | 343 | 44.2369 | -95.301 |
| MN27 | 2000 | 4.68 | 9.37 | 5.76 | 6.13 | 62.45 | 343 | 44.2369 | -95.301 |
| MN27 | 2001 | 4.48 | 8.59 | 5.42 | 6.8 | 74.69 | 343 | 44.2369 | -95.301 |
| MN27 | 2002 | 5.74 | 11.75 | 7.11 | 7.7 | 56.86 | 343 | 44.2369 | -95.301 |
| MN27 | 2003 | 3.42 | 5.9 | 3.99 | 4.71 | 45.03 | 343 | 44.2369 | -95.301 |
| MN27 | 2004 | 4.19 | 7.36 | 4.92 | 5.44 | 66.92 | 343 | 44.2369 | -95.301 |
| MN27 | 2005 | 6.86 | 10.02 | 7.6 | 9.03 | 82.73 | 343 | 44.2369 | -95.301 |
| MN27 | 2006 | 5.14 | 7.78 | 5.75 | 6.09 | 65.87 | 343 | 44.2369 | -95.301 |
| MN27 | 2007 | 4.82 | 6.43 | 5.2 | 5.79 | 64.02 | 343 | 44.2369 | -95.301 |
| MN27 | 2008 | 3.95 | 5.54 | 4.32 | 4.89 | 52.53 | 343 | 44.2369 | -95.301 |
| MN27 | 2009 | 3.37 | 4.13 | 3.55 | 3 | 52.71 | 343 | 44.2369 | -95.301 |
| MN27 | 2010 | 7.08 | 7.93 | 7.3 | 5.86 | 89.71 | 343 | 44.2369 | -95.301 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN28 | 1984 | 4.3833 | 9.3422 | 5.530336 | 14.01 | 86.6 | 337 | 46.1208 | -93.0042 |
| MN28 | 1985 | 3.2927 | 7.8349 | 4.339023 | 9.86 | 76.1 | 337 | 46.1208 | -93.0042 |
| MN28 | 1986 | 4.0503 | 9.4107 | 5.286085 | 11.88 | 83 | 337 | 46.1208 | -93.0042 |
| MN28 | 1987 | 3.0572 | 6.654 | 3.888457 | 7.54 | 48 | 337 | 46.1208 | -93.0042 |
| MN28 | 1988 | 5.2636 | 11.496 | 6.703702 | 10.24 | 62.3 | 337 | 46.1208 | -93.0042 |
| MN28 | 1989 | 2.4024 | 6.2695 | 3.290816 | 7.31 | 53.6 | 337 | 46.1208 | -93.0042 |
| MN28 | 1990 | 3.3138 | 9.3357 | 4.694623 | 11.31 | 79.3 | 337 | 46.1208 | -93.0042 |
| MN28 | 1991 | 4.3689 | 10.611 | 5.805738 | 11.16 | 94 | 337 | 46.1208 | -93.0042 |
| MN28 | 1992 | 3.391 | 8.7178 | 4.615167 | 9.61 | 66.9 | 337 | 46.1208 | -93.0042 |
| MN28 | 1993 | 3.3505 | 8.3829 | 4.507933 | 8.47 | 65.6 | 337 | 46.1208 | -93.0042 |
| MN28 | 1994 | 4.3478 | 10.328 | 5.72537 | 8.86 | 77.8 | 337 | 46.1208 | -93.0042 |
| MN28 | 1995 | 3.7075 | 10.939 | 5.364096 | 8.66 | 92.1512 | 337 | 46.1208 | -93.0042 |
| MN28 | 1996 | 4.1621 | 10.965 | 5.724569 | 8.5 | 90.0938 | 337 | 46.1208 | -93.0042 |
| MN28 | 1997 | 2.75 | 7.26 | 3.78 | 5.99 | 61.89 | 337 | 46.1208 | -93.0042 |
| MN28 | 1998 | 3.12 | 8.82 | 4.42 | 7.34 | 65.99 | 337 | 46.1208 | -93.0042 |
| MN28 | 1999 | 4.7 | 12.12 | 6.39 | 10.1 | 82.95 | 337 | 46.1208 | -93.0042 |
| MN28 | 2000 | 3.47 | 8.8 | 4.68 | 6.91 | 67.69 | 337 | 46.1208 | -93.0042 |
| MN28 | 2001 | 3.68 | 8.94 | 4.88 | 6.72 | 77.1 | 337 | 46.1208 | -93.0042 |
| MN28 | 2002 | 6.12 | 13.56 | 7.82 | 10.09 | 92.85 | 337 | 46.1208 | -93.0042 |
| MN28 | 2003 | 3.58 | 7.92 | 4.57 | 7.3 | 77.9 | 337 | 46.1208 | -93.0042 |
| MN28 | 2004 | 3.01 | 7.21 | 3.97 | 5.44 | 70.98 | 337 | 46.1208 | -93.0042 |
| MN28 | 2005 | 4.14 | 9.3 | 5.32 | 8.51 | 79.23 | 337 | 46.1208 | -93.0042 |
| MN28 | 2006 | 3.21 | 6.72 | 4.01 | 5.36 | 51.23 | 337 | 46.1208 | -93.0042 |
| MN28 | 2007 | 3.55 | 7.35 | 4.42 | 6.77 | 74.54 | 337 | 46.1208 | -93.0042 |
| MN28 | 2008 | 3.35 | 6.64 | 4.1 | 6.18 | 78.38 | 337 | 46.1208 | -93.0042 |
| MN28 | 2009 | 3.08 | 5.63 | 3.67 | 4.66 | 69.63 | 337 | 46.1208 | -93.0042 |
| MN28 | 2010 | 3.66 | 6.64 | 4.35 | 4.58 | 85.8 | 337 | 46.1208 | -93.0042 |
| MN32 | 1984 | 1.2706 | 5.4561 | 2.224176 | 6.62 | 65.8 | 429 | 48.4128 | -92.8292 |
| MN32 | 1985 | 2.4636 | 7.6009 | 3.63942 | 8.24 | 84.5 | 429 | 48.4128 | -92.8292 |
| MN32 | 1986 | 1.7841 | 4.3101 | 2.365679 | 4.93 | 48.8 | 429 | 48.4128 | -92.8292 |
| MN32 | 1987 | 2.8316 | 5.8403 | 3.528588 | 6.83 | 67.8 | 429 | 48.4128 | -92.8292 |
| MN32 | 1988 | 4.7108 | 9.349 | 5.787284 | 7.88 | 78.2 | 429 | 48.4128 | -92.8292 |
| MN32 | 1989 | 1.59 | 4.987 | 2.367252 | 5.33 | 59.3 | 429 | 48.4128 | -92.8292 |
| MN32 | 1990 | 1.2192 | 5.0636 | 2.095359 | 4.58 | 60.8 | 429 | 48.4128 | -92.8292 |
| MN32 | 1991 | 2.0327 | 6.3979 | 3.031408 | 5.93 | 70.9 | 429 | 48.4128 | -92.8292 |
| MN32 | 1992 | 2.4662 | 6.7397 | 3.446816 | 7.43 | 60.4 | 429 | 48.4128 | -92.8292 |
| MN32 | 1993 | 1.7845 | 4.9379 | 2.50788 | 4.87 | 61.3 | 429 | 48.4128 | -92.8292 |
| MN32 | 1994 | 2.7759 | 7.0824 | 3.765804 | 5.25 | 70.5 | 429 | 48.4128 | -92.8292 |
| MN32 | 1995 | 1.6699 | 5.95 | 2.647184 | 4.84 | 95.2754 | 429 | 48.4128 | -92.8292 |
| MN32 | 1996 | 2.9382 | 8.3795 | 4.185559 | 5.44 | 85.2424 | 429 | 48.4128 | -92.8292 |
| MN32 | 2000 | 1.06 | 4.02 | 1.73 | 2.75 | 48.09 | 429 | 48.4128 | -92.8292 |
| MN32 | 2001 | 2.8 | 8.48 | 4.09 | 5.46 | 92.94 | 429 | 48.4128 | -92.8292 |
| MN32 | 2002 | 3.19 | 8.5 | 4.4 | 5.56 | 70.63 | 429 | 48.4128 | -92.8292 |
| MN32 | 2003 | 1.67 | 5.42 | 2.53 | 3.18 | 52.34 | 429 | 48.4128 | -92.8292 |
| MN32 | 2004 | 2.8 | 6.98 | 3.75 | 5.54 | 78.63 | 429 | 48.4128 | -92.8292 |
| MN32 | 2005 | 2.82 | 6.81 | 3.73 | 5.3 | 79.05 | 429 | 48.4128 | -92.8292 |
| MN32 | 2006 | 2.37 | 5.33 | 3.05 | 4.09 | 55.52 | 429 | 48.4128 | -92.8292 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN32 | 2007 | 2.37 | 5.32 | 3.04 | 4.18 | 63.64 | 429 | 48.4128 | -92.8292 |
| MN32 | 2008 | 2.41 | 5.47 | 3.11 | 4.7 | 78.73 | 429 | 48.4128 | -92.8292 |
| MN32 | 2009 | 2.41 | 5.47 | 3.11 | 4.01 | 85.42 | 429 | 48.4128 | -92.8292 |
| MN32 | 2010 | 2.52 | 4.84 | 3.05 | 3.63 | 88.58 | 429 | 48.4128 | -92.8292 |
| MN99 | 1989 | 2.3351 | 6.9634 | 3.395124 | 10.49 | 77.2 | 351 | 47.3875 | -91.1958 |
| MN99 | 1990 | 3.1372 | 9.8946 | 4.683171 | 14.03 | 80.264 | 351 | 47.3875 | -91.1958 |
| MN99 | 1991 | 3.571 | 9.6799 | 4.973028 | 16.11 | 90.7034 | 351 | 47.3875 | -91.1958 |
| MN99 | 1992 | 3.3728 | 10.108 | 4.915116 | 15.21 | 78.9686 | 351 | 47.3875 | -91.1958 |
| MN99 | 1993 | 3.1145 | 9.6544 | 4.611225 | 11.3 | 76.8858 | 351 | 47.3875 | -91.1958 |
| MN99 | 1994 | 4.4265 | 11.209 | 5.985926 | 10.1 | 73.4822 | 351 | 47.3875 | -91.1958 |
| MN99 | 1995 | 4.3181 | 13.029 | 6.312625 | 11.82 | 93.0148 | 351 | 47.3875 | -91.1958 |
| MN99 | 1996 | 4.6267 | 15.672 | 7.15075 | 11.51 | 89.2556 | 351 | 47.3875 | -91.1958 |
| MN99 | 1997 | 2.01 | 7.11 | 3.17 | 5.9 | 59.5 | 351 | 47.3875 | -91.1958 |
| MN99 | 1998 | 3.4 | 11.98 | 5.35 | 11.06 | 93.2 | 351 | 47.3875 | -91.1958 |
| MN99 | 1999 | 3.33 | 10.32 | 4.92 | 8.94 | 77.65 | 351 | 47.3875 | -91.1958 |
| MN99 | 2000 | 3 | 9.55 | 4.49 | 8.36 | 68.92 | 351 | 47.3875 | -91.1958 |
| MN99 | 2001 | 3.5 | 10.84 | 5.17 | 9.1 | 94.31 | 351 | 47.3875 | -91.1958 |
| MN99 | 2002 | 1.78 | 5.75 | 2.68 | 4.19 | 55.21 | 351 | 47.3875 | -91.1958 |
| MN99 | 2003 | 2.34 | 6.32 | 3.25 | 5.93 | 58.88 | 351 | 47.3875 | -91.1958 |
| MN99 | 2004 | 3.3 | 9.51 | 4.71 | 8.79 | 73.94 | 351 | 47.3875 | -91.1958 |
| MN99 | 2005 | 3.55 | 8.59 | 4.7 | 8.28 | 85.03 | 351 | 47.3875 | -91.1958 |
| MN99 | 2006 | 3.17 | 8.37 | 4.36 | 7.72 | 75.54 | 351 | 47.3875 | -91.1958 |
| MN99 | 2007 | 3.35 | 6.95 | 4.17 | 7.17 | 85.01 | 351 | 47.3875 | -91.1958 |
| MN99 | 2008 | 2.99 | 7 | 3.91 | 7.68 | 73.73 | 351 | 47.3875 | -91.1958 |
| MN99 | 2009 | 2.63 | 5.98 | 3.4 | 5.81 | 74.23 | 351 | 47.3875 | -91.1958 |
| MN99 | 2010 | 2.05 | 5.73 | 2.89 | 5.02 | 79.76 | 351 | 47.3875 | -91.1958 |
| ND00 | 2001 | 1.24 | 3.43 | 1.74 | 2.51 | 35.53 | 841 | 46.8947 | -103.3777 |
| ND00 | 2002 | 1.99 | 4.17 | 2.49 | 2.77 | 30.98 | 841 | 46.8947 | -103.3777 |
| ND00 | 2003 | 2.36 | 4.42 | 2.84 | 3.15 | 42.66 | 841 | 46.8947 | -103.3777 |
| ND00 | 2004 | 0.88 | 2.07 | 1.15 | 1.67 | 27.74 | 841 | 46.8947 | -103.3777 |
| ND00 | 2005 | 1.82 | 4.14 | 2.35 | 3.34 | 48.18 | 841 | 46.8947 | -103.3777 |
| ND00 | 2006 | 1.44 | 3.11 | 1.82 | 2.15 | 24.33 | 841 | 46.8947 | -103.3777 |
| ND00 | 2007 | 2.02 | 3.41 | 2.34 | 2.53 | 35.66 | 841 | 46.8947 | -103.3777 |
| ND00 | 2008 | 1.29 | 2.64 | 1.6 | 1.98 | 26.87 | 841 | 46.8947 | -103.3777 |
| ND00 | 2009 | 1.29 | 2.63 | 1.6 | 2.07 | 34.31 | 841 | 46.8947 | -103.3777 |
| ND00 | 2010 | 2.11 | 3.96 | 2.53 | 2.61 | 58.09 | 841 | 46.8947 | -103.3777 |
| ND07 | 1982 | 0.97 | 4.09 | 1.67 | 5.37 | 54.25 | 611 | 47.6014 | -103.2642 |
| ND07 | 1983 | 0.61 | 2.52 | 1.04 | 2.92 | 26.16 | 611 | 47.6014 | -103.2642 |
| ND07 | 1984 | 0.61 | 2.42 | 1.02 | 4.03 | 22.69 | 611 | 47.6014 | -103.2642 |
| ND07 | 1985 | 0.78 | 2.6 | 1.2 | 3.72 | 32.41 | 611 | 47.6014 | -103.2642 |
| ND07 | 1987 | 0.05 | 0.33 | 0.11 | 0.41 | 5.02 | 611 | 47.6014 | -103.2642 |
| ND07 | 1988 | 0.53 | 1.89 | 0.84 | 2.31 | 22.76 | 611 | 47.6014 | -103.2642 |
| ND07 | 1989 | 1.26 | 3 | 1.65 | 3.04 | 35.37 | 611 | 47.6014 | -103.2642 |
| ND07 | 1990 | 1.15 | 2.71 | 1.51 | 3.54 | 30.82 | 611 | 47.6014 | -103.2642 |
| ND07 | 1991 | 1.02 | 3.25 | 1.53 | 2.89 | 35.83 | 611 | 47.6014 | -103.2642 |
| ND07 | 1992 | 0.88 | 2.57 | 1.27 | 2.76 | 31.24 | 611 | 47.6014 | -103.2642 |
| ND07 | 1993 | 1.05 | 3.46 | 1.6 | 3.83 | 46.15 | 611 | 47.6014 | -103.2642 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| ND07 | 1994 | 1.48 | 4.41 | 2.15 | 4.23 | 44.2 | 611 | 47.6014 | -103.2642 |
| ND07 | 1995 | 1.88 | 4.48 | 2.47 | 3.88 | 48.29 | 611 | 47.6014 | -103.2642 |
| ND07 | 1996 | 1.33 | 3.61 | 1.85 | 2.83 | 37.23 | 611 | 47.6014 | -103.2642 |
| ND07 | 1997 | 0.37 | 1.41 | 0.61 | 0.96 | 12.34 | 611 | 47.6014 | -103.2642 |
| ND07 | 1998 | 1.46 | 3.79 | 1.99 | 3.73 | 41.47 | 611 | 47.6014 | -103.2642 |
| ND07 | 1999 | 0.94 | 2.71 | 1.34 | 2.13 | 30.07 | 611 | 47.6014 | -103.2642 |
| ND07 | 2000 | 1.88 | 4.86 | 2.56 | 3.84 | 47.02 | 611 | 47.6014 | -103.2642 |
| ND08 | 1984 | 1.68 | 4.49 | 2.32 | 4.43 | 39.15 | 306 | 48.782 | -97.7546 |
| ND08 | 1985 | 1.33 | 3.73 | 1.88 | 4.15 | 56.24 | 306 | 48.782 | -97.7546 |
| ND08 | 1986 | 1.1 | 3.41 | 1.62 | 4.09 | 55.47 | 306 | 48.782 | -97.7546 |
| ND08 | 1987 | 1.84 | 4.77 | 2.51 | 4.11 | 42.51 | 306 | 48.782 | -97.7546 |
| ND08 | 1988 | 1.21 | 4 | 1.84 | 3.47 | 27.87 | 306 | 48.782 | -97.7546 |
| ND08 | 1989 | 1.6 | 3.55 | 2.04 | 2.9 | 30.81 | 306 | 48.782 | -97.7546 |
| ND08 | 1990 | 1.82 | 3.44 | 2.19 | 3.06 | 36.24 | 306 | 48.782 | -97.7546 |
| ND08 | 1991 | 2.34 | 5.39 | 3.04 | 5.32 | 58.68 | 306 | 48.782 | -97.7546 |
| ND08 | 1992 | 2.02 | 4.55 | 2.6 | 3.92 | 41.36 | 306 | 48.782 | -97.7546 |
| ND08 | 1993 | 2.77 | 5.51 | 3.4 | 4.72 | 62.08 | 306 | 48.782 | -97.7546 |
| ND08 | 1994 | 2.69 | 5.28 | 3.28 | 3.77 | 47.03 | 306 | 48.782 | -97.7546 |
| ND08 | 1995 | 3.02 | 5.55 | 3.6 | 4.57 | 58.5 | 306 | 48.782 | -97.7546 |
| ND08 | 1996 | 2.67 | 6.68 | 3.59 | 3.46 | 52.33 | 306 | 48.782 | -97.7546 |
| ND08 | 1997 | 1.93 | 4.27 | 2.47 | 3.37 | 59.87 | 306 | 48.782 | -97.7546 |
| ND08 | 1998 | 3.01 | 7.44 | 4.02 | 4.99 | 55.48 | 306 | 48.782 | -97.7546 |
| ND08 | 1999 | 2.61 | 5.06 | 3.17 | 3.42 | 47.21 | 306 | 48.782 | -97.7546 |
| ND08 | 2000 | 3.86 | 7.03 | 4.59 | 4.32 | 68.85 | 306 | 48.782 | -97.7546 |
| ND08 | 2001 | 2.24 | 4.34 | 2.72 | 2.67 | 44.09 | 306 | 48.782 | -97.7546 |
| ND08 | 2002 | 3.28 | 5.75 | 3.85 | 3.93 | 59.26 | 306 | 48.782 | -97.7546 |
| ND08 | 2003 | 2.38 | 3.92 | 2.74 | 2.85 | 39.6 | 306 | 48.782 | -97.7546 |
| ND08 | 2004 | 3.23 | 5.75 | 3.81 | 4.09 | 60.8 | 306 | 48.782 | -97.7546 |
| ND08 | 2005 | 2.85 | 4.85 | 3.31 | 3.54 | 58.08 | 306 | 48.782 | -97.7546 |
| ND08 | 2006 | 3.01 | 5.61 | 3.61 | 3.49 | 42.67 | 306 | 48.782 | -97.7546 |
| ND08 | 2007 | 3.88 | 5.54 | 4.27 | 4.08 | 67.76 | 306 | 48.782 | -97.7546 |
| ND08 | 2008 | 3.16 | 3.97 | 3.36 | 4.5 | 65.77 | 306 | 48.782 | -97.7546 |
| ND08 | 2009 | 2.34 | 3.95 | 2.71 | 2.94 | 56.13 | 306 | 48.782 | -97.7546 |
| ND08 | 2010 | 3.51 | 4.66 | 3.78 | 3.51 | 65.59 | 306 | 48.782 | -97.7546 |
| ND11 | 1984 | 1.77 | 4.34 | 2.36 | 4.99 | 37.31 | 578 | 47.1247 | -99.2381 |
| ND11 | 1985 | 1.59 | 3.25 | 1.97 | 3.41 | 31.15 | 578 | 47.1247 | -99.2381 |
| ND11 | 1986 | 1.77 | 4.77 | 2.45 | 4.93 | 52.37 | 578 | 47.1247 | -99.2381 |
| ND11 | 1987 | 1.9 | 4.61 | 2.52 | 3.32 | 37.89 | 578 | 47.1247 | -99.2381 |
| ND11 | 1988 | 1.34 | 4.26 | 2.01 | 3.59 | 24.33 | 578 | 47.1247 | -99.2381 |
| ND11 | 1989 | 2.17 | 4.42 | 2.69 | 3.72 | 37.21 | 578 | 47.1247 | -99.2381 |
| ND11 | 1990 | 1.81 | 3.63 | 2.23 | 2.73 | 32.23 | 578 | 47.1247 | -99.2381 |
| ND11 | 1991 | 1.91 | 3.39 | 2.25 | 2.7 | 35.38 | 578 | 47.1247 | -99.2381 |
| ND11 | 1992 | 1.68 | 3.13 | 2.02 | 3.03 | 31.26 | 578 | 47.1247 | -99.2381 |
| ND11 | 1993 | 2.54 | 5.5 | 3.22 | 4.05 | 65.08 | 578 | 47.1247 | -99.2381 |
| ND11 | 1994 | 2.95 | 5.79 | 3.6 | 4.61 | 52.3 | 578 | 47.1247 | -99.2381 |
| ND11 | 1995 | 2.05 | 4.22 | 2.54 | 3.29 | 49.89 | 578 | 47.1247 | -99.2381 |
| ND11 | 1996 | 2.09 | 4.67 | 2.68 | 3.25 | 37.12 | 578 | 47.1247 | -99.2381 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| ND11 | 1997 | 2.86 | 5.08 | 3.37 | 3.8 | 47.99 | 578 | 47.1247 | -99.2381 |
| ND11 | 1998 | 2.35 | 5.24 | 3.01 | 3.61 | 43.93 | 578 | 47.1247 | -99.2381 |
| ND11 | 1999 | 2.85 | 5.61 | 3.49 | 3.77 | 52.75 | 578 | 47.1247 | -99.2381 |
| ND11 | 2000 | 3.45 | 6.82 | 4.22 | 4.98 | 61.26 | 578 | 47.1247 | -99.2381 |
| ND11 | 2001 | 2.75 | 5.3 | 3.34 | 3.24 | 48.22 | 578 | 47.1247 | -99.2381 |
| ND11 | 2002 | 1.98 | 3.82 | 2.4 | 2.14 | 26.31 | 578 | 47.1247 | -99.2381 |
| ND11 | 2003 | 2.41 | 3.93 | 2.76 | 2.99 | 34.78 | 578 | 47.1247 | -99.2381 |
| ND11 | 2004 | 3.52 | 5.58 | 4 | 3.84 | 58.13 | 578 | 47.1247 | -99.2381 |
| ND11 | 2005 | 2.36 | 3.77 | 2.68 | 2.59 | 39.73 | 578 | 47.1247 | -99.2381 |
| ND11 | 2006 | 2.66 | 4.13 | 3 | 2.51 | 39.03 | 578 | 47.1247 | -99.2381 |
| ND11 | 2007 | 3.31 | 4.71 | 3.64 | 3.16 | 49.76 | 578 | 47.1247 | -99.2381 |
| ND11 | 2008 | 2.39 | 3.53 | 2.65 | 3.09 | 44.89 | 578 | 47.1247 | -99.2381 |
| ND11 | 2009 | 2.04 | 3.2 | 2.31 | 2.1 | 36.99 | 578 | 47.1247 | -99.2381 |
| ND11 | 2010 | 2.31 | 3.69 | 2.63 | 2.34 | 42.69 | 578 | 47.1247 | -99.2381 |
| WI09 | 1987 | 2.31 | 8.62 | 3.74 | 11.09 | 56.99 | 421 | 45.7964 | -88.3994 |
| WI09 | 1988 | 2.58 | 11.37 | 4.58 | 13.33 | 66.27 | 421 | 45.7964 | -88.3994 |
| WI09 | 1989 | 1.69 | 5.95 | 2.66 | 6.53 | 42.34 | 421 | 45.7964 | -88.3994 |
| WI09 | 1990 | 3.26 | 9.33 | 4.64 | 10.56 | 72.01 | 421 | 45.7964 | -88.3994 |
| WI09 | 1991 | 3.01 | 10.55 | 4.72 | 12.05 | 86.96 | 421 | 45.7964 | -88.3994 |
| WI09 | 1992 | 2.18 | 8.97 | 3.72 | 10.54 | 66.27 | 421 | 45.7964 | -88.3994 |
| WI09 | 1993 | 1.89 | 8.06 | 3.29 | 8.08 | 67.26 | 421 | 45.7964 | -88.3994 |
| WI09 | 1994 | 2.52 | 8.02 | 3.77 | 7.78 | 69.13 | 421 | 45.7964 | -88.3994 |
| WI09 | 1995 | 2.65 | 9.38 | 4.18 | 8.46 | 78.06 | 421 | 45.7964 | -88.3994 |
| WI09 | 1996 | 2.49 | 9.58 | 4.1 | 7.61 | 70.48 | 421 | 45.7964 | -88.3994 |
| WI09 | 1997 | 2.27 | 7.36 | 3.43 | 7.26 | 56.69 | 421 | 45.7964 | -88.3994 |
| WI09 | 1998 | 2.33 | 8.01 | 3.62 | 6.82 | 53.42 | 421 | 45.7964 | -88.3994 |
| WI09 | 1999 | 2.54 | 9.12 | 4.04 | 7.64 | 71.05 | 421 | 45.7964 | -88.3994 |
| WI09 | 2000 | 3.37 | 10.5 | 4.99 | 8.54 | 77.75 | 421 | 45.7964 | -88.3994 |
| WI09 | 2001 | 2.76 | 9.17 | 4.22 | 8.42 | 70.98 | 421 | 45.7964 | -88.3994 |
| WI09 | 2002 | 4.45 | 12.05 | 6.18 | 9.29 | 84.53 | 421 | 45.7964 | -88.3994 |
| WI09 | 2003 | 2.66 | 7.74 | 3.82 | 6.72 | 59.01 | 421 | 45.7964 | -88.3994 |
| WI09 | 2004 | 2.73 | 8.04 | 3.94 | 6.47 | 71.4 | 421 | 45.7964 | -88.3994 |
| WI09 | 2005 | 2.52 | 6.43 | 3.41 | 6.17 | 64.87 | 421 | 45.7964 | -88.3994 |
| WI09 | 2006 | 2.79 | 7.46 | 3.86 | 6.36 | 71.39 | 421 | 45.7964 | -88.3994 |
| WI09 | 2007 | 2.4 | 5.77 | 3.17 | 5.39 | 57.79 | 421 | 45.7964 | -88.3994 |
| WI09 | 2008 | 2.27 | 5.78 | 3.07 | 5.08 | 57.2 | 421 | 45.7964 | -88.3994 |
| WI09 | 2010 | 2.2 | 5.5 | 2.95 | 4.97 | 85.47 | 421 | 45.7964 | -88.3994 |
| WI10 | 2005 | 1.44 | 4.04 | 2.03 | 3.55 | 42.77 | 421 | 45.7964 | -88.3994 |
| WI10 | 2006 | 2.9 | 7.79 | 4.01 | 6.51 | 72.09 | 421 | 45.7964 | -88.3994 |
| WI10 | 2007 | 2.8 | 5.91 | 3.51 | 5.59 | 70.63 | 421 | 45.7964 | -88.3994 |
| WI10 | 2008 | 2.53 | 6.82 | 3.51 | 5.99 | 68.87 | 421 | 45.7964 | -88.3994 |
| WI10 | 2009 | 2.13 | 5.39 | 2.87 | 4.45 | 72.29 | 421 | 45.7964 | -88.3994 |
| WI10 | 2010 | 2.33 | 5.89 | 3.14 | 4.88 | 92.47 | 421 | 45.7964 | -88.3994 |
| WI25 | 1986 | 2.79 | 11.57 | 4.78 | 15.25 | 74.47 | 563 | 45.5633 | -88.8082 |
| WI25 | 1987 | 2.24 | 8.84 | 3.74 | 11.24 | 61.28 | 563 | 45.5633 | -88.8082 |
| WI25 | 1988 | 1.98 | 9.99 | 3.8 | 11.41 | 63.21 | 563 | 45.5633 | -88.8082 |
| WI25 | 1989 | 3.23 | 10.48 | 4.88 | 12.14 | 56.97 | 563 | 45.5633 | -88.8082 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| WI25 | 1990 | 4.29 | 11.99 | 6.04 | 14.57 | 91.98 | 563 | 45.5633 | -88.8082 |
| WI25 | 1991 | 3.61 | 13.23 | 5.8 | 14.55 | 85.41 | 563 | 45.5633 | -88.8082 |
| WI25 | 1992 | 3.52 | 12.72 | 5.61 | 15.15 | 85.33 | 563 | 45.5633 | -88.8082 |
| WI25 | 1993 | 3.66 | 13.95 | 6 | 14.26 | 86.01 | 563 | 45.5633 | -88.8082 |
| WI25 | 1994 | 3.68 | 11.86 | 5.54 | 12.18 | 74.31 | 563 | 45.5633 | -88.8082 |
| WI25 | 1995 | 3.31 | 12.14 | 5.32 | 11.26 | 79.67 | 563 | 45.5633 | -88.8082 |
| WI25 | 1996 | 4.6 | 15.27 | 7.02 | 13.93 | 92.66 | 563 | 45.5633 | -88.8082 |
| WI25 | 1997 | 2.73 | 10.87 | 4.58 | 9.17 | 62.69 | 563 | 45.5633 | -88.8082 |
| WI25 | 1998 | 2.73 | 10.66 | 4.53 | 9.67 | 71.72 | 563 | 45.5633 | -88.8082 |
| WI25 | 1999 | 2.97 | 10.39 | 4.66 | 8.58 | 68.78 | 563 | 45.5633 | -88.8082 |
| WI25 | 2000 | 3.96 | 13.01 | 6.01 | 11.21 | 83.8 | 563 | 45.5633 | -88.8082 |
| WI25 | 2001 | 3.71 | 12.65 | 5.75 | 11.59 | 75.63 | 563 | 45.5633 | -88.8082 |
| WI25 | 2002 | 4.37 | 13.47 | 6.44 | 10.49 | 88.89 | 563 | 45.5633 | -88.8082 |
| WI25 | 2003 | 4.08 | 11.65 | 5.8 | 9.44 | 77.82 | 563 | 45.5633 | -88.8082 |
| WI25 | 2004 | 3.93 | 12.31 | 5.84 | 9.58 | 82.11 | 563 | 45.5633 | -88.8082 |
| WI25 | 2005 | 3.32 | 9.13 | 4.64 | 8.58 | 66.14 | 563 | 45.5633 | -88.8082 |
| WI25 | 2006 | 3.06 | 8.05 | 4.2 | 7.32 | 71.64 | 563 | 45.5633 | -88.8082 |
| WI25 | 2007 | 2.61 | 6.54 | 3.51 | 5.76 | 57.14 | 563 | 45.5633 | -88.8082 |
| WI25 | 2008 | 3.14 | 8.84 | 4.44 | 7.7 | 67.11 | 563 | 45.5633 | -88.8082 |
| WI25 | 2009 | 2.29 | 5.25 | 2.96 | 4.73 | 66.28 | 563 | 45.5633 | -88.8082 |
| WI25 | 2010 | 3.23 | 7.64 | 4.24 | 6.92 | 92.31 | 563 | 45.5633 | -88.8082 |
| WI28 | 1983 | 3.25 | 11.58 | 5.15 | 16.13 | 64.07 | 385 | 44.7073 | -89.7716 |
| WI28 | 1984 | 3.65 | 10.61 | 5.24 | 16.18 | 81.19 | 385 | 44.7073 | -89.7716 |
| WI28 | 1985 | 3.61 | 10.06 | 5.08 | 15.34 | 69.46 | 385 | 44.7073 | -89.7716 |
| WI28 | 1986 | 2.71 | 10.16 | 4.4 | 14.77 | 77.3 | 385 | 44.7073 | -89.7716 |
| WI28 | 1987 | 1.72 | 7.64 | 3.06 | 9.36 | 54.78 | 385 | 44.7073 | -89.7716 |
| WI28 | 1988 | 2.27 | 8.64 | 3.71 | 11.05 | 52.86 | 385 | 44.7073 | -89.7716 |
| WI28 | 1989 | 4.49 | 11.01 | 5.98 | 13.14 | 62.55 | 385 | 44.7073 | -89.7716 |
| WI28 | 1990 | 3.56 | 8.56 | 4.7 | 10.42 | 75.52 | 385 | 44.7073 | -89.7716 |
| WI28 | 1991 | 3.24 | 9.83 | 4.74 | 12.57 | 75.21 | 385 | 44.7073 | -89.7716 |
| WI28 | 1992 | 3.07 | 9.33 | 4.49 | 11.88 | 78.22 | 385 | 44.7073 | -89.7716 |
| WI28 | 1993 | 3.51 | 11.52 | 5.33 | 12.62 | 83.66 | 385 | 44.7073 | -89.7716 |
| WI28 | 1994 | 2.68 | 7.65 | 3.81 | 7.94 | 57.86 | 385 | 44.7073 | -89.7716 |
| WI28 | 1995 | 3.85 | 11.9 | 5.68 | 12.49 | 77.2 | 385 | 44.7073 | -89.7716 |
| WI28 | 1996 | 3.69 | 9.98 | 5.12 | 8.49 | 66.45 | 385 | 44.7073 | -89.7716 |
| WI28 | 1997 | 2.99 | 9.31 | 4.43 | 8.75 | 58.47 | 385 | 44.7073 | -89.7716 |
| WI28 | 1998 | 3.01 | 10.66 | 4.75 | 10.67 | 65.23 | 385 | 44.7073 | -89.7716 |
| WI28 | 1999 | 2.97 | 8.54 | 4.24 | 8.11 | 65.07 | 385 | 44.7073 | -89.7716 |
| WI28 | 2000 | 3.6 | 9.88 | 5.03 | 9.03 | 79.39 | 385 | 44.7073 | -89.7716 |
| WI28 | 2001 | 3.94 | 11.28 | 5.61 | 10.64 | 77.43 | 385 | 44.7073 | -89.7716 |
| WI28 | 2002 | 4.89 | 12.56 | 6.64 | 11.19 | 87.97 | 385 | 44.7073 | -89.7716 |
| WI28 | 2003 | 3.05 | 8.28 | 4.24 | 7 | 55.14 | 385 | 44.7073 | -89.7716 |
| WI28 | 2004 | 3.38 | 7.69 | 4.36 | 7.09 | 69.76 | 385 | 44.7073 | -89.7716 |
| WI28 | 2005 | 2.91 | 6.69 | 3.77 | 7.03 | 59.99 | 385 | 44.7073 | -89.7716 |
| WI28 | 2006 | 4.24 | 9.49 | 5.44 | 8.73 | 70.57 | 385 | 44.7073 | -89.7716 |
| WI28 | 2007 | 3.47 | 7.02 | 4.28 | 7.43 | 76.95 | 385 | 44.7073 | -89.7716 |
| WI28 | 2008 | 3.39 | 8.29 | 4.51 | 7.01 | 67.2 | 385 | 44.7073 | -89.7716 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| WI28 | 2009 | 3.27 | 6.99 | 4.12 | 6.97 | 77.96 | 385 | 44.7073 | -89.7716 |
| WI28 | 2010 | 3.63 | 7.36 | 4.49 | 6.93 | 102.57 | 385 | 44.7073 | -89.7716 |
| WI32 | 2002 | 4.58 | 13.78 | 6.67 | 11.85 | 80.42 | 319 | 44.9308 | -88.755 |
| WI32 | 2003 | 4.24 | 11.01 | 5.78 | 10.02 | 70.87 | 319 | 44.9308 | -88.755 |
| WI32 | 2004 | 3.35 | 9.64 | 4.78 | 7.95 | 68.99 | 319 | 44.9308 | -88.755 |
| WI32 | 2005 | 3.72 | 9.11 | 4.95 | 8.63 | 63.07 | 319 | 44.9308 | -88.755 |
| WI32 | 2006 | 0.3 | 1.21 | 0.5 | 0.62 | 6.12 | 319 | 44.9308 | -88.755 |
| WI35 | 1999 | 4.06 | 11.19 | 5.68 | 9.38 | 81.12 | 472 | 45.2064 | -90.5978 |
| WI35 | 2000 | 5.36 | 13.47 | 7.21 | 10.81 | 104.93 | 472 | 45.2064 | -90.5978 |
| WI35 | 2001 | 5.14 | 13.47 | 7.04 | 11.81 | 106.7 | 472 | 45.2064 | -90.5978 |
| WI35 | 2002 | 6.12 | 15.49 | 8.26 | 13.5 | 111.3 | 472 | 45.2064 | -90.5978 |
| WI35 | 2003 | 3.84 | 9.56 | 5.14 | 8.13 | 80.09 | 472 | 45.2064 | -90.5978 |
| WI35 | 2004 | 4.39 | 10.5 | 5.79 | 8.46 | 91.52 | 472 | 45.2064 | -90.5978 |
| WI35 | 2005 | 4.55 | 9.35 | 5.65 | 8.98 | 75.26 | 472 | 45.2064 | -90.5978 |
| WI35 | 2006 | 3.79 | 8.78 | 4.93 | 6.9 | 73.63 | 472 | 45.2064 | -90.5978 |
| WI35 | 2007 | 4.1 | 8.8 | 5.18 | 7.7 | 77.27 | 472 | 45.2064 | -90.5978 |
| WI35 | 2008 | 4.11 | 8.56 | 5.13 | 7.84 | 72.75 | 472 | 45.2064 | -90.5978 |
| WI35 | 2009 | 3.41 | 6.59 | 4.14 | 5.59 | 85.64 | 472 | 45.2064 | -90.5978 |
| WI35 | 2010 | 3.93 | 7.72 | 4.8 | 6.64 | 107.65 | 472 | 45.2064 | -90.5978 |
| WI36 | 1981 | 2.4 | 8.89 | 3.88 | 12.87 | 72.55 | 501 | 46.0528 | -89.6531 |
| WI36 | 1982 | 4.01 | 12.81 | 6.01 | 19.34 | 104.31 | 501 | 46.0528 | -89.6531 |
| WI36 | 1983 | 2.29 | 9.36 | 3.89 | 13.12 | 83.7 | 501 | 46.0528 | -89.6531 |
| WI36 | 1984 | 2.75 | 8.55 | 4.07 | 11.57 | 80.1 | 501 | 46.0528 | -89.6531 |
| WI36 | 1985 | 3.29 | 11.27 | 5.1 | 14.37 | 103.31 | 501 | 46.0528 | -89.6531 |
| WI36 | 1986 | 1.45 | 7.61 | 2.85 | 9.72 | 75.43 | 501 | 46.0528 | -89.6531 |
| WI36 | 1987 | 1.96 | 8.76 | 3.5 | 10.82 | 68.2 | 501 | 46.0528 | -89.6531 |
| WI36 | 1988 | 1.73 | 9.25 | 3.44 | 10.01 | 73.83 | 501 | 46.0528 | -89.6531 |
| WI36 | 1989 | 2.46 | 7.61 | 3.63 | 8.3 | 58.52 | 501 | 46.0528 | -89.6531 |
| WI36 | 1990 | 3.57 | 9.8 | 4.99 | 11.32 | 92.26 | 501 | 46.0528 | -89.6531 |
| WI36 | 1991 | 3.21 | 10.43 | 4.85 | 11.41 | 95.84 | 501 | 46.0528 | -89.6531 |
| WI36 | 1992 | 2.53 | 9.31 | 4.07 | 12.23 | 71.87 | 501 | 46.0528 | -89.6531 |
| WI36 | 1993 | 1.67 | 6.86 | 2.85 | 5.99 | 71.33 | 501 | 46.0528 | -89.6531 |
| WI36 | 1994 | 2.78 | 8.63 | 4.11 | 8.18 | 70.78 | 501 | 46.0528 | -89.6531 |
| WI36 | 1995 | 2.17 | 8.91 | 3.7 | 7.21 | 81.62 | 501 | 46.0528 | -89.6531 |
| WI36 | 1996 | 3.61 | 11.9 | 5.5 | 10.17 | 93.81 | 501 | 46.0528 | -89.6531 |
| WI36 | 1997 | 2.22 | 7.86 | 3.5 | 6.07 | 75.03 | 501 | 46.0528 | -89.6531 |
| WI36 | 1998 | 2.34 | 7.96 | 3.62 | 6.28 | 65.68 | 501 | 46.0528 | -89.6531 |
| WI36 | 1999 | 2.54 | 8.96 | 4 | 7.17 | 83.7 | 501 | 46.0528 | -89.6531 |
| WI36 | 2000 | 3.23 | 9.25 | 4.6 | 6.79 | 78.9 | 501 | 46.0528 | -89.6531 |
| WI36 | 2001 | 2.96 | 8.97 | 4.33 | 6.96 | 81.69 | 501 | 46.0528 | -89.6531 |
| WI36 | 2002 | 4.63 | 12.42 | 6.41 | 9.23 | 97.52 | 501 | 46.0528 | -89.6531 |
| WI36 | 2003 | 2.16 | 6.97 | 3.26 | 5.25 | 65.36 | 501 | 46.0528 | -89.6531 |
| WI36 | 2004 | 2.89 | 6.72 | 3.77 | 5.61 | 74.2 | 501 | 46.0528 | -89.6531 |
| WI36 | 2005 | 2.65 | 6.38 | 3.5 | 6.03 | 77.06 | 501 | 46.0528 | -89.6531 |
| WI36 | 2006 | 2.8 | 6.41 | 3.62 | 4.85 | 67.2 | 501 | 46.0528 | -89.6531 |
| WI36 | 2007 | 2.28 | 4.83 | 2.87 | 4.73 | 62.69 | 501 | 46.0528 | -89.6531 |
| WI36 | 2008 | 1.94 | 5.14 | 2.67 | 4.47 | 62.07 | 501 | 46.0528 | -89.6531 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| WI36 | 2009 | 1.94 | 4.45 | 2.52 | 3.84 | 56.77 | 501 | 46.0528 | -89.6531 |
| WI36 | 2010 | 3.13 | 6.35 | 3.87 | 4.79 | 97.09 | 501 | 46.0528 | -89.6531 |
| WI37 | 1981 | 5.35 | 12.4 | 6.96 | 19.82 | 86.95 | 331 | 45.8228 | -91.8744 |
| WI37 | 1982 | 3.65 | 9.42 | 4.97 | 13.02 | 84 | 331 | 45.8228 | -91.8744 |
| WI37 | 1983 | 3.56 | 12.21 | 5.53 | 14.31 | 91.29 | 331 | 45.8228 | -91.8744 |
| WI37 | 1984 | 3.33 | 9.2 | 4.67 | 11.71 | 80.06 | 331 | 45.8228 | -91.8744 |
| WI37 | 1985 | 3.31 | 10.07 | 4.85 | 12.66 | 86.59 | 331 | 45.8228 | -91.8744 |
| WI37 | 1986 | 3.17 | 8.83 | 4.46 | 11.35 | 79.02 | 331 | 45.8228 | -91.8744 |
| WI37 | 1987 | 2.77 | 7.68 | 3.89 | 8.11 | 62.62 | 331 | 45.8228 | -91.8744 |
| WI37 | 1988 | 1.63 | 7.61 | 2.98 | 7.88 | 54.2 | 331 | 45.8228 | -91.8744 |
| WI37 | 1989 | 3.25 | 7.95 | 4.33 | 9.06 | 59.83 | 331 | 45.8228 | -91.8744 |
| WI37 | 1990 | 4.36 | 9.67 | 5.58 | 9.84 | 77.51 | 331 | 45.8228 | -91.8744 |
| WI37 | 1991 | 5.32 | 12.78 | 7.02 | 14.49 | 111.22 | 331 | 45.8228 | -91.8744 |
| WI37 | 1992 | 3.05 | 8.55 | 4.31 | 10.94 | 67.25 | 331 | 45.8228 | -91.8744 |
| WI37 | 1993 | 3.42 | 9.28 | 4.75 | 8.33 | 74 | 331 | 45.8228 | -91.8744 |
| WI37 | 1994 | 3.52 | 8.77 | 4.72 | 7.47 | 70.99 | 331 | 45.8228 | -91.8744 |
| WI37 | 1995 | 3.64 | 8.67 | 4.79 | 7.89 | 83.55 | 331 | 45.8228 | -91.8744 |
| WI37 | 1996 | 3.14 | 9.17 | 4.51 | 7.52 | 75.39 | 331 | 45.8228 | -91.8744 |
| WI37 | 1997 | 2.16 | 5.96 | 3.02 | 4.67 | 59.94 | 331 | 45.8228 | -91.8744 |
| WI37 | 1998 | 3.84 | 8.74 | 4.96 | 7.69 | 64.92 | 331 | 45.8228 | -91.8744 |
| WI37 | 1999 | 4.06 | 10.61 | 5.55 | 8.2 | 80.05 | 331 | 45.8228 | -91.8744 |
| WI37 | 2000 | 4.6 | 11.47 | 6.17 | 8.26 | 85.94 | 331 | 45.8228 | -91.8744 |
| WI37 | 2001 | 4.56 | 10.81 | 5.99 | 8.99 | 91.43 | 331 | 45.8228 | -91.8744 |
| WI37 | 2002 | 5.66 | 13.2 | 7.38 | 10.5 | 96.42 | 331 | 45.8228 | -91.8744 |
| WI37 | 2003 | 2.43 | 6.25 | 3.3 | 5.25 | 63.15 | 331 | 45.8228 | -91.8744 |
| WI37 | 2004 | 4.01 | 9.21 | 5.2 | 6.77 | 81.61 | 331 | 45.8228 | -91.8744 |
| WI37 | 2005 | 3.37 | 7.6 | 4.33 | 6.79 | 75.46 | 331 | 45.8228 | -91.8744 |
| WI37 | 2006 | 2.79 | 7.19 | 3.79 | 5.1 | 48.72 | 331 | 45.8228 | -91.8744 |
| WI37 | 2007 | 2.49 | 5.41 | 3.16 | 4.63 | 66.01 | 331 | 45.8228 | -91.8744 |
| WI37 | 2008 | 2.95 | 6.08 | 3.67 | 5.58 | 56.49 | 331 | 45.8228 | -91.8744 |
| WI37 | 2009 | 1.63 | 3.17 | 1.98 | 2.6 | 52.41 | 331 | 45.8228 | -91.8744 |
| WI37 | 2010 | 3.11 | 6.23 | 3.83 | 4.23 | 79 | 331 | 45.8228 | -91.8744 |
| WI97 | 2001 | 0.02 | 0.18 | 0.06 | 0 | 2.57 | 418 | 45.9944 | -91.3711 |
| WI97 | 2002 | 4.94 | 12.65 | 6.7 | 9.68 | 81.8 | 418 | 45.9944 | -91.3711 |
| WI97 | 2003 | 2.28 | 5.99 | 3.13 | 4.67 | 57.22 | 418 | 45.9944 | -91.3711 |
| WI97 | 2004 | 4.18 | 7.87 | 5.03 | 7.08 | 78.42 | 418 | 45.9944 | -91.3711 |
| WI97 | 2005 | 0.18 | 0.7 | 0.3 | 0.43 | 4.8 | 418 | 45.9944 | -91.3711 |
| WI98 | 1990 | 4.34 | 10.89 | 5.84 | 13.07 | 93.57 | 386 | 43.7023 | -90.5685 |
| WI98 | 1991 | 4.22 | 12.77 | 6.16 | 14.34 | 90.54 | 386 | 43.7023 | -90.5685 |
| WI98 | 1992 | 4.05 | 11.71 | 5.8 | 13.52 | 83.39 | 386 | 43.7023 | -90.5685 |
| WI98 | 1993 | 4.55 | 15.07 | 6.94 | 16.3 | 95.29 | 386 | 43.7023 | -90.5685 |
| WI98 | 1994 | 4.19 | 12.26 | 6.03 | 12.53 | 84.47 | 386 | 43.7023 | -90.5685 |
| WI98 | 1995 | 4.26 | 12.49 | 6.14 | 11.29 | 73.16 | 386 | 43.7023 | -90.5685 |
| WI98 | 1996 | 3.05 | 9.55 | 4.53 | 8.9 | 68.53 | 386 | 43.7023 | -90.5685 |
| WI98 | 1997 | 3.44 | 10.77 | 5.1 | 9.72 | 68.62 | 386 | 43.7023 | -90.5685 |
| WI98 | 1998 | 3.43 | 11.69 | 5.3 | 11.04 | 85.85 | 386 | 43.7023 | -90.5685 |
| WI98 | 1999 | 3.33 | 9.81 | 4.81 | 8.99 | 78.74 | 386 | 43.7023 | -90.5685 |

| ID | Year | NH4 | NO3 | inorgn | SO4 | cm | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| WI98 | 2000 | 4.53 | 12.38 | 6.32 | 10.5 | 80.07 | 386 | 43.7023 | -90.5685 |
| WI98 | 2001 | 5.32 | 13.68 | 7.23 | 13.22 | 100.28 | 386 | 43.7023 | -90.5685 |
| WI98 | 2002 | 4.79 | 13.33 | 6.73 | 11.43 | 81.25 | 386 | 43.7023 | -90.5685 |
| WI98 | 2003 | 3.99 | 9.32 | 5.21 | 8.07 | 65.32 | 386 | 43.7023 | -90.5685 |
| WI98 | 2004 | 4.37 | 10.1 | 5.68 | 8.94 | 90.82 | 386 | 43.7023 | -90.5685 |
| WI98 | 2005 | 3.57 | 8.16 | 4.62 | 8.27 | 67.45 | 386 | 43.7023 | -90.5685 |
| WI98 | 2006 | 4.01 | 8.89 | 5.13 | 9.47 | 79.27 | 386 | 43.7023 | -90.5685 |
| WI98 | 2007 | 4.28 | 9.8 | 5.54 | 9.11 | 115.67 | 386 | 43.7023 | -90.5685 |
| WI98 | 2008 | 4.28 | 10.46 | 5.69 | 9.2 | 107.2 | 386 | 43.7023 | -90.5685 |
| WI98 | 2009 | 3.95 | 7.56 | 4.78 | 6.73 | 80.92 | 386 | 43.7023 | -90.5685 |
| WI98 | 2010 | 4.33 | 9.03 | 5.41 | 7.34 | 119.74 | 386 | 43.7023 | -90.5685 |
| WI99 | 1985 | 3.02 | 13.59 | 5.42 | 19.68 | 90.01 | 288 | 42.5792 | -88.5006 |
| WI99 | 1986 | 3.55 | 13.37 | 5.78 | 21.37 | 83.43 | 288 | 42.5792 | -88.5006 |
| WI99 | 1987 | 4.01 | 15.51 | 6.62 | 21.47 | 80.01 | 288 | 42.5792 | -88.5006 |
| WI99 | 1988 | 2.62 | 10.58 | 4.43 | 15.33 | 69.72 | 288 | 42.5792 | -88.5006 |
| WI99 | 1989 | 3.82 | 12.05 | 5.69 | 17.22 | 67.94 | 288 | 42.5792 | -88.5006 |
| WI99 | 1990 | 3.57 | 13.3 | 5.78 | 18.09 | 96.84 | 288 | 42.5792 | -88.5006 |
| WI99 | 1991 | 4.01 | 13.38 | 6.14 | 18.71 | 90.01 | 288 | 42.5792 | -88.5006 |
| WI99 | 1992 | 2.98 | 12.02 | 5.03 | 15.44 | 80.14 | 288 | 42.5792 | -88.5006 |
| WI99 | 1993 | 4.33 | 17.35 | 7.28 | 20.58 | 100.61 | 288 | 42.5792 | -88.5006 |
| WI99 | 1994 | 3.04 | 11.08 | 4.87 | 12.2 | 62.83 | 288 | 42.5792 | -88.5006 |
| WI99 | 1995 | 4.11 | 15.04 | 6.6 | 16.45 | 89.6 | 288 | 42.5792 | -88.5006 |
| WI99 | 1996 | 3.48 | 12.65 | 5.56 | 13.64 | 74.92 | 288 | 42.5792 | -88.5006 |
| WI99 | 1997 | 3.68 | 12.61 | 5.71 | 12.62 | 75.2 | 288 | 42.5792 | -88.5006 |
| WI99 | 1998 | 4.59 | 16.22 | 7.24 | 17.71 | 93.55 | 288 | 42.5792 | -88.5006 |
| WI99 | 1999 | 3.17 | 14.64 | 5.77 | 15.39 | 89.57 | 288 | 42.5792 | -88.5006 |
| WI99 | 2000 | 4.13 | 16.14 | 6.85 | 14.76 | 110.01 | 288 | 42.5792 | -88.5006 |
| WI99 | 2001 | 4.77 | 15.2 | 7.14 | 15.6 | 99.9 | 288 | 42.5792 | -88.5006 |
| WI99 | 2002 | 3.85 | 12.19 | 5.75 | 11.91 | 78.02 | 288 | 42.5792 | -88.5006 |
| WI99 | 2003 | 3.85 | 10.57 | 5.38 | 11.4 | 72.13 | 288 | 42.5792 | -88.5006 |
| WI99 | 2004 | 3.43 | 9.29 | 4.76 | 9.21 | 77.4 | 288 | 42.5792 | -88.5006 |
| WI99 | 2005 | 3.85 | 11.43 | 5.57 | 12.11 | 71.11 | 288 | 42.5792 | -88.5006 |
| WI99 | 2006 | 4.93 | 13.22 | 6.82 | 14.53 | 94.76 | 288 | 42.5792 | -88.5006 |
| WI99 | 2007 | 5.53 | 12.56 | 7.14 | 12.92 | 106.83 | 288 | 42.5792 | -88.5006 |
| WI99 | 2008 | 4.54 | 11.67 | 6.16 | 12.42 | 114.53 | 288 | 42.5792 | -88.5006 |
| WI99 | 2009 | 4.17 | 10.08 | 5.52 | 10.43 | 102.78 | 288 | 42.5792 | -88.5006 |
| WI99 | 2010 | 4.16 | 9.78 | 5.45 | 9.07 | 85.48 | 288 | 42.5792 | -88.5006 |

# Appendix A2

## Minnesota Acidic Deposition Monitoring Sites and Data

**Minnesota acidic deposition monitoring sites and data from initiation of site through 2010. Data from NADP (at http://nadp.sws.uiuc.edu/, accessed September 2011)**

| code | name | year | NO3dep | depoN | depso4 | pcp | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN08 | HOV | 1991 | 8.79 | 4.30 | 12.43 | 81.8 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1992 | 9.23 | 4.57 | 13.26 | 69.7 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1993 | 6.39 | 3.11 | 7.51 | 62.4 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1994 | 9.20 | 4.71 | 8.25 | 63.1 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1995 | 8.42 | 4.07 | 7.23 | 75.3 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1996 | 12.50 | 5.66 | 10.36 | 94.0 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1997 | 8.40 | 3.74 | 5.90 | 53.7 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1998 | 10.52 | 4.83 | 10.20 | 76.1 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 1999 | 9.56 | 4.62 | 8.37 | 64.2 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2000 | 9.77 | 4.64 | 8.43 | 60.9 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2001 | 9.70 | 4.64 | 8.22 | 86.6 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2002 | 5.92 | 3.01 | 4.20 | 51.0 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2003 | 5.98 | 3.03 | 5.57 | 50.6 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2004 | 7.47 | 3.75 | 6.70 | 65.5 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2005 | 8.36 | 4.44 | 8.00 | 76.9 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2006 | 7.03 | 3.16 | 5.74 | 51.7 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2007 | 6.40 | 3.67 | 6.23 | 69.0 | 47.847 | -89.963 | 224 |
| MN08 | HOV | 2008 | 8.33 | 4.52 | 9.14 | 76.45 | 47.8472 | -89.9625 | 224 |
| MN08 | HOV | 2009 | 4.64 | 2.77 | 4.52 | 57.67 | 47.8472 | -89.9625 | 224 |
| MN08 | HOV | 2010 | 4.59 | 2.4 | 3.73 | 59.71 | 47.8472 | -89.9625 | 224 |
| MN16 | MAR | 1979 | 11.88 | 5.45 | 15.28 | 77.5 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1980 | 8.31 | 3.69 | 8.66 | 64.9 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1981 | 8.49 | 3.95 | 10.24 | 77.7 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1982 | 7.81 | 3.74 | 10.42 | 81.7 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1983 | 8.19 | 3.95 | 9.48 | 70.0 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1984 | 7.81 | 3.96 | 9.94 | 75.4 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1985 | 7.70 | 3.58 | 9.43 | 91.9 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1986 | 7.84 | 3.78 | 8.86 | 76.8 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1987 | 8.02 | 3.88 | 8.67 | 78.5 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1988 | 9.05 | 3.54 | 8.26 | 92.7 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1989 | 8.81 | 4.84 | 9.05 | 76.2 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1990 | 6.38 | 3.11 | 5.50 | 56.2 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1991 | 6.98 | 3.16 | 6.96 | 69.4 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1992 | 8.05 | 3.98 | 8.05 | 82.9 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1993 | 7.26 | 3.31 | 6.44 | 73.6 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1994 | 9.20 | 4.71 | 6.71 | 83.9 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1995 | 7.66 | 3.61 | 5.78 | 89.3 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1996 | 8.01 | 3.29 | 5.60 | 78.8 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1997 | 6.81 | 2.88 | 4.49 | 74.9 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1998 | 7.93 | 4.20 | 6.72 | 79.7 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 1999 | 9.82 | 5.05 | 7.74 | 90.7 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2000 | 8.10 | 3.98 | 5.76 | 73.3 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2001 | 6.73 | 3.22 | 4.77 | 81.4 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2002 | 7.90 | 4.46 | 5.91 | 73.1 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2003 | 6.16 | 3.42 | 4.52 | 62.5 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2004 | 7.30 | 4.18 | 5.89 | 76.5 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2005 | 7.21 | 3.89 | 5.87 | 72.6 | 47.531 | -93.469 | 431 |

| code | name | year | NO3dep | depoN | depso4 | pcp | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN16 | MAR | 2006 | 5.85 | 3.27 | 4.59 | 55.0 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2007 | 6.62 | 4.15 | 5.54 | 72.1 | 47.531 | -93.469 | 431 |
| MN16 | MAR | 2008 | 6.28 | 3.85 | 5.29 | 70.76 | 47.5311 | -93.4686 | 431 |
| MN16 | MAR | 2009 | 4.59 | 2.76 | 3.81 | 64.74 | 47.5311 | -93.4686 | 431 |
| MN16 | MAR | 2010 | 5.01 | 2.98 | 3.68 | 78.85 | 47.5311 | -93.4686 | 431 |
| MN18 | FER | 1981 | 7.16 | 3.39 | 10.38 | 67.0 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1982 | 6.71 | 3.15 | 10.20 | 78.8 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1983 | 7.09 | 3.20 | 8.38 | 88.8 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1984 | 5.48 | 2.44 | 6.80 | 56.9 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1985 | 6.46 | 2.82 | 8.19 | 74.4 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1986 | 5.84 | 2.24 | 6.72 | 66.8 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1987 | 5.91 | 2.99 | 6.20 | 62.3 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1988 | 8.76 | 2.98 | 7.75 | 85.6 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1989 | 5.11 | 2.47 | 4.99 | 52.5 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1990 | 5.82 | 2.85 | 5.63 | 65.5 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1991 | 6.22 | 2.70 | 5.93 | 68.0 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1992 | 5.13 | 2.25 | 5.93 | 61.6 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1993 | 5.89 | 2.57 | 5.57 | 69.3 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1994 | 6.81 | 3.54 | 5.55 | 69.2 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1995 | 4.36 | 2.02 | 3.47 | 57.3 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1996 | 7.02 | 3.25 | 5.00 | 71.3 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1997 | 3.69 | 1.55 | 2.74 | 42.7 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1998 | 7.53 | 3.77 | 6.25 | 62.4 | 47.946 | -91.496 | 524 |
| MN18 | FER | 1999 | 8.31 | 4.29 | 6.93 | 76.2 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2000 | 6.27 | 2.95 | 5.05 | 64.6 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2001 | 7.56 | 3.70 | 5.55 | 75.9 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2002 | 5.71 | 2.88 | 4.03 | 56.1 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2003 | 5.60 | 3.03 | 5.58 | 58.6 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2004 | 5.65 | 3.20 | 4.32 | 68.8 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2005 | 6.54 | 3.45 | 5.41 | 72.4 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2006 | 4.39 | 2.43 | 3.47 | 53.0 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2007 | 6.12 | 3.60 | 5.26 | 76.8 | 47.946 | -91.496 | 524 |
| MN18 | FER | 2008 | 6.06 | 3.51 | 5.55 | 79.68 | 47.9464 | -91.4961 | 524 |
| MN18 | FER | 2009 | 3.85 | 2.23 | 3.36 | 59.23 | 47.9464 | -91.4961 | 524 |
| MN18 | FER | 2010 | 3.02 | 1.53 | 2.05 | 51.04 | 47.9464 | -91.4961 | 524 |
| MN28 | GRI | 1984 | 9.34 | 5.53 | 14.01 | 86.6 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1985 | 7.83 | 4.34 | 9.86 | 76.1 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1986 | 9.41 | 5.29 | 11.88 | 83.0 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1987 | 6.65 | 3.89 | 7.54 | 48.0 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1988 | 11.50 | 6.70 | 10.24 | 62.3 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1989 | 6.27 | 3.29 | 7.31 | 53.6 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1990 | 9.34 | 4.69 | 11.31 | 79.3 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1991 | 10.61 | 5.81 | 11.16 | 94.0 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1992 | 8.72 | 4.62 | 9.61 | 66.9 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1993 | 8.38 | 4.51 | 8.47 | 65.6 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1994 | 10.33 | 5.73 | 8.86 | 77.8 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1995 | 10.94 | 5.36 | 8.66 | 92.2 | 46.121 | -93.004 | 337 |

| code | name | year | NO3dep | depoN | depso4 | pcp | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN28 | GRI | 1996 | 10.97 | 5.72 | 8.50 | 90.1 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1997 | 7.26 | 3.78 | 5.99 | 61.9 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1998 | 8.82 | 4.42 | 7.34 | 66.0 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 1999 | 12.12 | 6.39 | 10.10 | 83.0 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2000 | 8.80 | 4.68 | 6.91 | 67.7 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2001 | 8.94 | 4.88 | 6.72 | 77.1 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2002 | 13.56 | 7.82 | 10.09 | 92.9 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2003 | 7.92 | 4.57 | 7.30 | 77.9 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2004 | 7.21 | 3.97 | 5.44 | 71.0 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2005 | 9.30 | 5.32 | 8.51 | 79.2 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2006 | 6.72 | 4.01 | 5.36 | 51.2 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2007 | 7.35 | 4.42 | 6.77 | 74.5 | 46.121 | -93.004 | 337 |
| MN28 | GRI | 2008 | 6.64 | 4.1 | 6.18 | 78.38 | 46.1208 | -93.0042 | 337 |
| MN28 | GRI | 2009 | 5.63 | 3.67 | 4.66 | 69.63 | 46.1208 | -93.0042 | 337 |
| MN28 | GRI | 2010 | 6.64 | 4.35 | 4.58 | 85.8 | 46.1208 | -93.0042 | 337 |
| MN32 | VOY | 1984 | 5.46 | 2.22 | 6.62 | 65.8 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1985 | 7.60 | 3.64 | 8.24 | 84.5 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1986 | 4.31 | 2.37 | 4.93 | 48.8 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1987 | 5.84 | 3.53 | 6.83 | 67.8 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1988 | 9.35 | 5.79 | 7.88 | 78.2 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1989 | 4.99 | 2.37 | 5.33 | 59.3 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1990 | 5.06 | 2.10 | 4.58 | 60.8 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1991 | 6.40 | 3.03 | 5.93 | 70.9 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1992 | 6.74 | 3.45 | 7.43 | 60.4 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1993 | 4.94 | 2.51 | 4.87 | 61.3 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1994 | 7.08 | 3.77 | 5.25 | 70.5 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1995 | 5.95 | 2.65 | 4.84 | 95.3 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 1996 | 8.38 | 4.19 | 5.44 | 85.2 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2000 | 4.02 | 1.73 | 2.75 | 48.1 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2001 | 8.48 | 4.09 | 5.46 | 92.9 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2002 | 8.50 | 4.40 | 5.56 | 70.6 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2003 | 5.42 | 2.53 | 3.18 | 52.3 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2004 | 6.98 | 3.75 | 5.54 | 78.6 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2005 | 6.81 | 3.73 | 5.30 | 79.1 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2006 | 5.33 | 3.05 | 4.09 | 55.5 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2007 | 5.32 | 3.04 | 4.18 | 63.6 | 48.413 | -92.829 | 429 |
| MN32 | VOY | 2008 | 5.47 | 3.11 | 4.7 | 78.73 | 48.4128 | -92.8292 | 429 |
| MN32 | VOY | 2009 | 5.47 | 3.11 | 4.01 | 85.42 | 48.4128 | -92.8292 | 429 |
| MN32 | VOY | 2010 | 4.84 | 3.05 | 3.63 | 88.58 | 48.4128 | -92.8292 | 429 |
| MN99 | WOL | 1989 | 6.96 | 3.40 | 10.49 | 77.2 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1990 | 9.89 | 4.68 | 14.03 | 80.3 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1991 | 9.68 | 4.97 | 16.11 | 90.7 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1992 | 10.11 | 4.92 | 15.21 | 79.0 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1993 | 9.65 | 4.61 | 11.30 | 76.9 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1994 | 11.21 | 5.99 | 10.10 | 73.5 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1995 | 13.03 | 6.31 | 11.82 | 93.0 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1996 | 15.67 | 7.15 | 11.51 | 89.3 | 47.388 | -91.196 | 351 |

| code | name | year | NO3dep | depoN | depso4 | pcp | lat | long | elev |
|---|---|---|---|---|---|---|---|---|---|
| MN99 | WOL | 1997 | 7.11 | 3.17 | 5.90 | 59.5 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1998 | 11.98 | 5.35 | 11.06 | 93.2 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 1999 | 10.32 | 4.92 | 8.94 | 77.7 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2000 | 9.55 | 4.49 | 8.36 | 68.9 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2001 | 10.84 | 5.17 | 9.10 | 94.3 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2002 | 5.75 | 2.68 | 4.19 | 55.2 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2003 | 6.32 | 3.25 | 5.93 | 58.9 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2004 | 9.51 | 4.71 | 8.79 | 73.9 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2005 | 8.59 | 4.70 | 8.28 | 85.0 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2006 | 8.37 | 4.36 | 7.72 | 75.5 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2007 | 6.95 | 4.17 | 7.17 | 85.0 | 47.388 | -91.196 | 351 |
| MN99 | WOL | 2008 | 7 | 3.91 | 7.68 | 73.73 | 47.3875 | -91.1958 | 351 |
| MN99 | WOL | 2009 | 5.98 | 3.4 | 5.81 | 74.23 | 47.3875 | -91.1958 | 351 |
| MN99 | WOL | 2010 | 5.73 | 2.89 | 5.02 | 79.76 | 47.3875 | -91.1958 | 351 |

**Attachment P**

**Supplemental Air Emissions Risk Analysis (AERA ) - Plant Site**




# NorthMet Project

# Supplemental Air Emissions Risk Analysis (AERA) – Plant Site

**Version 3**

**Issue Date: March 25, 2013**

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## 1.0 Executive Summary

An initial Plant Site Air Emissions Risk Analysis (AERA) Report was submitted to the Minnesota Pollution Control Agency (MPCA) in May 2005 for the NorthMet Project (Project) in support of the Scoping Environmental Assessment Worksheet (EAW) (Reference (1)). A second AERA for the Plant Site was submitted in March 2007 for the updated Project description to support the draft Environmental Impact Statement (DEIS) (Reference (2)). Because of proposed Project changes, Poly Met Mining Inc. (Poly Met) was requested to provide this supplemental AERA to reflect the proposed changes to support preparation of the Supplemental Draft Environmental Impact Statement (SDEIS). This supplemental AERA evaluated the current Project and the associated changes in estimated emissions. This screening human health risk analysis followed the MPCA-accepted August 2011 Work Plan. This analysis was conducted similar to the 2007 Plant Site AERA with some exceptions (Section 5.5).

This document is being provided as a stand-alone document for review and will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Air Data Package will be resolved in favor of this document.

### 1.1 Chemicals for Evaluation (CFE)

Following the methodology described in the August 2011 Work Plan, ten chemicals were identified for quantitative evaluation (CFE). The CFE for this Supplemental AERA are as follows: acetaldehyde, arsenic compounds*, cobalt compounds, crystalline silica, diesel particulate, hydrochloric acid (HCl), manganese compounds, nickel compounds*, nitrogen oxides ($NO_x$)*, and dioxins/furans (2,3,7,8-TCDD toxicity equivalent basis, TEQ). Sulfuric acid was added to the list of CFE following additional review of the chemicals evaluated in the 2007 AERA and was assessed semi-quantitatively in this AERA.

These CFEs include three risk driver chemicals from the 2007 AERA (asterisked above), specific chemicals from the 2007 AERA that now have toxicity values and were not previously evaluated (acetaldehyde, cobalt compounds, crystalline silica, diesel particulate), and chemicals that were included because of an increase in emissions (hydrochloric acid, manganese). In addition, emissions of dioxins/furans from mobile diesel combustion were added to the emission inventory for the Plant Site and included as a CFE. Further information on risk driver chemicals and the selection of CFE is in Section 4.0.

### 1.2 Exposure Assessment

Exposure assumptions for assessing chronic risks in the 2012 Supplemental AERA are similar to those used for the 2007 AERA. The annual (chronic) exposure and health risk estimates are based on a receptor's assumed exposure to the maximum modeled air concentration from Plant Site operations (same methodology as in the 2007 AERA). Use of a maximum air concentration is identified by U.S. Environmental Protection Agency (USEPA) (Reference (3)) as a component of assessing the Maximum Exposed Individual (MEI). Assessing potential health risks to an MEI can be part of calculating a Theoretical Upper Bounding Estimate (TUBE). The TUBE "…can

be easily calculated and designed to estimate exposure, dose and risk levels that are expected to exceed the levels experienced by all individuals in the actual distribution" (Reference (4)). In this AERA, acute inhalation and chronic inhalation for multipathway exposure effects (for both cancer and noncancer) assume MEI exposure (see Large Table 1 and Large Table 2 for details regarding exposure, receptor location, toxicity, and type of exposure assumptions).

*Exposure Assumptions for the Off-site Worker*. For an off-site worker receptor, potential acute and chronic inhalation exposure was assessed. Potential acute (1-hour) exposure was assessed directly with no adjustment to the exposure time period. The chronic inhalation exposure time period was adjusted to a Reasonable Maximum Exposure (RME; 8 hours per day, 250 days per year, for 25 years) for cancer and chronic noncancer risk.

*Exposure Assumptions for the Resident and Farmer Receptors*. Potential health risks were assessed for two routes of exposure; direct via inhalation and indirect via food consumption. Multipathway exposure evaluates concurrent exposure to contaminants by both inhalation and food consumption. Potential resident and farmer multipathway risks were estimated for receptor locations not directly adjacent to the Plant Site property boundary. The Plant Site is located on a portion of the industrial lands formerly owned and used by LTV Steel Mining Company (LTVSMC). The past use and current conditions of this land indicate that there are no current residents and there is no potential for future residents on land within the former LTVSMC ambient air boundary. This area is zoned as mining development or Industrial by St. Louis County and the City of Hoyt Lakes and prohibits residential or farming development. Therefore, potential resident and farmer multipathway risks were estimated for receptor locations at the former LTVSMC ambient air boundary. The inhalation component of resident/farmer multipathway risk assumes MEI exposure (maximum air concentration at the receptor node, 24 hours/day, 365 days/year over a 70 year lifetime) for both cancer and noncancer effects. The ingestion part of multipathway risk assumes exposure for 30 years for a resident and 40 years for a farmer as adjusted in the MPCA's multipathway screening factors. The southern part of the former LTVSMC ambient air boundary is approximately 4.8 kilometer (about 3 miles) from the Plant Site ownership boundary. Potential acute inhalation risk was also calculated at the former LTVSMC ambient air boundary to provide an estimate of potential health risk to the general public as in addition to offsite workers.

Exposure point concentrations were estimated from air dispersion modeling. For this analysis a deposition algorithm was used for particulate emissions that utilized the half-life modeling in the AERMOD model (version 12060) to better represent potential air concentrations related to fugitive dust emissions and transport. The algorithm was previously described in the Class II Modeling Protocol (Reference (5)) and the document titled Supplemental Plant Site AERA- Risk Analysis and Respirable Fraction of Dust-Based Emissions Version 1, submitted to the MPCA on October 29, 2012 and approved on November 14, 2012 (Reference (6)). In addition, the acute (1-hour) $NO_2$ concentration was calculated using the approach approved for Plant Site $NO_2$ National Ambient Air Quality Standard (NAAQS) modeling, the Ozone Limiting Method (OLM) modeling protocol. The OLM modeling used USEPA's conservative default 50% in-stack conversion factor, meaning that it is assumed 50% of the $NO_x$ emitted from the stack is in

the form of $NO_2$. The conversion of the remaining 50% of the $NO_x$ emissions to $NO_2$ is calculated based on the estimated $NO_2$ and ozone concentrations.

### 1.3 Estimated Potential Incremental Human Health Risks and Conclusions

Maximum modeled air concentrations for the 10 CFE were input to the MPCA's Risk Assessment Screening Spreadsheet (RASS; version 20120302) and initial risks were calculated. The initial summed noncancer acute (1-hour) inhalation risk (hazard index) based on maximum modeled air concentrations regardless of toxic endpoint or receptor location, at the PolyMet ownership boundary does not exceed the guideline value of 1 (Table 1-1). Additional details on acute inhalation risks are in Section 7.2.1.

Potential chronic incremental health risks for an off-site worker (inhalation) at the Plant Site ownership boundary and for a famer or resident at the former LTVSMC ambient air boundary (multipathway) do not exceed the guideline value of 1E-05 for carcinogens and 1 for non-cancer endpoints (Table 1-1). Risk driver chemicals (chemicals having potential non-cancer risks of 0.1 or greater or potential carcinogenic risk of 1E-06 or greater) included the following:

- Off-site worker (inhalation only at the Plant Site boundary
    - Arsenic compounds: potential non-cancer acute HQ = 0.1
    - Cobalt compounds: potential non-cancer chronic HQ = 0.2; potential cancer risk = 4E-06
    - NO2 : potential non-cancer acute HQ = 0.5 (based on OLM modeling)
      HCl : potential non-cancer acute HQ = 0.4
    - Nickel compounds: potential non-cancer acute HQ = 0.3; potential non-cancer chronic HQ = 0.8; potential cancer risk = 6E-06
- Farmer/resident receptor (multipathway risk; former LTVSMC ambient air boundary)
    - Cobalt compounds: potential cancer risk = 2E-06
    - $NO_2$ : potential non-cancer acute HQ=0.4
    - Nickel compounds: potential non-cancer HQ = 0.1; potential cancer risk = 3E-06
    - Farmer only: Dioxin/furans (2,3,7,8-TCDD equivalents); potential cancer risk = 6E-06

Table 1-1 provides a comparison of risks estimated for this Supplemental AERA to those previously estimated in the 2007 Plant Site AERA. Overall, the estimated incremental health risks for this Supplemental AERA are considered similar (i.e., within the same range) to those estimated in the 2007 AERA.

Table 1-2 summarizes uncertainty and conservatism in the risk analysis. Overall, when following the regulatory agency risk assessment methodology, including emission estimation methodology for particulate metals and estimating $NO_2$ inhalation risk using the OLM modeling protocol approved for use in the Plant Site NAAQS modeling, estimated risks are considered to be conservative and meet the intent of a screening assessment to not underestimate risks.

Based on estimated potential incremental risks for the Project (current and previous Project Description), adverse effects to human health are not expected to be associated with potential air emissions from Plant Site activities.

**Table 1-1 Comparison Summary of the Estimated Incremental Human Health Risks for the Supplemental Air Emissions Risk Analysis (AERA) Conducted for the Proposed NorthMet Plant Site near Hoyt Lakes, Minnesota**

| Exposure Route | Exposure Scenario | Receptor | Potential noncancer effects (Hazard Index)(1) | | Potential cancer effects (Risk Estimate)(2) | |
|---|---|---|---|---|---|---|
| | | | 2007(3) | 2012(4) | 2007(3) | 2012(4) |
| Inhalation Only Exposure | Acute (1 hour)(5) | Off-Site Worker<br>Plant-Site property ownership boundary | 1 | 1 | N/A | N/A |
| | Acute (1 hour)(5) | Resident at former LTVSMC ambient air boundary | 0.2 | 0.5 | NA | NA |
| | Chronic (greater than 1 year) | Off-site Worker (RME)<br>Plant-Site property ownership boundary | 0.5 | 1 | $3x10^{-6}$ | $1x10^{-5}$ |

| Exposure Route | Exposure Scenario | Receptor | Potential noncancer effects (Hazard Index)[1] | | Potential cancer effects (Risk Estimate)[2] | |
|---|---|---|---|---|---|---|
| | | | 2007[3] | 2012[4] | 2007[3] | 2012[4] |
| Multipathway Exposure<br>Receptors at the former LTVSMC ambient air boundary[5] | Chronic-total multipathway (inhalation+food consumption) | Farmer (MEI for inhalation, RME for ingestion for cancer effects) | 0.2 | 0.2 | $5x10^{-6}$ | $1x10^{-5}$ |
| | | Resident (MEI for inhalation, RME for ingestion for cancer effects) | 0.2 | 0.2 | $4x10^{-6}$ | $5x10^{-6}$ |

MEI = Maximum Exposed Individual; for chronic risk, exposure to the maximum modeled air concentration is assumed to occur 24 hours per day for 365 days per year.
RME = Reasonable Maximum Exposure for an off-site worker; exposure 8 hours per day, 250 days per year.
N/A = not applicable and not assessed

(1) Hazard Index is the sum of individual non-cancer chemical risks for acute or chronic exposure. Risks were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version as current at the time the analysis was conducted) and rounded to 1 significant figure per USEPA 2005 HHRAP guidance. Incremental non-cancer (chronic and acute) guideline value is 1.

(2) Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version 20120302) and rounded to 1 significant figure per USEPA 1989 RAGS and 2005 HHRAP guidance. Incremental cancer risk guideline value is 1E-05, Minnesota Department of Health (MDH).

(3) Risk estimates are as presented in the 2007 Plant Site AERA. Chronic inhalation risks are based on RME exposure at the PolyMet Plant Site ownership boundary. Multipathway risks are based on MEI exposure at the former LTVSMC ambient air boundary. Acute risk is based on maximum concentrations at the PolyMet ownership boundary and the former LTVSMC ambient air boundary.

(4) Risk estimates for the current Project Description as of October 2012. Chronic inhalation risks are based on RME exposure for an off-site worker at the PolyMet Plant Site ownership boundary. Multipathway risks are based on MEI exposure at the former LTVSMC ambient air boundary. Acute risk is based on maximum concentrations at the PolyMet ownership boundary and the former LTVSMC ambient air boundary. (See footnote 5 for acute inhalation risk.)

(5) For the current risk analysis and the 2007 AERA, the HI for Acute risk includes the risks estimated for $NO_X$ emissions (evaluated as $NO_2$). The 2007 analysis used a conversion factor of 0.75 to estimate $NO_2$ concentrations from modeled $NO_X$ concentrations. In the 2012 analysis, the approved OLM modeling protocol from the Plant Site NAAQS modeling was used to estimate acute (1-hour) $NO_2$ concentrations. See Section 5.3 for additional information on the OLM modeling protocol.

**Table 1-2 Summary of Uncertainty and Conservatism in the Supplemental Air Emissions Risk Analysis (AERA) Conducted for the Proposed NorthMet Project Plant Site near Hoyt Lakes, Minnesota**

| Risk Component | Effect on 2007 Risk Estimates | Effect on 2012 Risk Estimates |
|---|---|---|
| **Emission Estimates** | | |
| Use of controlled potential emission rates in all standard calculations including AERMOD inputs and the following assumptions:<br>- operations continue 24 hours/day, 7 days/week, 365 days/year at the Plant (except for Tailings Basin construction activities, which are seasonal)<br>- emissions from on-site vehicles are based on the worst case year with the maximum vehicle fleet size. | Overestimates potential risk | Overestimates potential risk |
| 2007: Use of the USEPA factor for screening analysis that assumes 75% of the NOx emissions are instantly converted to $NO_2$ (Reference (7)). The primary sources of $NO_x$ are natural gas fired space heaters assumed to run all year and diesel fuel emissions. This is a conservative estimate because this conversion of NO to $NO_2$ is likely on the order of 0.1 to 0.5 based on actual monitoring data and information in Podrez 2012 (Reference (8)) and on the order of several hours to days based on information in (Reference (9)).<br>2012: Use of the Ozone Limiting Method modeling protocol approved for Plant Site NAAQS modeling for estimating one-hour $NO_2$ concentrations (with assumption that 50% of in stack $NO_x$ is $NO_2$). | Overestimates potential acute inhalation risk | Overestimates potential acute inhalation risk |
| Estimating dioxin emissions from haul trucks. Potential emissions from Haul Trucks are estimated using USEPA's emission factor for dioxin/furans derived from a 1996 tunnel study using diesel formulations from the 1990's.<br>The diesel engines at the Plant Site are required to burn low sulfur fuels and may have newer engine technologies. Although these changes were made to reduce criteria pollutant emissions, including products of incomplete combustion, the exact impact of these changes (e.g. fuel) on the estimated potential dioxin/furan emissions is not known. Recent research by USEPA (Reference (10)) indicates emissions based on older formulations of diesel fuel are higher compared to emissions from recent diesel fuel formulations. | N/A | Likely overestimates potential health risk |

| Risk Component | Effect on 2007 Risk Estimates | Effect on 2012 Risk Estimates |
|---|---|---|
| Did not evaluate impacts from sources that occur intermittently for short periods of time such as emissions from use of the emergency generators or diesel powered fire pumps. However, if these types of sources are in operation then other parts of the process are likely shut down or have reduced operations and overall emissions from the facility would likely be lower than at full operation. | Likely no effect on estimated risks | Likely no effect on estimated risks |
| The largest sources of emissions for the Project were included in the 2007 AERA and the 2012 Supplemental AERA, However, not all emissions sources were included in the quantitative analysis for either AERA; some minor sources of emissions were not included. (See Section 5.3.1.6) | Likely no effect on estimated risk | Likely no effect on estimated risk |
| Some chemicals were not evaluated in the 2007 analysis because they did not have an inhalation toxicity value or they were screened out of the 2012 analysis based on the insignificant risk results from the 2007 AERA (according to AERA guidance). | Likely no effect on estimated risk | Likely no effect on estimated risk. |
| **Exposure and Bioavailability of Chemicals** | | |
| MEI Concept, chronic multipathway risk. For chronic inhalation exposure, the maximum modeled air concentration for an averaging time period was used to estimate potential risks. USEPA guidance identifies this as a Maximum Exposed Individual (MEI). It is very unlikely that an individual would be living near the boundary of the facility or at the former LTVSMC ambient air boundary. An individual would not be outside 24 hours/day, 7 days/week, for 365 days/year in Minnesota. | Overestimates potential risk | Overestimates potential risk |
| RME Concept, chronic inhalation risk for an off-site worker. It is very unlikely that an individual would be working outside at the PolyMet boundary for an entire career of 8 hours/day, 5 days/week, 250 days/year. | Overestimates potential risk | Overestimates potential risk |
| Air dispersion modeling was conducted with the AERMOD model. For the 2007 analysis, AERMOD was run in regulatory mode. For the 2012 analysis, a deposition algorithm utilizing the half-life modeling in AERMOD was used to better represent fugitive dust emissions. | Overestimates potential risk | Overestimates potential risk |

| Risk Component | Effect on 2007 Risk Estimates | Effect on 2012 Risk Estimates |
|---|---|---|
| **Toxicity Values** | | |
| Use of provisional toxicity value (a PPRTV) in the RASS for cobalt (a worker exposure value) to assess potential risks cancer risks. | Not a CFE in 2007 | Likely overestimates potential risk |
| Use of nickel unit risk value (from IRIS) which is derived from studies using nickel subsulfide in refinery dust. Nickel cancer potency is very dependent on solubility and the speciation of each nickel compound. The bioaccessibility and bioavailability by inhalation of the nickel compounds from the Plant operations is not known. | Overestimates potential risk | Overestimates potential risk |
| Use of PAH toxicity values that are derived by extrapolation and are considered to be highly uncertain. PAHs were assessed in 2007 and 2012. None of the PAHs assessed were risk drivers in either analysis. | Likely no effect on estimated risk | Likely no effect on estimated risk |
| 2007: Speciated PAH compounds, beryllium, cadmium, and lead were evaluated for multipathway risks using the MPCA's Risk Assessment Screening Spreadsheet (RASS). These chemicals had insignificant risks. Some persistent chemicals did not have Multipathway Screening Factors (e.g. arsenic) and were excluded from the indirect pathway risk estimates.<br>2012: All chemicals for evaluation considered PBT had screening factors (arsenic, dioxins/furans). The PBT chemicals evaluated in the 2007 AERA (e.g., speciated PAH compounds) had insignificant risk and were screened out of evaluation for the 2012 analysis according to AERA guidance. | May underestimate potential risk | May underestimate potential risk |
| The RASS only evaluates chemicals with inhalation benchmarks. Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks. Of these chemicals only the PAHs are considered PBT chemicals. PAHs that were evaluated quantitatively in 2007 were screened out of the supplemental AERA because of insignificant risks according to AERA guidance. | Likely no effect on estimated risk | Likely no effect on estimated risk |

| Risk Component | Effect on 2007 Risk Estimates | Effect on 2012 Risk Estimates |
|---|---|---|
| **Risk Characterization (Risk Estimates)** | | |
| In terms of risk characterization the following assumptions were made:<br>- all chemicals have an additive effect<br>- assumed all non-carcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects.<br>- Cancer risks summed across modes/mechanisms of action; carcinogenic unit risks have the same weight of evidence for human carcinogenicity | Likely overestimates potential risk | Likely overestimates potential risk |
| Assumption that all metals exist in a physical form and size range that makes them 100% respirable bioavailable by inhalation. As determined in Version 5 of the emission inventory, about 31% of the metal emissions for the Plant Site are associated with rock handling operations. Metals from rock handling are much more likely to be inherent to the mineral structure of the rocks and present as compounds. Therefore, it is very unlikely that 100% of metals will be in a respirable size range and be bioavailable by inhalation. In terms of multipathway exposure, it is unlikely that 100% of the metals will be bioavailable by ingestion. | Overestimates potential risk | Overestimates potential risk |
| Synergism/antagonism was not considered | May under- or over- estimate risk | May under- or over- estimate risk |
| For carcinogens when the Unit Risk is based on the 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as the risks from a number of carcinogens are summed (Reference (11)). | Overestimates potential risk | Overestimates potential risk |
| For non-carcinogens, the Hazard Index was summed across all toxicity endpoints. This is not realistic because different chemicals can have different toxicity endpoints. | Overestimates potential risk | Overestimates potential risk |

(1) Key for Effects Determination:

- Overestimates potential risk: A value or assumption intentionally chosen to provide high risk estimates
- Likely Overestimates potential risk: A value or assumption intentionally chosen that is expected to provide high risk estimates
- May overestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a high risk estimate
- Underestimates potential risk: A gap in information or an available value that is known to provide a low risk estimate
- Likely underestimates potential risk: A gap in information or an available value that may provide a low risk estimate
- May underestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a low risk estimate.
- Likely no effect on estimated risk: Value or assumption that is known or suspected to have very little, if any, effect on potential risk

## 1.4 Estimated Potential Cumulative Inhalation Risks

When determining the need for an environmental impact statement during the environmental review process, Minnesota Rules 4410.1700 subpart 7, item B requires the Responsible Governmental Unit (RGU) to determine "cumulative potential effects of related or anticipated projects." Potential projects considered for inclusion in the cumulative risk analysis were those within about 10 kilometers (about 6 miles) of the Project. The two nearby existing facilities counted in this cumulative analysis were; 1) the Mesabi Nugget Large Scale Demonstration Plant and Mesabi Mining[1] (particulate metals, $NO_2$), and 2) Minnesota Power Syl Laskin Plant ($NO_2$).

A summary of the maximum estimated potential cumulative inhalation risk to a potential resident receptor from background exposure (calculated by MPCA from monitoring data), non-Project air emissions (Mesabi Mining Project and Mesabi Nugget LSDP, existing Laskin Energy Center), and Project air emissions (the incremental risk estimated from the Mine Site and the Plant Site) are summarized in Table 1-3 and below. Although there are no guideline values for cumulative risk, the estimated cumulative risk is compared to the incremental risk guideline values for a single facility or project. Please note that using the incremental risk guidelines in this manner only provides a broad context for reviewing the results.

- The potential incremental risk from the PolyMet Mine and Plant Sites together contribute about 57% of the estimated potential cumulative acute risk. Total cumulative inhalation risk does not exceed the incremental acute risk guideline value of one.

- Potential incremental risk from the NorthMet Mine and Plant Sites accounts for only 7% of the estimated potential total cumulative chronic noncancer risk. Potential cumulative noncancer chronic risks do not exceed the incremental chronic noncancer guideline value of one and are predominately from risks based on monitored background air concentrations.

- Potential incremental risk from the NorthMet Mine and Plant Sites accounts for only 9% of the estimated potential total cumulative cancer risk. Cancer risk from monitored background air concentrations is greater than the incremental cancer risk guideline value of 1E-05, thus cumulative risk is also above this value.

Further details regarding cumulative inhalation risk may be found in Section 11.0 and Large Figure 1.

[1] MPCA has expressed uncertainty as to whether or not the Mesabi Mining project is currently reasonably foreseeable, but it was included in the cumulative analysis per the work plans.

**Table 1-3 Maximum Estimated Potential Cumulative Inhalation Risks for the Receptors of Interest for Supplemental AERAs for the NorthMet Mine Site and Plant Site**

| Estimated Potential Risk[1] | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| **Background[2]** | | | |
| Ambient air (calculated by MPCA) | 3E-05 | 1 | 0.4 |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | NA | NA | 0.01 |
| Total Background [3] | 3E-05 | 1 | 0.4 |
| **Incremental** | | | |
| NorthMet (Plant Site + Mine Site) | 3E-06 | 0.1 | 0.6 |
| Mesabi Mining Project and Mesabi Nugget LSDP [4] | NA | 0.1 | 0.02 |
| Total Incremental [3] | 3E-06 | 0.2 | 0.6 |
| **Cumulative** | | | |
| Total Cumulative Risk [3] | 4E-05 | 1 | 1 |
| % of Cumulative Risk from the Project (Plant Site and Mine Site combined) | 9% | 7% | 57% |

(1) The maximum potential cumulative risk out of the 4 receptor locations evaluated is presented in Table 1-3 for cancer, noncancer chronic, and noncancer acute risk. The potential cumulative risk estimated at each of the four receptors is presented in Attachment G.
(2) Background risks were calculated by the MPCA based on MPCA 2008-2010 monitoring data from Virginia, Ely and Cloquet.
(3) As per USEPA (2005) HHRAP guidance, all reported risk values are rounded to one significant digit. Totals, however, are calculated from unrounded values (i.e., two or more significant figures) and may differ from the value obtained by adding the rounded values shown in the table.
(4) LSDP = Large Scale Demonstration Plant (Mesabi Nugget).

## 1.5 Screening Fish Consumption Pathway Assessment from Estimated Incremental Mercury Deposition

The Plant Site has the potential to emit approximately 4 pounds of mercury per year. The Minnesota Mercury Risk Estimation Method (MMREM) was used to assess:

- Two emission speciation scenarios for the Plant Site
  - Scenario 1: 25% elemental; 50% oxidized; 25% particle bound
  - Scenario 2: 80% elemental; 10% oxidized; 10% particle-bound
- Potential increases in mercury bioaccumulation in fish in five nearby lakes (Heikkilla Lake, Colby Lake, Whitewater Lake, Wynne Lake, and Sabin Lake)

- Potential increases in health risks via the chronic fish consumption pathway for recreational, subsistence/tribal, and subsistence anglers.

Heikkilla, Colby and Whitewater lakes are within 10 km (about 6 miles) of the Plant Site and Wynne and Sabin Lakes are within 12 km (about 7 miles) of the Plant Site

The potential increases in fish mercury concentrations potentially related to Plant Site mercury emissions are estimated to be between 0.0006 to 0.004 ppm for emissions Scenario 2 and 0.002 to 0.016 ppm for emissions Scenario 1, respectively, for the lakes evaluated. The potential changes in fish mercury (Hg) concentrations are small compared to existing fish Hg concentrations (background ranges from 0.35 ppm for Whitewater Lake to 1.34 ppm for Wynne Lake) that result in already elevated "background" Hg hazard quotients as calculated by the MPCA MMREM spreadsheet (see additional details in section 10.3). This potential change estimated by the model corresponds to a potential increase over background levels of 0.2 to 0.4% for emissions Scenario 2 and 0.6 to 1.6% for emissions Scenario 1, respectively.

Additionally, emissions Scenario 1 is a conservative overestimation of oxidized mercury speciation. Scenario 2 is the estimated likely speciation of mercury emissions from the Plant Site based on engineering estimates and limited data from other autoclaves (Reference (12)). The two-staged scrubbing system proposed for the autoclave will effectively control particle-bound and oxidized mercury, so any emitted mercury is expected to be predominantly in an elemental form. The potential incremental increases in mercury fish tissue concentrations under emissions Scenario 2 only range from 0.2% to 0.4% of background concentrations. Table 1-4 summarizes the potential incremental increases in the estimated fish Hg concentrations in lakes within 12 km of the proposed Plant Site. The modeled potential increases in fish tissue mercury concentrations, which are considered worst case scenarios, are small compared to the existing fish tissue concentrations and the variability of concentrations in each lake considered. The estimated potential increases would not change the fish advisory or lake impairment status of any of the lakes considered. Further details regarding the incremental increases in fish tissue mercury concentrations are found in Section 10.0.

**Table 1-4 Summary of Potential Incremental Increases in Fish Mercury Concentrations Related to Estimated Mercury Deposition from the Proposed NorthMet Project Plant Site Near Hoyt Lakes, Minnesota**

| Lake | MN DNR # | Scenario[1] | Existing Ambient Fish Hg Concentration (mg/kg Hg)[2] | | Incremental Increase in Fish Hg Concentration (mg/kg Hg) | % Increase in Hg |
|---|---|---|---|---|---|---|
| | | | Range | Statistics | | |
| Heikkilla Lake | 69025300 | Scenario 1 | NA[3] | 95% UCL=0.65<br>SD=0.344 | 0.010 | 1.6% |
| | | Scenario 2 | | | 0.0026 | 0.4% |
| Colby Lake | 69024900 | Scenario 1 | 0.49 - 1.23 | 95% UCL=0.93<br>SD=0.221 | 0.010 | 1.1% |
| | | Scenario 2 | | | 0.0026 | 0.3% |
| White-water Lake | 69037600 | Scenario 1 | 0.12 - 0.90 | 95% UCL=0.35<br>SD=0.131 | 0.0022 | 0.6% |
| | | Scenario 2 | | | 0.0006 | 0.2% |
| Wynne Lake | 69043402 | Scenario 1 | 0.35 – 2.06 | 95% UCL=1.34<br>SD=0.572 | 0.016 | 1.2% |
| | | Scenario 2 | | | 0.0039 | 0.3% |
| Sabin Lake | 69043401 | Scenario 1 | 0.44 - 1.62 | 95% UCL=1.02<br>SD=0.390 | 0.012 | 1.2% |
| | | Scenario 2 | | | 0.0030 | 0.3% |

(1) Emissions Scenario 1: 25% elemental Hg, 50% oxidized Hg, 25% particle-bound Hg
Emissions Scenario 2: 80% elemental Hg, 10% oxidized Hg, 10% particle-bound Hg
(2) Current MPCA fish tissue mercury standard is set at 0.2 mg/kg Hg
(3) No fish tissue data available for Heikkilla Lake. The existing fish mercury concentration is assumed to be similar to that of the other four lakes evaluated. The 95% UCL includes the data from Colby, Whitewater, Wynne, Sabin, and Bear Island lakes.

## 2.0 Introduction

In May 2005, Poly Met Mining Inc. (PolyMet) submitted an Air Emissions Risk Analysis (AERA) in support of the Scoping Environmental Assessment Worksheet (EAW) to the MPCA (Reference (1)). A second AERA was completed in March 2007 in support of the draft Environmental Impact Statement (DEIS) for the NorthMet Project (Project) (Reference (2)). Because of the conservatism in the risk analysis, all incremental potential health risks calculated in the 2007 AERA were considered to be acceptable and it was concluded that no adverse human health risks were expected to be associated with this Project's air emissions. Since preparation of the DEIS, PolyMet has proposed changes to Plant Site operations and a Supplemental Draft EIS (SDEIS) is currently being prepared to evaluate the revised Project. PolyMet has been requested to submit a supplemental AERA to re-assess the potential human health risks associated with the Project's air emissions. A Work Plan for the Supplemental Plant Site AERA was accepted by the MPCA in August 2011 (Reference (13)).

This supplemental 2012 AERA reflects the most current design and operations for the Plant Site as described by the Plant Site Emission Inventory Version 5, submitted on June 6, 2012. This report includes:

- a list of chemicals potentially emitted from Plant Site activities
- a summary of estimated emissions for the individual chemicals
- a list of chemicals for quantitative risk evaluation
- air dispersion modeling results for all relevant emission sources at the Plant Site (including vehicle and locomotive emissions and fugitive emissions from tailings basin roads)
- chemical-specific inhalation and total multipathway (inhalation + indirect pathway) incremental health risks based on potential air emissions from Plant Site operations
- a qualitative screening analysis (Uncertainty Discussion)
- a cumulative risk evaluation including other nearby and reasonably foreseeable projects
- an evaluation of potential health effects from Project mercury emissions via the fish consumption pathway

## 2.1 Purpose of the Supplemental 2012 AERA

The primary objectives of this 2012 Supplemental AERA are to:

- conduct a conservative assessment of potential incremental human health risks that may be associated with the air emissions of the Project as reflected in the Plant Site Emission Inventory
- compare the estimated potential risks associated with the currently proposed Plant Site emissions with the risks estimated in the March 2007 AERA and assess the differences or similarities in risk estimates
- provide supplemental risk information to be used in the SDEIS and the air permitting process

## 2.2 Approach to the AERA

PolyMet has followed the August 2011 Work Plan (Reference (13)) and the MPCA's most current AERA guidance ((Reference (14)) in conducting this risk analysis.

The MPCA's AERA process ((Reference (14)) is designed to determine whether or not chemical emissions from sources and/or source groups are a potential health risk via inhalation and/or from multipathway (inhalation plus indirect) exposure. As defined by the MPCA, the term "risk" generally refers to estimated cancer risks (risk estimate) and the potential for noncancer health effects. Noncancer health effects are described using a Hazard Quotient (HQ) (for a single chemical) or a Hazard Index (HI) as the sum of HQs. In the AERA process, "quantitative analysis" specifically refers to the estimation of cancer risks and hazard indices using the MPCA's Risk Assessment Screening Spreadsheet (RASS, version 20120302). The AERA process additionally includes a "qualitative analysis," which identifies and discusses issues for which public health impacts cannot be easily quantified.

It is important to note that because of the limitations inherent in the risk assessment process, the risk characterization in this AERA or any health risk assessment cannot predict actual health outcomes, such as cancer. In other words, this or any health risk assessment does not provide an estimate of actual risk to a real person.

The 2012 Supplemental AERA was based on the following risk assessment guidance documents:

**State of Minnesota**

- Air Emissions Risk Analysis (AERA) Guidance. Version 1.1. MPCA, September 2007 (Reference (14))
- How to Conduct a Cumulative Air Emissions Risk Analysis. MPCA, March 2009 (Reference (15))

- Cumulative Air Emissions Risk Analysis at the MPCA – Background Document. MPCA, March 2009 (Reference (16))

**USEPA**

- Guidelines for the Health Risk Assessment of Chemical Mixtures. USEPA, 1986 (Reference (17))
- Risk Assessment Guidance for Superfund Volume 1 – Human Health Evaluation Manual Part A. USEPA, 1989 (Reference (18))
- Guidelines for Developmental Toxicity Risk Assessment. USEPA, 1991 (Reference (19))
- Guidelines for Exposure Assessment. USEPA, 1992 (Reference (4))
- Guidance for Data Usability in Risk Assessment. USEPA, 1992 (Reference (20))
- Exposure Factors Handbook, USEPA, 2011 (Reference (21))
- Risk Assessment for the Waste Technologies Industries (WTI) Hazardous Waste Incinerator Facility – Volume V. Human Health Risk Assessment. USEPA, 1997 (Reference (11))
- Guidelines for Carcinogenic Risk Assessment. USEPA, 1986, 1996, 2005 (References (22), (23), (24))
- Residual Risk Report to Congress. USEPA, 1999 (Reference (25))

# 3.0 Site Characterization

## 3.1 Facility Description

PolyMet plans to construct and operate a mine six miles (approximately 10 kilometers) south of the town of Babbitt, in northeastern Minnesota (Mine Site). In addition, PolyMet plans to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailings Basin and build an ore processing facility at the former LTVSMC site just north of Hoyt Lakes, MN (referred to as the Plant Site) about 8 miles (approximately 13 kilometers) to the west of the Mine site. The locations of these two facilities are shown in Large Figure 2. A detailed description of the NorthMet Project is provided in the March 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement (EIS) (Reference (26)) and the NorthMet Project Description Version 4 submitted October 31, 2012.

This ore processing site will be a state-of-the-art facility for the hydrometallurgical processing of ore for metal extraction and will:

- produce an enriched copper flotation concentrate product and differing grades of a nickel concentrate
- separate precipitates of nickel/cobalt and platinum/palladium/gold for further refining
- produce carbon dioxide and gypsum byproducts which may be sold
- upon the Hydrometallurgical Plant becoming operational ship or process nickel concentrates based on equipment maintenance schedules, customer requirements and overall Project economics

Flotation tailings from the concentration process will be disposed of on top of the former LTVSMC taconite tailings basin. Hydrometallurgical residue from the hydrometallurgical process will be disposed in a hydrometallurgical residue facility consisting of a single lined cell located adjacent to the southwest corner of Cell 2W of the Tailings Basin.

## 3.2 Site Environment Description

The Proposed Process Plant is located in northern Minnesota, within the corporate boundaries of the city of Hoyt Lakes (occupying parts of Sections 8, 9, 16, 17, Township 59 North, Range 14 West, St. Louis County). Additional former LTVSMC supporting operations, which will also be reactivated as part of the Plant Site, include the former LTVSMC Tailings Basin and the Area 1 and Area 2 Shops. These facilities are located within the Plant Site operating boundary. The Plant Site is approximately 4 miles (approximately 6 kilometers) north of the residents of Hoyt Lakes, and approximately 6 miles (approximately 10 kilometers) northeast of the residents of Aurora, Minnesota, within an industrial and mining area generally defined by the former LTVSMC ambient air boundary. PolyMet's land holdings at the Plant Site are within an area zoned Mining Development or Industrial by St. Louis County and the City of Hoyt Lakes. The

past use and current zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Lands immediately adjacent to the former LTVSMC ambient air boundary are primarily undeveloped and dominated by extensive forests and large wetlands (peat-lands).

The Project site lies within the Nashwauk Uplands of the Northern Superior Uplands in the Laurentian Mixed Forest Province (Reference (27)). Landforms within the Nashwauk Uplands include end moraines, outwash plains, and lake plains. Soils vary from medium to coarse texture. Forestry and mining are the most important land uses presently. The surface relief of the Uplands is generally gently rolling, with local relief ranging from about 10 to 30 feet. In some locations, the local relief can range up to 200+ feet (e.g., Embarrass Mountains). Slopes are mostly short and irregular. The landscape includes many closed depressions, most of which contain peat-lands.

## 4.0 Identifying Chemicals for Quantitative Evaluation

As described in the August 2011 Work Plan, the chemicals for evaluation (CFE) in this Supplemental 2012 AERA include:

- risk driver chemicals from the March 2007 Plant Site AERA
- chemicals with new toxicity values which were not evaluated in the 2007 Plant Site AERA
- as requested by the MPCA, manganese
- chemicals for which either an increase in emissions and /or a change or addition in a toxicity value suggests the chemical would now be considered a risk driver chemical (2007 adjusted risk is now greater than 1E-06 for cancer or noncancer risk greater than 0.1)

### 4.1 Risk Driver Chemicals from the 2007 AERA

Chemicals for Potential Evaluation (CFPE) were identified for the March 2007 AERA using a variety of sources of emission information (see the Plant Site Emission Inventory, Version 5). The focus of that effort was to identify those chemicals that may be emitted to air from Plant Site operations that may be of potential human health concern if exposure to those chemicals occurs at levels above thresholds that are generally considered safe.

The quantitative risks from the 2007 AERA are used as the basis for determining potential risk-driver chemicals. A chemical is considered a "risk driver" if the hazard quotient for an individual chemical is above 0.1 or the cancer risk for an individual chemical is greater than 1E-06.

Of the 39 chemicals that were quantitatively evaluated for inhalation and multipathway health risks in the March 2007 AERA, 3 were identified as "risk drivers": arsenic compounds, nickel compounds, and nitrogen dioxide (estimated from $NO_x$ emissions). These 3 chemicals were quantitatively evaluated in this Supplemental AERA.

### 4.2 Chemicals That Now Have Toxicity Values

Chemicals that were listed as CFPE in the 2007 Plant Site AERA without a toxicity value, but that now have a toxicity value in the MPCA's Risk Assessment Screening Spreadsheet (RASS), include the following: acetaldehyde (for acute toxicity), cobalt compounds, crystalline silica, and diesel particulate matter (DPM). In addition, emissions of dioxins/furans from mobile diesel combustion were added to the chemicals evaluated for the Plant Site.

These chemicals were added to the list of chemicals for quantitative evaluation for this Supplemental AERA.

Crystalline silica emission calculations were added to Version 6 of the emission inventory based on previously approved calculation procedures. All other chemicals evaluated in this supplemental AERA were included in previous versions of the inventory.

In addition, an acute benchmark concentration for sulfuric acid was added to the RASS since the 2007 version. Sulfuric acid was added as a CFE and assessed semi-quantitatively (see Section 4.3). Additional Chemicals to Evaluate Due to Changes in Emissions or Toxicity

Emission estimates from Plant Site sources have been updated to reflect changes in proposed operations since submittal of the 2007 AERA. Sources of Plant Site operations are listed below:

- ore crushing and grinding operations
- autoclave operations
- hydrometallurgical process tank operations
- process consumable handling processing and storage
- fugitive dust emissions from tailings basing operations
- diesel combustion emissions (from construction equipment used in ongoing operations at the Tailings Basin and locomotives)

Large Table 3 presents the comprehensive list of 64 pollutants in the AERA inventory identified in 2007 or 2012 to be potentially emitted from the proposed Plant Site activities. Estimated emissions of these chemicals from the 2007 AERA and 2012 estimates are compared. Potential emissions of metals were conservatively estimated based on total PM and the concentration of a metal in specific types of mineral material (ore, concentrate, tailings). Potential emissions of metals from natural gas combustion (based on AP-42 listings) and mobile source diesel fuel (fuel oil) combustion were also calculated. Details regarding emissions calculations for all combined emissions scenarios are available in the NorthMet Plant Site Emissions Inventory which was submitted on December 17, 2012 (Version 6).

Because both emission changes and toxicity value changes may have occurred since 2007, CFPE were reassessed for potential importance to the risk estimates. The following methodology to calculate a “revised risk estimate” (RRE) was used to determine whether any changes were significant with regard to emissions or toxicity values.

1. For chemicals that only have emission changes since 2007

   RRE = March 2007 risk x (1 + %change in emissions)

2. For chemicals that only have changes to toxicity value since 2007

   RRE = March 2007 risk x (1 + %change in toxicity value)

3. For chemicals that have both changes in emissions and toxicity value since 2007

   RRE = March 2007 risk x (1 + % change in emissions)(1 + % change in toxicity value)

Any chemical with an RRE greater than or equal to risk driver levels (0.1 for noncancer risks and 1E-06 for cancer risks) would be included in the quantitative risk assessment for the Supplemental AERA. Large Table 4 identifies the revised risk estimates for all CFPEs with toxicity factors. The analysis of changes in emissions and toxicity factors identifies hydrochloric acid is an additional chemical to be evaluated quantitatively for human health risks. Therefore, hydrochloric acid is included as a CFE for this Supplemental AERA.

The RRE for sulfuric acid is calculated even though an acute reference concentration was not available in 2007. The March 2007 risk was estimated using the current acute reference concentration value for sulfuric acid (RASS version 20120302) and the maximum modeled 1-hour concentration from the 2007 analysis. The percent change in emissions was then applied to the estimated March 2007 risk value as shown below and in Large Table 3.

RRE (sulfuric acid) = Est. March 2007 risk x (1 + % change in emissions)

RRE (sulfuric acid) = 0.048 x (1-45%) = 0.026

The Revised Risk Estimate for sulfuric acid is included in the total acute hazard index for the Plant Site. Note that the RRE for sulfuric acid (0.026; Large Table 4) does not indicate that it would be a risk driver chemical.

### 4.3 Chemicals for Evaluation (CFE)

The following chemicals have been identified as CFE for this Supplemental AERA:

- Acetaldehyde
- Arsenic compounds
- Cobalt compounds
- Diesel Particulate
- Dioxins/furans
- Hydrochloric acid
- Manganese compounds

- Nickel compounds
- Nitrogen oxides (as $NO_2$)
- Silica, crystalline
- Sulfuric acid (evaluated semi-quantitatively using a Revised Risk Estimate (RRE).

## 4.4 Chemicals Screened out of the Quantitative Evaluation

Chemicals not identified in Section 4.3 were not quantitatively evaluated for the Supplemental AERA. These chemicals were screened out of evaluation based on estimated low risks as determined in both the 2007 AERA and in the determination of RREs (see Section 0). For comparison, the estimated risks for the chemicals screened out of quantitative evaluation, as determined in the 2007 AREA and as RREs, are presented in Table 4-1. These estimated risks would not likely change the final determination of risk estimates presented in this Supplemental AERA within the reporting values of one significant digit.

**Table 4-1 Potential Risk Estimates of Chemicals Screened Out of the Supplemental Plant Site AERA using both 2007 Risk Results and Revised Risk Estimates (RREs) Based on Changes in Emission Estimates and/or Toxicity Values**

| Source or Location of Estimated Potential Risks | Potential Risks from Chemicals in the 2007 AERA with Insignificant Risk (reported results from RASS version 20060829) | Revised Risk Estimates (RREs) for Chemicals with Insignificant Risk in the 2007 AERA (Based on emission and toxicity value changes since 2007) |
|---|---|---|
| *Inhalation Risks at the PolyMet Plant Site Operating Boundary* | | |
| Acute | 0.090 | 0.099 |
| Chronic Noncancer (RME) | 0.10 | 0.048 |
| Cancer (RME) | 4.2E-07 | 1.9E-07 |
| *Multipathway Risks at the Former LTVSMC Ambient Air Boundary* | | |
| Farmer Noncancer (MEI) | 0.023 | 0.015 |
| Farmer Cancer (MEI) | 1.3E-06 | 1.4E-06 |
| Resident Noncancer (MEI) | 0.023 | 0.012 |
| Resident Cancer (MEI) | 2.5E-07 | 1.4E-07 |

Note that iron is not considered a chemical for potential evaluation. Although iron is present in the ore, it is not in high enough concentrations to be extracted as a product at the Project. Iron also does not have an inhalation benchmark so it is not quantitatively assessed in the RASS. Previous mining projects, such as Essar and the Keetac Expansion, that have evaluated iron through the oral pathway have not shown iron to be a risk driver chemical and iron was not considered to be an issue for human health risk. The relatively lower iron concentrations in the ore compared to the ore processed in the Essar and Keetac projects indicate that iron is highly unlikely to be a risk driver chemical for the Project.

# 5.0 Exposure Assessment and Estimating Exposure Point Concentrations

## 5.1 Exposure Assessment Concepts

### 5.1.1 Maximum Exposed Individual (MEI) at the Former LTVSMC Ambient Air Boundary

Exposure assessment is the process of looking at how people are exposed to chemicals from their environments. For this analysis, maximum modeled air concentrations were used to assess potential inhalation risks. As an additional refinement, acute (1-hour) inhalation risks by receptor were also estimated. The acute risk by receptor uses the modeled concentrations of all chemicals evaluated at each receptor to determine a risk estimate for each receptor modeled. The maximum calculated risk for any modeled receptor is then considered the refined risk estimate or risk by receptor. The USEPA (Reference (3)) considers the use of maximum modeled air concentrations in a risk analysis to assess a Maximum Exposed Individual (MEI) and defines the MEI as an exposure scenario based on using the *"…modeling node where the maximum ambient air concentration occurs, regardless of whether there is a person there or not*…." In general, the MEI analysis assumes that a hypothetical receptor would live in the area of the estimated maximum concentration and be outdoors 24 hours per day, 365 days per year for their lifetime.

This exposure concept uses the maximum point estimate for ambient air concentrations as the potential dose and compares this concentration to toxicity values to generate near maximum risk estimates. Factors such as typical (or central tendency) exposure frequency and duration (as applied to the maximum concentration), bioavailability, variability in exposure point concentrations, and chemical speciation are not considered. Assessing health risks to an MEI is a high end estimate and similar to calculating the theoretical upper bound estimate (maximum exposure, expected to exceed the levels experienced by all individuals in the actual distribution). Therefore, a potential maximum inhalation component of cancer and noncancer multipathway risk is calculated for resident and farmer at the former LTVSMC ambient air boundary. In terms of the ingestion component, the MPCA's Multipathway Screening Factors used in the RASS assume 30 years of exposure for a resident and 40 years of exposure for a farmer resulting in a reasonable maximum exposure (RME) for the ingestion portion of the multipathway risk.

Important considerations for the MEI concept are as follows:

- According to USEPA (Reference (28)), the theoretical upper bound estimate "…can be easily calculated and designed to estimate exposure, dose, and risk levels that are expected to exceed the levels experienced by all individuals in the actual distribution…."

- The estimated risk presented under the MEI concept should not be used to draw conclusions regarding potential public health impacts or be used as an indicator of actual risks.

- The MEI scenario is a useful screening tool to determine if more detailed analyses or the inclusion of other exposure concepts (such as the central tendency exposure) are warranted.

- Risk management decisions should be based on realistic exposure scenarios rather than the hypothetical MEI (Reference (25)).

Assessing the MEI using the MPCA AERA methodology ensures that a conservative approach is used to assess potential health risks and protect public health (including sensitive populations) with a suitable margin of safety. Although presentation of potential risks using more plausible assumptions can assist in risk management decisions, when potential health risks are assessed to be at or below acceptable guidelines using the MPCA AERA methodology, adverse health effects, even in sensitive populations, are not expected.

### 5.1.2 Reasonable Maximum Exposure (RME) for an Off-Site Worker

An alternate exposure concept, Reasonable Maximum Exposure (RME), was used for chronic inhalation risk estimates at the PolyMet Plant Site ownership boundary. In general, RME refers to people who are at the high end of the exposure distribution (approximately the 95th percentile) and is intended to assess exposures that are higher than average, but still within a realistic range and considered health protective. An RME exposure concept is similar to the MEI in that is uses maximum modeled air concentrations based on potential to emit or permitted emissions. The exposure time, frequency and duration, however, are adjusted to "reasonable maximum" levels. The RME exposure is used in this analysis to estimate exposure to a potential off-site worker. USEPA has default exposure factors for a worker on land that is considered commercial or industrial. The USEPA default values under this scenario are to assume that a hypothetical receptor will be in the area 8 hours per day, 250 days per year, for 25 years (Reference (29)). Because there are no current residents and the land use and zoning preclude any future residents at the PolyMet Plant Site ownership boundary, potential resident and farmer risk at this boundary are not estimated.

## 5.2 Exposure and Dose

### 5.2.1 Inhalation Exposure (Direct Exposure)

Following MPCA guidance, the RASS is used to calculate potential inhalation risks to receptors located at the area of the highest modeled air concentration for specific types of receptors. The location of hypothetical receptors for this analysis is a person at the Plant Site property boundary (an off-site worker), and a person at the former LTVSMC ambient air boundary (resident and/or farmer). The RASS is designed to assess potential inhalation health risks from the following durations of inhalation exposures:

- short-term, acute, (exposure to maximum concentration of a chemical in ambient air for the one hour averaging time), and

- long-term, chronic (exposure to maximum concentration of a chemical in ambient air for the annual averaging time).

The AERA methodology, as integrated into the MPCA's Risk Assessment Screening Spreadsheet (RASS), uses simple generic equations to calculate potential chemical exposure to a hypothetical receptor through inhalation. In this application the modeled air concentration for a chemical at the Plant Site boundary is synonymous with potential dose for all acute and chronic durations. In actuality, real exposure occurs during uptake of the chemical through the respiratory tract after inhalation. Once the chemical is absorbed from the respiratory tract a certain amount becomes available to interact with specific organs or cells within the body (i.e. the delivered dose). For the analysis presented in this report, assuming that 100% of the maximum modeled air concentration is absorbed and accounts for the delivered dose is an overestimation of potential inhalation incremental risk, especially for chronic exposure.

Acute, inhalation pathway risk was also estimated at the former LTVSMC ambient air boundary to provide an estimate of exposure for the general public.

### 5.2.2 Multipathway Exposure (Indirect; Ingestion)

Multipathway exposure assessment is an important part of risk assessment for chemicals that are emitted into air and considered persistent, bioaccumulative, and/or toxic (PBT) and that can deposit to water, soil, and sediment and be present for long periods of time. PBT chemicals can be associated with particulate matter and come from both natural sources and from human activities. Some particles settle onto soil and vegetation surfaces and into surface water (lakes, rivers, streams) and are persistent in the environment. Particles that settle into surface waters can deposit in the sediment and bioaccumulate in aquatic ecosystems. PBT chemicals have the potential to become part of the food chain by being deposited on plants (and/or incorporated into plants) and subsequently eaten by animals (e.g. cattle, poultry) and incorporated into food products. Potential exposure to PBT chemicals from food as well as incidental ingestion of soil is part of the multipathway assessment for the resident and farmer. Using the maximum estimated air concentrations for the annual averaging time period, potential multipathway exposures are accounted for in the AERA methodology for two generic receptor types:

- A resident who consumes vegetables grown in his or her own garden, which are all assumed to receive deposition from the Project, and

- A farmer who, in addition to consuming homegrown vegetables, regularly eats home-grown meat, eggs, and dairy products which are all assumed to be affected by deposition from the Project.

As previously discussed, the Plant Site is within an industrial district and is also within the area encompassed by the former LTVSMC ambient air boundary. As a result, there is currently no residential or farming development, nor is there a potential for future residential or farming development to be on the lands immediately adjacent to the PolyMet ownership boundary. Therefore, potential multipathway risks for a potential resident and farmer receptor were

calculated at the more distant former LTVSMC ambient air boundary, with the nearest point of this boundary being approximately 4.8 km (about 3 miles) from the Plant Site ownership boundary. See Large Table 1 and Large Table 2 for a summary of exposure, dose and toxicity endpoint information.

**Table 5-1 Summary of Exposure Scenarios and Receptors Evaluated for the Supplemental Air Emissions Risk Analysis (AERA) for the Proposed Plant Site Near Hoyt Lakes, Minnesota**

| Receptor(s) | Type of Exposure |
|---|---|
| Off-site worker at the Plant Site Property Boundary | Inhalation<br>Short-term, acute inhalation: breathing maximum 1 hour modeled air concentration of a chemical in ambient air<br>Long-term, chronic inhalation: breathing maximum annual modeled air concentration of a chemical in ambient air (RME) |
| Resident or Farmer at or outside the former LTVSMC ambient air boundary | Inhalation<br>Short-term, acute inhalation: breathing maximum 1 hour modeled concentration of a chemical in ambient air |
| Resident who eats vegetables from his/her garden at the former LTVSMC ambient air boundary | Total Multipathway Exposure (Inhalation + Ingestion)<br>Long-term, chronic ingestion of vegetables from the garden (including incidental soil ingestion) + breathing maximum annual air concentration (MEI). The MPCA"s Multipathway Screening Factors for the ingestion portion of the multipathway risk for potential cancer effects assume exposure over 30 years. |
| Farmer who eats vegetables from his/her garden and meat and dairy products from his/her farm just outside the former LTVSMC ambient air boundary | Total Multipathway Exposure (Inhalation + Ingestion)<br>Long-term, chronic ingestion of vegetables, meat, and dairy products from the farm (including incidental soil ingestion)+ breathing maximum annual air concentration (MEI). The MPCA's Multipathway Screening Factors for the ingestion portion of the multipathway risk for potential cancer effects assume exposure over 40 years. |

All CFEs that are identified as PBTs (i.e., arsenic, dioxins/furans) have multipathway screening factors (Attachment A) in the MPCA's RASS (version 20120302) used in this AERA. The status of all CFEs and risk-driver chemicals in terms of PBTs and multipathway screening factors is listed in Table 5-2. Although diesel particulate itself is not a risk driver nor does it have a multipathway screening factor, arsenic and dioxin/furan emissions are associated with diesel particulate matter and are considered to be PBT chemicals.

**Table 5-2 Multipathway Screening Factors for the Chemicals for Evaluation in the Supplemental Air Emissions Risk Analysis (AERA) Conducted for the Proposed NorthMet Plant Site Near Hoyt Lakes, Minnesota**

| Chemical Name | Risk Driver In the 2012 AERA? | RASS-Multipathway Screening Factor? | RASS-PBT |
|---|---|---|---|
| Acetaldehyde | No | No | No |
| Arsenic Compounds | Yes | Yes | Yes |
| Cobalt compounds | Yes | No | No |
| Crystalline Silica | No | No | No |
| Diesel Particulate (1) | No | No | No |
| Dioxins/Furans (2,3,7,8-TCDD equivalents) | Yes | Yes | Yes |
| Hydrochloric Acid | Yes | No | No |
| Manganese Compounds | No | No | No |
| Nickel Compounds | Yes | No | No |
| Nitrogen oxides(as $NO_2$) | Yes | No | No |

(1) Contributes arsenic and dioxin/furan emissions, which were modeled separately for individual chemical risk estimates.

## 5.3 Estimating Exposure Point Concentrations

Exposure concentrations are used to estimate potential incremental inhalation risk. These exposure concentrations (i.e., air concentrations), are derived through the use of an approved air dispersion model and estimates of maximum or permitted chemical emissions from Version 6 of the Plant Site Emission Inventory. Maximum modeled air concentrations were derived using AERMOD (version 12060). In addition, the OLM protocol approved for use in Plant Site NAAQS modeling was used to model $NO_2$ emissions for the acute (1-hour) exposure.

### 5.3.1 Estimating Emissions

Emission estimates were summarized in Section 4.0. The discussion here provides additional information on the emission estimates for the current Plant Site emission inventory. The emission calculations include the assumption that all operations will occur 24 hours/day 365 days/year at the Process Plant. Construction operations at the Tailings Basin are assumed to occur only from 6AM to 6PM (wind erosion at the Tailings Basin can potentially occur at any time of per day whenever wind speeds exceed the threshold value). Tailings Basin construction emissions from traffic on unpaved roads and tailpipe emissions were also assumed to be limited to the construction season from April through September. Hourly and annual emission rates were calculated and these have been summarized in Large Table 3. The majority of emissions from the

Plant Site come from point sources at the Process Plant. The Potential to Emit (PTE) was primarily based on the information listed below:

- material use and production projections; mass balance
- vendor information on material composition including information disclosed on an MSDS
- engineering analysis and computation, including data from the MetSim process flow simulation produced for the project
- geology and whole rock data for ore compiled by PolyMet
- beneficiation and Hydrometallurgical Pilot Plant data; air, solid, liquid sampling data from the studies completed in 2000, 2005 and 2006
- AP-42 emission factors (Reference (30)) and applicable emission standards

The most recent emission calculations for the NorthMet Project Mine Site were submitted in Version 6 of the emissions inventory submitted on December 17, 2012. An updated emission inventory will be provided with this report or soon thereafter to address comments received on the crystalline silica emission calculations.

Additional discussion for selected categories of emission calculations is provided in the following subsections: point sources, fugitive sources and mobile sources.

#### 5.3.1.1 Point Source Emissions

The majority of sources of emissions associated with Plant Site activities are point sources. The point sources associated with Plant Site activities have been divided into five categories that tend to be similar in nature. The categories are as follows:

- Ore processing operations: Includes the Process Plant operation from the ore railcar dumping to the flotation process where the sulfide minerals are concentrated.
- Autoclave operations: The Autoclave is where the valuable metals are leached from the concentrate using pressure oxidation and related equipment.
- Hydrometallurgical Process Tanks: Includes processes used to separate and recover the valuable metals from the leach solution.
- Process consumables handling sources: These include the handling, transfer and storage of the additives used in the flotation process, the Autoclave and the Hydrometallurgical Processes Tanks.

- Combustion sources and fuel tanks, which includes boilers, heaters, emergency diesel engines and fuel oil and gasoline tanks.

#### 5.3.1.2 Fugitive Sources

The fugitive emission sources at the Plant Site are primarily from:

- Dust emissions from the ongoing construction of the Tailings Basin dams with assumed hours of operations from 6AM to 6PM.

- Wind erosion from the Tailings Basin assumed to occur 24 hours per day, 365 days per year as indicated in the meteorological data.

- Fugitive handling sources, which include the outdoor handling, transfer and storage of the process consumables assumed to operate 24 hours per day, 365 days per year.

#### 5.3.1.3 Mobile Sources

Emissions were calculated for the Tailings Basin dam construction equipment using diesel fuel included VOCs, speciated PAHs, diesel particulate, dioxins/furans, and particulate metals.

Emission calculations for locomotive emissions (diesel fuel combustion) included VOCs, speciated PAHs and metals. These emissions are based on the loading and idling time of the locomotives at the Plant Site. For dioxins/furans, there are no emission factors for locomotives. The dioxin/furans emission factors for heavy duty vehicles were applied to locomotives on a fuel usage basis (References (31), (32)).

#### 5.3.1.4 Particulate Metal Emission Estimate

For the 2007 Plant Site AERA, particulate metal emission estimates were based on total particulate with a diameter cut-point of 30 microns (approx. $PM_{30}$). The same approach was used for this Supplemental AERA.

#### 5.3.1.5 Crystalline Silica

Potential emissions of crystalline silica are associated with ore processing, flotation tailings management and with dust emissions associated with construction of the Tailings Basin dams. Potential crystalline silica emissions from activities involving LTVSMC tailings are calculated using a $PM_4$ basis. The $PM_4$ basis for crystalline silica emissions is used for risk assessment because the California Reference Exposure Level (REL) is based on the definition of inhalable particulate as defined by NIOSH (i.e., $PM_4$). However, the potential crystalline silica emissions from the Process Plant operations (e.g. handling and processing of ore from the Mine Site), are based on total particulate ($PM_{30}$). Further discussion of crystalline silica is included in the "Crystalline Silica in NorthMet Particulate Emissions" (version 2, March 28, 2012) and version 6 of the Plant Site emission inventory.

#### 5.3.1.6 Small Sources Not Modeled

Emission sources were modeled for the AERA under typical operating scenarios so upset conditions or breakdown/malfunction emission scenarios were not evaluated. In addition, a few minor emission sources were screened out of analysis as directed in the AERA guidance.

- *Emergency diesel generators* - Two diesel powered backup generators (Emission Units 128 and 129) will be used at the Plant Site to provide backup in case of a power failure. An additional generator may be installed at the potential Waste Water Treatment Facility at the Tailings Basin. Following MPCA AERA guidance (Reference (14)), the emergency backup generators at the WWTP were not included in the AERA modeling.

- *Diesel powered fire pumps (EU 304 and 305)* – Two diesel powered fire pumps will be used to pump water in case of a fire. Operations are similar to an emergency generator in that emissions only occur during maintenance and testing or during an emergency situation. These sources were not included in the AERA modeling according to MPCA AERA guidance.

- *Diesel and gasoline tanks (EU 325, EU 336 and EU 337)* – One diesel tank and two gasoline tanks to support Plant Site Activities were screened out using MPCA AERA guidance.

- *Fugitive dust from light vehicle traffic* – Fugitive dust from Light vehicle traffic does not result in emissions of any pollutants evaluated in this supplemental AERA.

- *Propane fired boiler and heaters* – A small propane fired boiler is located in the Area Administrative Building. Indirect fired propane heaters will be installed in the Area 1 Shop (EU 334). Propane fired infrared heaters will be located in the Area 2 Shop (EU 130). These emission sources were screened out of the analysis using MPCA AERA guidance.

- *Natural gas or electric heater* – A natural gas or an electric heater will be required to heat the nitrogen used to reactivate the adsorbers in the oxygen plant. For the purposes of the emission calculations, it has been assumed that a natural gas fired heater will be used (EU 335). Potential emissions associated with this natural gas heater are small and using MPCA AERA guidance have been screened out of the analysis.

### 5.3.2 Air Dispersion Modeling

The fate and transport of chemicals, after being emitted from the various Plant Site activities and the tailings basin to ambient air, is dependent on the source release characteristics, meteorological conditions, terrain characteristics, atmospheric physical and chemical processes (pollutant scavenging, wet and dry deposition rates, etc.), physical and chemical characteristics of the compounds, and land use. For this risk analysis the AERMOD model (version 12060) was used to estimate maximum air concentrations for the 1-hour and annual averaging time periods.

Meteorological data used in the modeling are for Hibbing, MN (2006-2010) and they were processed using AERMET (version 11059). Large Figure 2 and Large Figure 3 show the receptor grid.

For this AERA, and consistent with the compliance modeling conducted for Class II areas, a site-specific deposition algorithm was developed for the Plant Site to better represent potential fugitive dust emissions transport and air concentrations. For the AERA modeling the particulate depletion half-life time step was changed from 1,100 seconds ($PM_{10}$ gravitational settling basis used for Class II modeling) to 370 seconds ($PM_{30}$ gravitational settling basis) (Reference (33)). This algorithm is discussed in detail in the addendum to the Mine Site Class II Modeling Protocol submitted to the Minnesota State agencies on March 12, 2012 (Reference (5)) and the Plant Site AERA Work Plan as amended in October 29 2012. Emission estimates of $NO_2$ were modeled using the OLM modeling protocol for acute (one-hour) $NO_2$ concentrations as was approved for the Plant Site $NO_2$ NAAQS modeling. Use of this protocol was suggested by the MPCA on December 4, 2012.

The OLM modeling used USEPA's default conservative assumption that 50% of the $NO_x$ emitted from the stack is present as $NO_2$. The conversion of the remaining 50% of the NOx emissions to $NO_2$ is calculated based on the estimated $NO_2$ and ozone concentrations. If the maximum $NO_x$ concentration is greater than the ozone concentration, the formation of $NO_2$ is limited by the ambient ozone concentration. If the maximum $NO_x$ concentration is less than the ozone concentration, the model assumes complete conversion of $NO_x$ to $NO_2$. Based on stack testing conducted at a variety of sources, typical $NO_2$:$NO_x$ ratios from stack sources are < 10%. There has been much less $NO_2$:$NO_x$ ratio testing conducted on exhaust emission from mobile sources, however the San Joaquin Valley Air Pollution Control District reports ratios ranging from 6 – 25% for trucks (i.e., factors of 0.06 to 0.25) (Reference (34)).

The total Plant Site emission rates that were modeled are presented in Table 5-3 and the maximum modeled air concentrations are provided in Table 5-4. Electronic versions of the input and output files (post-processing files) for the chemicals that were modeled are included with the AERA report submitted to the MPCA.

The maximum modeled air concentrations occur at the PolyMet Plant Site property ownership boundary (Large Figure 4 and Large Figure 5) and are used to assess potential inhalation risks for an off-site worker receptor. In addition, the acute risk estimate at the Plant Site boundary was refined using a risk by receptor approach – the refined risk was calculated using the modeled air concentration of all chemicals evaluated at each receptor. Potential multipathway chronic risks were also assessed for a potential resident and a potential farmer but only for those receptors located outside the former LTVSMC ambient air boundary (see Large Figure 2 and Large Figure 3). Risk to a potential subsistence fisher from mercury emissions was evaluated for areas at several nearby lakes and is discussed in Section 10.0.

**Table 5-3 Estimated Total Plant Site Related Hourly and Annual Emission Rates Modeled for the Supplemental Air Emissions Risk Analysis (AERA) conducted for the proposed NorthMet Plant Site Near Hoyt Lakes, Minnesota**

| Chemical Name | Total Plant Site Emission Rate (grams/second) | |
|---|---|---|
| | Hourly rate | Annual rate |
| Acetaldehyde | 1.66E-05 | 9.49E-07 |
| Arsenic Compounds | 3.03E-03 | 7.75E-04 |
| Cobalt Compounds | | 5.44E-03 |
| Crystalline Silica | | 1.30E+00 |
| Diesel Particulate Matter | | 4.47E-02 |
| Hydrochloric Acid | 2.45E+00 | 2.90E-02 |
| Manganese Compounds | | 5.91E-02 |
| Nickel Compounds | 1.33E-01 | 1.36E-01 |
| Oxides of Nitrogen ($NO_x$ as $NO_2$) | 1.10E+01 | |
| Dioxins/Furans (as 2,3,7,8-TCDD TEQ) | | 1.12E-10 |

**Table 5-4 Maximum Modeled Air Annual and Hourly Air Concentrations Evaluated in the Supplemental Air Emissions Risk Analysis (AERA) Conducted for the Proposed Plant Site Near Hoyt Lakes, Minnesota**

| Chemical Name | PolyMet Plant Site Ownership Boundary Maximum Modeled Air Concentrations Hourly ($\mu g/m^3$) | PolyMet Plant Site Ownership Boundary Maximum Modeled Air Concentrations Annual ($\mu g/m^3$) | Former LTVSMC Ambient Air Boundary Maximum Modeled Air Concentrations Annual ($\mu g/m^3$) |
|---|---|---|---|
| Acetaldehyde | 1.48E-03 | 6.69E-07 | 1.20E-07 |
| Arsenic compounds | 2.20E-02 | 7.43E-04 | 3.27E-05 |
| Cobalt compounds | | 5.87E-03 | 2.32E-04 |
| Crystalline Silica | | 2.55E-01 | 4.75E-02 |
| Diesel Particulate Matter | | 5.26E-01 | 4.38E-02 |
| Hydrochloric Acid | 9.38E+02 | 7.26E-02 | 7.12E-03 |
| Manganese compounds | | 5.48E-02 | 1.95E-03 |
| Nickel compounds | 2.94E+00 | 1.64E-01 | 6.18E-03 |
| Nitrogen Dioxide($NO_2$)(1) | 2.39E+02 | | |
| Dioxins/Furans (as 2,3,7,8-TCDD TEQ) | | 8.14E-10 | 6.85E-11 |

(1) Estimated $NO_2$ concentrations were modeled using the approved Plant Site OLM protocol approved for NAAQS modeling.

## 5.4 Receptor Locations and Risk Concept Applications

Reasonably expected future land use is a critical consideration for a risk assessment with regard to receptor locations and application of risk concepts. Resident and/or farmer receptors are assessed where residential and/or farming land use has the potential to occur in the future. When other future land use prohibits residential and/or farming land uses in specific areas, risks are typically not estimated for the farmer or resident receptor at those locations.

With regard to the Plant Site, PolyMet's projected land holdings and the entire plant location are within the corporate boundaries of the city of Hoyt Lakes on industrial lands within the former LTVSMC ambient air boundary (see Large Figure 2 and Large Figure 3). As a result of this past land use and current zoning there are not currently any residential or farming developments within the former LTVSMC ambient air boundary, nor is there the potential for a future resident or farming operations to be in this area. Therefore, potential multipathway impacts are evaluated for a potential farmer and resident receptor at the former LTVSMC ambient air boundary.

### 5.4.1 Maximum Exposed Off-property Receptor

Under the RME exposure concept used to assess the chronic off-site worker risk estimates, it was assumed that a hypothetical person is present at the location of maximum modeled concentrations regardless of whether or not conditions indicate that an off-site worker would be present for the concept duration and frequency.

Under the MEI exposure concept used to assess multipathway resident and farmer risk estimates, it was assumed that a hypothetical person is present at the locations of maximum modeled concentrations regardless of whether or not anyone lives, or has the ability to live at this location, or in the general area. There are currently no actual residents or farmers in the areas adjacent to either the Plant Site property ownership boundary or the former LTVSMC ambient air boundary and no individuals are expected to be residing in these areas in the foreseeable future during active mining operations. In addition, soil, current forest vegetation, and climate indicate that any future farming development in this area is highly unlikely. Therefore, the assumption that a resident or farmer is present at the former LTVSMC ambient air boundary likely overestimates the potential risk to any "real" receptor.

### 5.4.2 Indoor Air versus Outdoor Air

For the farmer and resident receptors, it was further assumed that the hypothetical individual is continuously exposed to outdoor air for a lifetime (24 hours per day, 365 days per year, for 70 years). In reality people spend a considerable amount of time indoors, where concentrations of project related emissions are most likely lower. For the maximum off-site receptor assessed for chronic off-site worker risks, it was assumed that the hypothetical individual is exposed to outdoor air for an entire "career" (8 hours per day, 250 days per year, for 25 years). Assumptions regarding, exposure, receptor location, toxicity, and type of exposure can be found in Large Table 1 and Large Table 2. Because it is unlikely for an actual worker to be exposed to outdoor air at this site for an entire career, the potential inhalation risks for the off-site worker are overestimated.

It has been estimated that U.S. residents spend only 6% of a day outdoors and 87% of a day indoors (Reference (35)). Concentrations of particulate metal in air, associated with potential emissions from the proposed Mine Site operations, are different for indoor versus outdoor environments. When people are indoors, they reduce their exposure to outdoor air contaminants. A recent study measured the contribution of outdoor air concentrations of $PM_{2.5}$ to indoor air, and to personal exposure (as measured by subjects wearing a personal environmental monitor) in Los Angeles, CA, Houston TX, and Elizabeth NJ. The mean percent contribution of outdoor $PM_{2.5}$ to indoor air was 60% (Reference (35)). The mean concentration of outdoor $PM_{2.5}$ to personal exposure was even lower, 26%. Most sources of indoor air pollutants are released from within buildings (Reference (36)). However, for the MEI exposure concept, it was conservatively assumed that a person would be outdoors continuously. In addition, it was assumed that all metals in ambient air would be in the respirable size range, bioaccessible, and bioavailable (less than or equal to 10 microns in diameter).

## 5.5 Changes to AERA Methodology Compared to the March 2007AERA

For the most part, the methodology used in this Supplemental AERA is the same or similar to that used in the March 2007 Plant Site AERA. Changes that are not specified in detail in the work plan for the Supplemental AERA are described here.

- The most recent versions of the RASS and AERMOD were used for the Supplemental AERA. As a result, cobalt was added as a CFE because it now has an inhalation toxicity value (provisional value; discussed in Attachment B) in addition to pollutants described in the Work Plan.

- The air dispersion modeling included plume depletion half-life terms to model deposition of particulate sources in the Supplemental AERA (see Section 5.3.2 for more details) to better represent transport and fate of particulate dust.

- The Plant Site OLM-modeling protocol for the $NO_2$ NAAQS was used to model acute (1-hour) $NO_2$ concentrations.

- Diesel fuel combustion emissions and particulate metal emissions from fugitive dust associated with dam construction related mobile sources at the Tailings Basin were added to the analysis.

## 6.0 Toxicity Assessment

The objective of the toxicity assessment is to identify potentially toxic effects caused by chemicals of interest and to examine the dose-response relationship. For this Supplemental AERA, all of the CFE have toxicity values available in the MPCA's RASS (version 20120302). These toxicity values were used in this AERA without modification. No alternative toxicity values were used in this evaluation.

### 6.1 Toxicity Endpoints Evaluated for the CFE

There are 10 CFE in this AERA. The toxicity values used for analysis were those in the RASS. The CFEs and their health endpoints as assessed in the RASS are listed in Table 6-1.

**Table 6-1 Toxicity Endpoints Evaluated for Chemicals for Evaluation for the Plant Site**

| Chemical For Evaluation | Evaluated for Noncancer Effects | Evaluated for Cancer Effects |
|---|---|---|
| Acetaldehyde | x | x |
| Arsenic Compounds | x | x |
| Cobalt Compounds | | x |
| Diesel Exhaust Particulate | x | x |
| Hydrochloric Acid | x | |
| Manganese Compounds | x | |
| Nickel Compounds | x | x |
| Nitrogen Oxides | x | |
| Silica, crystalline | x | |
| Dioxin/Furans (2,3,7,8-TCDD equivalents) | x | x |

# 7.0 Quantitative Risk Estimates (Risk Characterization)

## 7.1 General Methodology

Risk characterization is the process whereby exposure point concentrations and toxicity information are combined to generate estimates of potential health risks. These estimates are compared to acceptable incremental guideline risk values. The USEPA (Reference (37)) defines risk characterization as the process that "*... integrates information from the preceding components of the risk assessment and synthesizes an overall conclusion about risk that is complete, informative, and useful for decision makers. ...*". However, because of the limitations inherent in the risk assessment process it is very important to recognize that the risk characterization in this AERA or any health risk assessment cannot predict actual health outcomes, such as cancer. In other words, this or any health risk assessment does not provide an estimate of actual risk to a real person.

In the AERA process, "quantitative analysis" specifically refers to the estimation of additional lifetime potential cancer risks and potential noncancer health effects using the MPCA's RASS. The most recent electronic version of the RASS (version 20120302) was obtained from the MPCA. An individual RASS file was then set up to estimate potential risks at the Plant Site projected ownership boundary (inhalation only for an off-site worker, acute (1-hour) and chronic) and at the former LTVSMC ambient air boundary (multipathway risks for a famer and resident).

The highest estimated noncancer acute inhalation risks occur at the Plant Site property ownership boundary and are applied to a potential off-site worker receptor. Potential acute inhalation risks at the more distant former LTVSMC ambient air boundary were also estimated for a potential resident and/or farmer receptor.

Guideline values for incremental cancer risk (from the MDH, 1E-05) and noncancer risk (HQ or HI = 1) are reported to one significant figure per USEPA guidance (References (18), (38)) (e.g., incremental cancer risk would be reported as 1E-06 or noncancer risk of 0.8). However, sometimes intermediate risk estimates and the final risk estimates from the MPCA's RASS are shown to two significant figures for completeness and for comparison to the estimated risks for health endpoints.

Further details on the methodology and assumptions used to calculate potential risk estimates can be found in Attachment C.

## 7.2 Risk Results

### 7.2.1 Off-Site Worker Potential Inhalation Risks at the PolyMet Ownership Boundary

Risk results obtained from the individual RASS runs are summarized in Table 7-1. Risks for acute and chronic exposures are summarized below.

#### 7.2.1.1 Non-cancer Acute (1-hour)

- Estimated potential inhalation acute health risks for individual chemicals (HQs) were below the guideline value of 1.

- Estimated potential summed inhalation acute health risk based on maximum modeled air concentrations at any location expressed as a Hazard Index (HI) was 1.2 (which rounds to 1) compared to a guideline value of 1. The risk-driver chemicals for acute inhalation risk, based on maximum estimated air concentrations, are $NO_2$ (HQ = 0.5), hydrochloric acid (HQ=0.4), and nickel compounds (HQ=0.3) and arsenic compounds (HQ=0.1).

- The potential risk from $NO_2$ is based on $NO_2$ air concentrations estimated using the MPCA approved Plant Site OLM modeling protocol.

- The acute RRE for sulfuric acid is HQ=0.03 (included in the summed acute inhalation risk).

- Estimated risks calculated for the 2012 Supplemental AERA are in the same range as the risks calculated for the March 2007 AERA.

#### 7.2.1.2 Non-cancer, chronic

- Estimated potential noncancer chronic inhalation risks for the individual chemicals evaluated were below the Hazard Index guideline value of 1.0.

- The summed potential noncancer chronic inhalation risk, for all chemicals combined, regardless of toxic endpoint, is 1.1 and does not exceed the guideline value of 1 when rounded to one significant digit.

- The summed potential noncancer chronic inhalation risk for the respiratory endpoint, which is the endpoint having the highest estimated risk, is 1.0, which does not exceed the guideline value of 1.

- The risk driver chemicals for chronic noncancer inhalation risk are nickel compounds (HQ=0.8), and cobalt (HQ=0.2).

- Estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the March 2007 AERA.

#### 7.2.1.3 Cancer, chronic

- Estimated potential inhalation cancer risks for the individual chemicals evaluated were below the MDH guideline value of 1E-05.

- The summed potential cancer chronic inhalation risk for all carcinogens combined, regardless of the mode of action, is 1E-05, which does not exceed MDH cancer risk guideline of 1E-05.

- The risk driver chemicals for chronic cancer risk are nickel compounds (6E-06) and cobalt (4E-06).

- Estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the March 2007 AERA

### 7.2.2 Farmer and Resident Receptor Risks at the Former LTVSMC Ambient Air Boundary

#### 7.2.2.1 Noncancer, acute inhalation

- Estimated potential inhalation acute health risks for individual chemicals (HQs) were below the guideline value of 1.

- Estimated potential summed inhalation acute health risk using maximum concentrations regardless of toxic endpoint, expressed as a Hazard Index (HI), was 0.5, and is less than the guideline value of 1.

- The risk-driver chemical for acute inhalation risk is nitrogen dioxide (HQ = 0.4).

- The acute RRE for sulfuric acid is HQ=0.009 (included in total risk).

- Estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the March 2007 AERA

#### 7.2.2.2 Noncancer, multipathway chronic

- Estimated potential multipathway noncancer chronic risks for individual chemicals (HQs) did not exceed the guideline value of 1.

- Estimated potential summed noncancer chronic risk for both a farmer and resident receptor, regardless of toxic endpoint, equals 0.2 and is less than the guideline value of 1.

- The risk-driver chemical for multipathway chronic noncancer risk is nickel compounds (HQ=0.1) for both a farmer and resident.

- Estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the March 2007 AERA

#### 7.2.2.3 Cancer, multipathway chronic

- Farmer Receptor:
    - Estimated summed potential cancer risks for all carcinogens combined regardless of target organ is 1x10-5 which does not exceed the MDH guideline value of 1x10-5.
    - Risk-driver chemicals for multipathway exposure (food consumption and inhalation) are dioxins/furans (6x10-6), nickel compounds (3x10-6), and cobalt (2x10-6).
    - The indirect exposure pathway (consumption of home grown produce, dairy and meat) contributes about 54% of the estimated potential incremental risk.
- Resident Receptor:
    - Estimated summed potential risks for all carcinogens combined, regardless of target organ, is 5x10-6 and does not exceed the MDH guideline value of 1x10-5.
    - Risk-driver chemicals for multipathway exposure (food consumption and inhalation) are nickel compounds (3x10-6), and cobalt (2x10-6)
- For both the Farmer and Resident receptors, estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the March 2007 AERA

**Table 7-1 Comparison Summary of the Estimated Incremental Human Health Risks for the Supplemental Air Emissions Risk Analysis (AERA) Conducted for the Proposed NorthMet Plant Site near Hoyt Lakes, Minnesota**

| Exposure Route | Exposure Scenario | Receptor | Potential noncancer effects (Hazard Index)[1] | | Potential cancer effects (Risk Estimate)[2] | |
|---|---|---|---|---|---|---|
| | | | 2007[3] | 2012[4] | 2007[3] | 2012[4] |
| Inhalation Only Exposure | Acute (1 hour)[5] | Off-Site Worker<br>Plant-Site property ownership boundary | 1 | 1[6] | N/A | N/A |
| | Acute (1 hour)[5] | Resident at former LTVSMC ambient air boundary | 0.2 | 0.5[6] | NA | NA |
| | Chronic (greater than 1 year) | Off-site Worker (RME)<br>Plant-Site property ownership boundary | 0.5 | 1 | $3x10^{-6}$ | $1x10^{-5}$ |
| Multipathway Exposure<br>Receptors are at the former LTVSMC ambient air boundary[5] | Chronic-total multipathway (Inhalation + incidental soil ingestion + food consumption) | Farmer (MEI-for inhalation, RME for ingestion for cancer effects) | 0.2 | 0.2 | $5x10^{-6}$ | $1x10^{-5}$ |
| | | Resident (MEI for inhalation, RME for ingestion for cancer effects) | 0.2 | 0.2 | $4x10^{-6}$ | $5x10^{-6}$ |

MEI = Maximum Exposed Individual; for chronic risk, exposure to the maximum modeled air concentration is assumed to occur 24 hours per day for 365 days per year.

RME = Reasonable Maximum Exposure for an off-site worker; exposure 8 hours per day, 250 days per year.

N/A = not applicable and not assessed

(1) Hazard Index is the sum of individual non-cancer chemical risks for acute or chronic exposure. Risks were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version as current at the time the analysis was conducted) and rounded to 1 significant figure per USEPA 2005 HHRAP guidance. Incremental non-cancer (chronic and acute) guideline value is 1.

(2) Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version 20120302) and rounded to 1 significant figure per USEPA 1989 RAGS and 2005 HHRAP guidance. Incremental cancer risk guideline value is 1E-05, MDH.

(3) Risk estimates are as presented in the 2007 Plant Site AERA. Chronic inhalation risks are based on RME exposure at the PolyMet Plant Site ownership boundary. Multipathway risks are based on MEI exposure at the former LTVSMC ambient air boundary. Acute risk is based on maximum concentrations at the PolyMet ownership boundary and the former LTVSMC ambient air boundary.

(4) Risk estimates for the current Project Description as of October 2012. Chronic inhalation risks are based on RME exposure for an off-site worker at the PolyMet Plant Site ownership boundary. Multipathway risks are based on MEI exposure at the former LTVSMC ambient air boundary. Acute risk is based on maximum concentrations at the PolyMet ownership boundary and the former LTVSMC ambient air boundary.

(5) For the current risk analysis and the 2007 AERA, the HI for Acute risk includes the risks estimated for $NO_X$ emissions (evaluated as $NO_2$). The 2007 analysis used a conversion factor of 0.75 to estimate $NO_2$ concentrations from modeled $NO_X$ concentrations. In the 2012 analysis, the Plant Site OLM modeling protocol was used to estimate acute (1-hour) $NO_2$ concentrations. See Section 5.3 for additional information on the OLM modeling protocol.

(6) The acute RRE for sulfuric acid is 0.026 at the Plant Site Boundary. The RRE was added to the HI estimated from modeled concentrations HI + RRE = 1 at the Plant Site Boundary. The acute RRE for sulfuric acid at the former LTVSMC boundary = 0.017*(1-45%)=0.009. The RRE was added to the HI: HI + RRE = 0.5 at the former LTVSMC boundary

## 7.3 Assessment of Early Life Sensitivity and Exposure to Carcinogens

Animal studies have shown that young animals (e.g. birth to weaning) can be more sensitive to exposure to some carcinogens than adult animals. The chemical cancer potency can be greater when animals are exposed early in life, depending on how the chemical causes cancer (mode of action). Both USEPA and MDH recommend adjusting cancer risk estimates to account for early life exposure (Reference (39)). This is especially true for chemicals which are carcinogens by the mutagenic mode of action. Additionally, MDH recommends applying age adjustments to all linear carcinogens regardless of mode of action. Potential cancer risks can be adjusted for early life exposure using Age Dependent Adjustment Factors (ADAFs) (Reference (39)).

Age adjustments for early life exposure are sometimes incorporated into toxicity values (i.e. slope factor or inhalation unit risk) themselves. When this occurs, cancer risk estimates using these values are considered already adjusted for early life exposure. Five of the CFE were assessed for potential cancer effects; acetaldehyde, arsenic compounds, cobalt compounds, nickel compounds, and dioxins/furans (as 2,3,7,8-TCDD equivalents). Diesel engine exhaust has recently been classified as a carcinogen by the International Agency for Research on Cancer. Currently, a toxicity value to assess potential cancer effects is not available for diesel engine exhaust (or diesel particulate matter). However, carcinogenic constituents of diesel particulate matter (i.e. arsenic, dioxins/furans, PAHs) were evaluated for potential cancer risks in this AERA. A summary relating to their carcinogenicity is in Table 7-2.

**Table 7-2 Assessment of Carcinogens in Terms of Adjustments for Early Life Exposure**

| Chemical For Evaluation Evaluated as a Carcinogen | MPCA Status In terms of Early Life Adjustment (Reference (40)) | Action Taken in the AERA |
|---|---|---|
| Acetaldehyde | Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment. | None<br>(Not a risk driver) |
| Arsenic Compounds | On MPCA list of Pollutant of Interest in terms of age adjustment | None<br>(Not a risk driver) |
| Cobalt Compounds | Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment. | None<br>PPRTV documentation recommends against age adjustment for cobalt because the mutagenic mode of action has not been clearly established for cobalt<br>(Reference (41)) |
| Diesel Particulate Matter | Currently not evaluated as a carcinogen in the RASS. | None<br>(Constituents of diesel particulate matter that are risk drivers such as arsenic, cobalt compounds, nickel and dioxins/furans were assessed separately) |
| Nickel Compounds | Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment. | Adjusted Risk Estimate<br><br>(MDH Toxicity Value in RASS is from IRIS, and does not appear to be age adjusted) |
| Dioxin/Furans (2,3,7,8-TCDD equivalents) | On MPCA list of Pollutant of Interest in terms of age adjustment | None<br>MDH advises against age adjustment for dioxins/furans (Reference (40)). |

Cobalt compounds, nickel compounds, and dioxins/furans were the only CFE which were risk drivers for carcinogenicity at the Plant Site boundary. Early life exposures are not expected to occur at the Plant Site boundary, given the current and reasonably foreseeable future land use and industrial/mining zoning. Therefore, adjustments to inhalation cancer risk estimates at the Plant Site boundary were not made.

The risk drivers for the resident and/or farmer cancer risk by multipathway exposure at the former LTVSMC ambient air boundary are cobalt, nickel and dioxins/furans. The MDH recommends against making age adjustments for dioxins/furans, although the MPCA has noted that the toxicity value for dioxins/furans in the current version of the RASS has been age adjusted. The toxicity values in the RASS for cobalt and nickel were not age adjusted. PPRTV

documentation recommends against age adjustment for cobalt because the mutagenic mode of action has not been clearly established for cobalt (Reference (41)).

MPCA recommends multiplying the cancer risk estimate by 1.6 to account for early life exposure. If the cancer risk estimate for nickel is multiplied by 1.6, and added to the total cancer risk estimate, the age adjusted risk remains at or below the MDH guideline of 1E-05 for both the farmer and the resident. No additional adjustments were made to the cancer risk estimates to incorporate early-life sensitivity.

The potential cancer risks after adjusting the cancer risk estimate for nickel are shown in Table 7-3.

**Table 7-3 Multipathway Resident and Farmer Age Adjusted Cancer Risk Estimate based on Early Life Exposure Age Adjustment for Nickel**

| | Multipathway Farmer Cancer Risk | Multipathway Resident Cancer Risk |
|---|---|---|
| Total Cancer Risk (unadjusted) | 1 E-05 | 5E-06 |
| Unadjusted risk estimate for nickel compounds | 3E-06 | 3E-06 |
| Age adjusted risk estimate for nickel compounds[1] | 5E-06 | 5E-06 |
| Age Adjusted Total Cancer Risk Estimate[2] | 1E-05 | 7E-06 |

(1) Age Adjusted Nickel Risk = Unadjusted Nickel Risk X 1.6
(2) Age Adjusted Total Cancer Risk = Unadjusted Total Cancer Risk – Unadjusted Nickel Risk + Age Adjusted Nickel Risk
***Additional details regarding early exposure age adjusted risk is provided in Attachment D.***

Additional discussions of the toxicity values found in the MPCA's RASS (version 20120302) for the CFE evaluated in this Supplemental AERA may be found in Attachment B and details regarding the early exposure age adjusted risk may be found in Attachment D.

## 7.4 Percent of Emissions Assessed; Potential Additional Risk from Chemicals Not Evaluated Quantitatively for Risks

In the 2007 Plant Site AERA, a total of 74 CFPE were identified. Of these, 64 chemicals had emissions quantified in both the 2007 and 2012 emission inventories. Of the 64 chemicals in the EI, 44 were identified as CFE for the 2007 analysis. Of the 44 CFE, 3 were identified as "risk driver chemicals" (cancer risk of 1E-06 or greater; noncancer risk of 0.1 or greater). The other 36 CFE were identified as being insignificant for risk. The 3 risk driver chemicals from the 2007 Plant Site AERA (i.e., nickel, $NO_2$, and arsenic) were quantitatively assessed in this Supplemental AERA in addition to other chemicals discussed in Section 4.0. Because the other 36 CFE from the 2007 Plant Site AERA had very small estimates of potential risk, excluding

them from this Supplemental AERA does not have an effect on the final estimated risks for this analysis. The estimated risk from these screened out chemicals is discussed in Section 4.4

There were 20 chemicals not evaluated quantitatively in the 2007 Plant Site AERA because toxicity factors were not available for these chemicals at the time. Since 2007 toxicity values have become available for some of these chemicals and were thus included in this Supplemental AERA quantitatively. When the Supplemental AERA and the 2007 AERA are considered together, 48 chemicals, or about 93% of the emission inventory has been quantitatively evaluated for risks. Most of the unevaluated mass is from emissions of methyl isobutyl carbinol and nitrous oxide ($N_2O$).

## 7.5 Conclusions - Potential Incremental Human Health Risks

The potential health risks related to potential Plant Site air emissions were calculated based on the maximum modeled air concentrations at specific receptors assuming operations at the Plant run 24 hours/day, 365 days/year and dam-related construction operations at the Tailings Basin are assumed to run from 6AM to 6PM. The following conclusions can be made based on this 2012 AERA:

- the potential incremental acute, chronic noncancer, and cancer inhalation risks using maximum modeled air concentrations for a potential off-site worker at the PolyMet Plant Site ownership boundary do not exceed the guideline values

- potential total multipathway cancer and noncancer chronic risks (inhalation + indirect pathways) estimated for a future resident and farmer receptor at the former LTVSMC ambient air boundary do not exceed the MDH guideline value of 1E-05 for potential cancer risks or 1 for potential non-cancer risks

- the potential incremental acute inhalation risk is less than the guideline value of 1 at the former LTVSMC ambient air boundary

- potential incremental cancer risk at the former LTVSMC ambient air boundary for the farmer and resident do not exceed the MDH guideline of 1E-05 when adjusted for early life exposure

In summary, taking into account the conservatism in the emission estimates, toxicity values, multipathway screening factors, and the assumption that each particulate metal is in the respirable size range and is 100% available for absorption, adverse human health impacts are not expected to be associated with the potential air emissions from the proposed Plant Site operations evaluated in this AERA.

# 8.0 Uncertainty Analysis

## 8.1.1 General Conservatism in the Risk Estimates

Conservative assumptions are those that tend to maximize estimates of exposure (References (4), (18)). As part of the risk assessment process, risks are estimated as a function of exposure and toxicity. The combination of several conservative assumptions can lead to unrealistically conservative bounding estimates (References (4), (18)), with the result that the potential estimated risks are likely to be greatly overestimated. Combining maximum exposure point concentrations with maximum values for exposure frequency and duration in combination with upperbound toxicity values, results in a potential cancer risk estimate that may be thousands of times greater than those for the average exposed individual. The use of the MEI and RME concepts, assumptions about metal speciation and bioavailability, and the way toxicity factors and emission factors are used, all contribute to an assessment that overestimates potential exposure and risks.

In this Supplemental AERA the following represent sources of conservatism that result in overestimation of potential human health risks:

- use of maximum modeled air concentrations as the dose for each chronic receptor
- the assumption that the maximum modeled concentrations all occur at the same receptor when estimating potential chronic risks and acute inhalation risk at the former LTVSMC ambient air boundary; the exception is for the refined estimate of acute inhalation risk at the PolyMet Plant Site operating boundary where the risk-by-receptor approach was used
- the assumption that receptors will be exposed to the maximum modeled ambient air concentration for the entire chronic time period
- for chronic multipathway risk, the toxicity values used in the MPCA's RASS make dosimetric adjustments for human exposures and exposure adjustments which assume exposure 24 hours/day, 365 days/year for 70 years
- the risk estimates for non-carcinogens are summed across all toxicity endpoints, regardless of potential toxic effects
- the risk estimates for carcinogens are summed for all types of cancer endpoints, regardless of the type of cancer the chemical is associated with causing
- assumption that metals inherent to the mineral structure of a rock particle are 100% bioavailable and in the respirable size fraction ($PM_{10}$ or smaller)

## 8.2 Conservatism in the Quantitative Health Risk Assessment Due to Uncertainty and Variability

The risk assessment process is subject to uncertainty and variability from a variety of sources. These are inherent in the risk assessment process and are not unique to this AERA. Uncertainties represent incomplete knowledge about certain parameters, and the values of the parameters generally depend upon limited data and model predictions. Variability, on the other hand, represents true heterogeneity and inherent differences within a population, across geographic regions, and throughout a given time period (Reference (42)). Variability is inherent in any group of people.

The main difference between uncertainty and variability is that variability can only be better characterized, but not necessarily reduced. In addressing uncertainty and variability, the AERA methodology and the risk assessment approach in general is to add conservatism to specific components of the risk analysis (e.g., emission estimates, potential exposures, modeled air concentrations, etc.).

The major sources of uncertainty for this AERA are briefly discussed in the following sections.

### 8.2.1 A Summary of Sources and Direction of Uncertainty and Variability in Risk Analysis Parameters

The major sources of uncertainty for this AERA are found in Table 8-1 and are discussed in further detail in Attachment E. Sources of variability in the analysis are found in Table 8-2.

**Table 8-1 Summary of Sources and Direction of Uncertainty in the Parameters used for the Supplemental Air Emissions Risk Analysis (AERA) for the Proposed NorthMet Plant Site near Hoyt Lakes, Minnesota**

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| **Exposure Assessment** | | | |
| Basis of Chemical Selection | AP-42: Compilation of Air Pollution Factors | May under- or over-estimate potential risk | Low |
| | All chemicals of potential significant impact which have toxicity values for comparison | May under- or over-estimate potential risk | Low |
| | Professional judgment and acceptance by reviewing agency | May under – or over-estimate risk | Low |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| Emissions<br>Emissions | Controlled potential emissions used in all standard calculations including AERMOD inputs from emission inventory. | Overestimates potential risk | Moderate |
| | Assumption that all operations at the Process Plant occur 24 hours/day for 365 days/year (except for Tailings Basin construction activities, which are seasonal) | Overestimates potential risk | Moderate |
| | Use of highest projected annual fuel usage for any year for on-site construction vehicles | Overestimates potential risk | Moderate |
| | Estimating dioxin emissions from haul trucks. For this 2012 AERA, USEPA's emission factor for dioxin/furans was not based on burning low sulfur fuels or new engine technologies, but was derived from a 1996 tunnel study using diesel formulations from the 1990's. The diesel engines at the Plant Site are required to burn low sulfur fuels and may have newer engine technologies. Although these changes were made to reduce criteria pollutant emissions, including products of incomplete combustion, the exact impact of these changes on the dioxin/furan emission factor is not known. Recent research by USEPA (Reference (10)) indicates emissions based on older formulations of diesel fuel are higher compared to emissions from recent diesel fuel formulations. | Likely overestimates potential risk | Moderate |
| | Did not evaluate impacts from sources that occur intermittently for short periods of time such as emissions from use of the emergency generators or diesel powered fire pumps. However, if these types of sources are in operation then other parts of the process are likely shut down or have reduced operations and overall emissions from the facility would likely be lower than at full operation. | Likely no effect on estimated risks | Likely no effect on estimated risks |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| Emissions | All sources of emissions were modeled except those that did not emit the pollutants included in the supplemental AERA or sources that were excluded per MPCA Guidance or according to AERA guidance. | Likely no effect on estimated risks | Likely no effect on estimated risks |
| Air Dispersion Modeling | Meteorological data from a single station input to AERMOD | May under- or over-estimate potential risk | Moderate |
| | Air dispersion modeling was conducted with the AERMOD model. For the 2007 analysis, AERMOD was run in regulatory mode. For the 2012 analysis, a deposition algorithm utilizing the half-life modeling in AERMOD was used to better represent fugitive dust emissions. This overestimates potential air concentrations. | Overestimates potential risk | Moderate |
| | Comparison to air monitoring data that shows model results are generally within a factor of 2. 40 CFR Part 51 Appendix W states “1) Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and 2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area” (Reference (43)) | Overestimates potential risk | Moderate |
| | Assumption of 50% in stack conversion of NO to $NO_2$ in the OLM modeling. | Overestimates potential risk | Moderate |
| Exposure point concentrations | Used maximum modeled air concentrations for chronic risk estimates. | Overestimates potential risk | Moderate |
| | Assumed that the worst case meteorological conditions over a five year period are representative of conditions over the exposure duration for chronic risk estimates. This is the same approach used for demonstrating compliance with ambient air quality standards. | Overestimates potential risk | Moderate |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| Exposure parameters | It is very unlikely that an individual would be living near the boundary of the facility or at the former LTVSMC ambient air boundary. An individual would not be outside 24 hours/day, 7 days/week, for 365 days/year in Minnesota | Overestimates potential risk | High |
| | RME Concept, chronic inhalation risk for an off-site worker. It is very unlikely that an individual would be working outside at the PolyMet boundary for an entire career of 8 hours/day, 5 days/week, 250 days/year. | Overestimates potential risk | High |
| Multipathway screening factors | The development of the MPS Factors was not site-specific, and as a result their level of accuracy is unknown. | May under- or over-estimate potential risk | Moderate |
| | The RASS only evaluates chemicals with an inhalation benchmark. Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks. Of these chemicals, only the PAHs are considered PBT chemicals. PAHs that were evaluated quantitatively in 2007 were screened out of the supplemental 2012 AERA according to the Work Plan for this Supplemental AERA and MPCA AERA guidance. | May underestimate potential risk | Low |
| **Toxicity Assessment** | | | |
| Acute toxicity values | Extrapolation from longer term studies to a 1 hour equivalent. | May overestimate potential risk | Low |
| | Incorporation of uncertainty factors, modifying factors, safety factors, and exposure frequency and duration into the toxicity values. | May overestimate potential risk | Moderate |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| Chronic noncancer toxicity values | Primarily derived from animal studies which often use of the most sensitive species/strain/sex | May overestimate potential risk | Moderate |
| | Use of data solely from positive studies | May overestimate potential risk | Moderate |
| | Assumption that absorption of the chemical evaluated is the same as the absorption of the chemical used in toxicity testing. | May under- or over- estimate potential risk | Moderate |
| | Incorporation of uncertainty factors, modifying factors, and safety factors | May overestimate potential risk | Moderate |
| | Toxicity values are primarily derived high doses while most environmental exposures are at low doses | May overestimate potential risk | Moderate |
| | Toxicity value for a single chemical may not incorporate all possible endpoints | May underestimate potential risk | Moderate |
| | Use of surrogate toxicity values to represent chemical mixtures | May under-or over-estimate potential risk | Moderate |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| Cancer toxicity values | Use of cancer unit risk/slope factors which are generally upper 95$^{th}$ % confidence limits derived from the linearized model. General assumption of linear non-threshold dose/response | Overestimates potential risk | Moderate |
| | Cancer unit risk/slope factors are primarily derived from animal studies. Use of data from most sensitive species/strain/sex. Use of data solely from positive studies. | May overestimate potential risk | Moderate |
| | For carcinogens when the Unit Risk is based on the 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as the risks from a number of carcinogens are summed (Reference (11)). | Overestimates potential risk | Moderate |
| | Use of nickel unit risk value (from IRIS) which is derived from studies using nickel subsulfide in refinery dust. Nickel cancer potency is very dependent on the solubility and speciation of each nickel compound. The bioaccessibility and bioavailability of the nickel compounds from Plant Site operations is not known. | Overestimates potential risk | Moderate |
| | Use of provisional toxicity value (PPRTV) in the RASS for cobalt (a worker exposure value) to assess potential risks cancer risks. | Overestimates potential risk | Moderate |
| | Use of PAH toxicity values that are derived by extrapolation and are considered to be highly uncertain. PAHs were assessed in 2007 and 2012. None of the PAHs assessed were risk drivers in either analysis. | Likely no effect on estimated risks | Likely no effect on estimated risks |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| Multipathway Screening Assessment | 2007: Speciated PAH compounds, beryllium, cadmium, and lead were evaluated for multipathway risks using the MPCA's Risk Assessment Screening Spreadsheet (RASS). These chemicals had insignificant risks. Some persistent chemicals did not have Multipathway Screening Factors (e.g., arsenic) and were excluded from the indirect pathway risk estimates.<br>2012: All chemicals for evaluation considered PBT had screening factors (arsenic, dioxins/furans). The PBT chemicals evaluated in the 2007 AERA (e.g., speciated PAH compounds) had insignificant risk and were screened out of evaluation for the 2012 analysis according to AERA guidance. | May underestimate potential risk | Low |
| | The RASS only evaluates chemicals with an inhalation benchmark. Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks and are not evaluated for multipathway exposure (ingestion plus inhalation). Of these chemicals only the PAHs are considered PBT chemicals. PAHs that were evaluated quantitatively in 2007 were screened out of the supplemental AERA because of insignificant risks according to AERA guidance. | May underestimate potential risk | Low |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| **Risk Characterization** | | | |
| Inhalation Risks | Assumption that all metals exist in a physical form and size range that makes them 100% bioavailable by inhalation and in a respirable size range. As determined in Version 5 of the emission inventory, about 31% of the metal emissions for the Plant Site are associated with rock handling operations. Metals from rock handling are much more likely to be inherent to the mineral structure of the rocks and present as compounds. Therefore, it is very unlikely that 100% of metals will be in a respirable size range and be bioavailable by inhalation. In terms of multipathway exposure, it is unlikely that 100% of the metals will be bioavailable by ingestion. | Overestimates potential risk | High |
| | Assumed that the chemicals assessed in the risk analysis (e.g., particulate metals) are in the same form as the chemicals upon which the toxicity values are based. | Overestimates potential risk | Moderate |
| | Assumed that all chemicals have an additive effect. | Overestimates potential risk | Moderate |
| | Upper bound values for exposure parameters were used. | Overestimates potential risk | High |
| | Assumed that all noncarcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects. | Likely overestimates potential risk | Moderate |
| | Assumed that all carcinogenic unit risks have the same weight of evidence for human carcinogenicity. | Overestimates potential risk | High |
| | Acute risk for sulfuric acid was determined using an RRE based on 2007 modeled concentration and not 2012 modeled concentrations | May under or overestimate potential risk | Low |

| Risk Analysis Component | Comment | Effect on Risk Estimate | Overall Impact |
|---|---|---|---|
| | Chemicals without toxicity values could not be directly evaluated. | Underestimates potential risk | Low |
| | Risks to especially sensitive receptors (e.g. an unborn child, very young children, those whose health is compromised with preexisting conditions) were not specifically evaluated. However, this evaluation relies upon the toxicity value development process that accounts for these sensitive populations. | May underestimate potential risk | Moderate |
| | Synergism/antagonism was not considered | May under- or over-estimate potential risk | Unknown |

(1) Key for Effects Determination:

- Overestimates potential risk: A value or assumption intentionally chosen to provide high risk estimates
- Likely Overestimates potential risk: A value or assumption intentionally chosen that is expected to provide high risk estimates
- May overestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a high risk estimate
- Underestimates potential risk: A gap in information or an available value that is known to provide a low risk estimate
- Likely underestimates potential risk: A gap in information or an available value that may provide a low risk estimate
- May underestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a low risk estimate.
- Likely no effect on estimated risk: Value or assumption that is known or suspected to have very little, if any, effect on potential risk

**Table 8-2 Summary of Sources of Variability in the Parameters used for the Supplemental Air Emissions Risk Analysis (AERA) for the Proposed NorthMet Plant Site near Hoyt Lakes, Minnesota**

| Source of Variability | Comments | Impact of Risk Analysis |
|---|---|---|
| Daily, seasonal, and yearly meteorological conditions | An agency-approved meteorological dataset for a 5 year time period is used in the air dispersion modeling. Maximum emission rates and worst case meteorological conditions are used to determine the maximum modeled air concentration. The maximum modeled air concentration for the respective 1-hour and annual averaging time period is used to assess the respective potential risks. | Likely none |
| Actual Plant Site activities on a day-to-day basis that may alter emissions. | Potential emission calculations tend to overestimate emissions, especially over longer time periods, because the plant does not operate at maximum capacity 100% of the time; Potential maximum hourly and maximum annual emissions modeled for the AERA and a receptor is assumed to be exposed to the modeled air concentration for the entire exposure time period. | Likely none or small |
| Differences in receptor susceptibility to actual chemical exposure and actual exposure durations. | Toxicity values are developed to be conservative and protective of sensitive populations. Actual exposures are typically lower than the potential exposures evaluated in a risk analysis and that is why risk results from this AERA, or any risk assessment, cannot be used as an indicator of actual risk to any receptor. | Likely none or small |

# 9.0 Qualitative Screening Analysis for Specific AERA Topics

## 9.1 Land Use and Receptors Information

Land use within 10 kilometers (about 6 miles) of the Plant Site is rural and predominantly mine lands or natural forest/wetlands. The nearest potential resident is located approximately 4.8 kilometers (about 3 miles) north/northwest of the Plant Site.

See Section 3.0 for the general facility and site descriptions.

## 9.2 Sensitive Receptors

The proposed Plant Site is to be located within the industrial area generally identified by the former LTVSMC ambient air boundary (see Large Figure 2 and Large Figure 3). Potentially sensitive receptors within 3 kilometers (about 2 miles) of the proposed facility only include individuals engaging in potential recreational activities (such as snowmobiling, hunting, etc.) within the area encompassed by the former LTVSMC ambient air boundary. Other potentially sensitive receptors, such as day cares/preschools, schools, civic and government centers, hospitals, retirement homes/communities, etc., are not present within 3 kilometers (about 2 miles) of the proposed Plant Site.

Due to the past use and current and reasonably foreseeable future zoning as industrial lands, people cannot live at the Plant Site property ownership boundary and therefore they are not expected to be exposed to Plant Site air emissions by indirect pathways (i.e., home-grown food consumption). Therefore, indirect pathway risks (cancer and noncancer) would not apply.

There is also the potential for individuals to engage in recreational activities (snowmobiling, hunting, etc.) within 10 km (about 6 miles) of the proposed facility. Potential individuals engaging in recreational activities would not be expected to be present within the 10 km zone for any length of time (less than one day and likely for no more than a few hours). Therefore, chronic risks likely would not apply. Based on the acute inhalation risks calculated at the PolyMet Plant Site property ownership boundary (worst case respiratory HI is 1 for all chemicals) and at the former LTVSMC ambient air boundary (worst case HI is 0.5 for all chemicals), no potential adverse health impacts to these potential individuals are expected.

## 9.3 Multipathway Receptors

Another type of “sensitive receptor” is the population surrounding a facility that could be exposed to the PBT pollutants emitted to air from a facility via the food pathway. The Plant Site operations are estimated to release only very small amounts of PBT chemicals; however MPCA AERA guidance indicates that PBTs may need some consideration beyond the indirect risks calculated in the RASS. Site information indicates that some agricultural lands are present within 10 kilometers of the facility (see Large Figure 6), although agriculture is not a predominant land use. Water bodies (lakes, rivers) are also present within 12 kilometers of the Plant Site (Embarrass River, Partridge River, Heikkilla Lake, Colby Lake, Whitewater Lake, Sabin Lake,

Wynne Lake, Kaunonen Lake). Therefore, multipathway receptors were evaluated for potential risks.

The RASS evaluates two generic receptors: 1) a farmer who only consumes homegrown vegetables, meat (beef, pork, and poultry) and dairy products, and 2) a nearby resident who consumes vegetables grown in his/her garden. Further discussion on potential risks to a generic farmer and a generic resident is provided in the next section. The multipathway exposure assessment also includes incidental ingestion of soil as a source of exposure.

### 9.3.1 Farmers and Residents

A review of zoning and land use within 10 kilometers (about 6 miles) of the proposed Plant Site identified small areas of agricultural lands (Large Figure 6): small farms approximately 4.5 kilometers to the northwest of the proposed facility. This is also the closest area to the Plant Site with land identified as "agricultural."

The nearest current residents to the proposed plant location are as follows:

- Approximately 8.3 kilometers (about 5 miles) south of the proposed plant location on the north side of the town of Hoyt Lakes

- Approximately 10.5 kilometers (about 7 miles) southwest of the proposed plant location on the northeast side of the town of Aurora

Chemicals assessed for multipathway risks include acetaldehyde, selected metals, diesel particulate matter, crystalline silica, and dioxins/furans. The estimated total multipathway risks, assuming the farmer receptor and resident receptors are immediately adjacent to the former LTVSMC ambient air boundary, are as follows: cancer = 1E-05 for the farmer receptor, 5E-06 for the resident; the non-cancer chronic hazard index is 0.2 for both the farmer and resident. These risk estimates indicate that no adverse health effects to potential farmer or resident receptors would be expected to be associated with potential air emissions from Plant Site operations.

### 9.3.2 Fishers

Water bodies are located within 12 kilometers (about 7 miles) of the proposed facility (Embarrass River, Partridge River, Heikkilla Lake, Colby Lake, Whitewater Lake, Wynne Lake, Sabin Lake, and Kaunonen Lake). The MPCA's RASS does not assess chemical deposition to water bodies or accumulation in fish or humans consuming the fish because of the very large variability in the surrounding water bodies. The variations in watershed size, water body turnover rate, flow rate, etc. make it difficult to describe an appropriate assessment at this time (References (14) (44)).

Overall, emission estimates for PBTs (e.g., arsenic, dioxin/furans and mercury) from the Plant Site are low. Low emissions, combined with the expectation that only a very small % of the

emissions would deposit locally near the facility, indicates that the potential deposition to surface waters (lakes and rivers) of PBTs resulting from plant site operations is likely small.

The PBT chemical emitted from the Plant Site of most concern to human health through the fish pathway is mercury. Fish consumption can be a significant route of exposure to mercury in terms of human health and fish consumption is the most likely route that human health would be affected through deposition to waterbodies. Potential health risks from mercury exposure via the fish consumption pathway have been assessed as part of this AERA. Additional discussion about exposure to mercury via the fish consumption pathway and a more detailed analysis of potential mercury deposition to nearby lakes from estimated air emissions from the Plant Site and estimated risks to a fisher are summarized can be found in Section 10.0

The only other PBT chemicals that were chemicals for evaluation for the Plant Site were arsenic and dioxins/furans. In general, arsenic does not biomagnify in the aquatic food chain (Reference (45)). The emission sources associated with the project do not have significant dioxin/furan emissions. The only identified potential emissions source is diesel fuel combustion. Therefore the contribution of dioxins/furans to the environment from this project is very small and it has been assessed for multipathway risks as part of this supplemental AERA. Overall, the small emissions from the project make it unlikely that dioxin/furans from this site would bioaccumulate in the aquatic ecosystem and this type of analysis was not included in the agreed upon scope for the AERA.

## 9.4 Chemicals and Emissions

The discussions under this section of the AERA are to provide the reader with additional qualitative information and perspective on chemicals and emissions associated with the Plant Site.

### 9.4.1 Mixtures and Surrogate Toxicity Values

In terms of risk driver chemicals, the following chemical was used as a surrogate for CFEs in the Supplemental 2012 Plant Site AERA:

- Nickel subsulfide was used as a surrogate for all nickel compounds

Calculating risks using surrogate toxicity values to represent chemical mixtures introduces a high level of uncertainty to the risk estimates. At best, surrogate toxicity values can be used as a screening tool in risk evaluation. The MPCA guidance (Reference (44)) states that: *"With a goal of not under-predicting risk, all available toxicity values for chemicals in a given mixture are considered, and a chemical is selected because its toxicity relative to the other chemicals in the mixture is greater. There may, however, be instances in which the mixture contains chemicals with higher toxicity than the surrogate, in which case the potential exists for risks from the mixture to be under-predicted."* In this AERA, the use of surrogate toxicity values is assumed to provide a conservative estimate of potential inhalation risks because nickel at this site likely exists in a different form that that on which the surrogate toxicity value is based.

### 9.4.2 Sensitizers

Respiratory sensitizers are of particular concern and can cause severe adverse reactions sometimes at very small concentrations for persons who have been previously sensitized to the chemical. Chemicals potentially emitted from the Plant Site that are identified as sensitizer chemicals include: beryllium, cobalt, formaldehyde and nickel compounds. Of these, only cobalt and nickel have been identified as potential risk-drivers and are included in this AERA analysis.

A reference toxicity concentration (RfCs, HRVs, RELs, or PPRTVs) is generally considered by the USEPA to be protective against asthma and other potential effects for non-sensitized individuals (Reference (46)). The annual chronic noncancer toxicity values in the RASS are from the following sources:

- beryllium: RfC from USEPA Integrated Risk Information System (IRIS)
- cobalt: PPRTV from USEPA Superfund Health Risk Technical Support Center
- formaldehyde: REL from California EPA Office of Environmental Health Hazard Assessment for the Hot Spots program
- nickel compounds: REL from California EPA Office of Environmental Health Hazard Assessment for the Hot Spots program

MDH assesses chemical toxicity in order to develop HRVs which become part of Minnesota Rules. HRVs are derived to be protective of the "…most sensitive portion of the population" (Reference (47)). MDH goes on to acknowledge the following:

> However, HRVs may not be protective of every individual. Certain people are hypersensitized by exposures to high concentrations of particular chemicals during occupational chemical use or in other situations. Because ranges of exposures that result in such hypersensitivities are highly variable and poorly studied, MDH is unable to derive HRVs that would be protective of all sensitized individuals. Chemicals that are known to cause sensitization are noted in the chemical lists found in rule parts 4717.8100 - 4717.8250 (Reference (47)).

With the exception of formaldehyde, none of the chemicals noted as respiratory sensitizers in the AERA are those for which MDH has noted in Minnesota Rules, parts 4717.8100-4717-8250 as being able to cause respiratory sensitization from environmental exposures (Reference (48)). According to the USEPA IRIS database, the RfC for beryllium was established to protect for potential respiratory sensitization. Although the documentation for derivation of the cobalt PPRTV states that the PPRTV may not be protective of those with a hypersensitivity to cobalt (Reference (41), MDH does not consider it a chemical known to cause sensitization. The chronic REL for nickel was established to be protective of the respiratory system and the blood forming system. Again, nickel is not considered a chemical considered by MDH as known to cause respiratory sensitization. Formaldehyde was not a risk driver based on revised risk estimates and

emissions are estimated to only be 0.0588 tons/year. The chronic REL was established to be protective of the respiratory system. Based on this information, the potential for emissions from the Plant Site to cause respiratory sensitization to the general public is considered unlikely.

### 9.4.3 Developmental Toxicants/Chemicals with Ceiling Values

Exposure to developmental/reproductive toxicants can have long lasting effects. Pregnant women are a sensitive subgroup who must be given special consideration in a risk analysis. Chemicals that are developmental toxicants may directly harm an unborn child. Those chemicals for which sufficient scientific evidence was available to develop an IHB for developmental effects have been noted in the RiskCalcs worksheet of the MPCA's RASS.

Of special importance are chemicals with HRVs and California RELs that are known to be developmental toxicants. Acute HRVs with developmental endpoints have been identified in the RASS as chemicals with "ceiling values" that should not be exceeded. The potential acute exposure, that is the resulting maximum estimated hourly concentration from a facility, is compared to the ceiling value to determine whether the ceiling value has been exceeded. Like chronic chemicals and other exposure scenarios, ceiling value chemicals with ratios of less than 0.1 of the acute threshold can be excluded from further analysis. Ceiling values do not apply to surrogate values.

Developmental toxicants potentially emitted from the Plant Site include: arsenic, benzene, carbon disulfide, and mercury. Of these, only arsenic has been identified as a potential risk driver and is included in this AERA analysis based on acute inhalation. Mercury health impacts are summarized in Section 10.3. Risk results from the MPCA's RASS indicate that no ceiling values were exceeded. Therefore, potential impacts to the general public from exposure to developmental toxicants associated with Plant Site operations are not expected.

### 9.4.4 Criteria Pollutants

Modeling at the Plant Site for particulate matter less than 10 microns in size ($PM_{10}$), particulate matter less than 2.5 microns in size ($PM_{2.5}$), sulfur dioxide ($SO_2$), and nitrogen oxides ($NO_x$) has been completed. Carbon monoxide (CO) was not modeled because its estimated emissions are relatively small and exceedances of the ambient air quality standards are not expected.

Criteria pollutant modeling results are shown in Large Table 5 and all modeling results indicate compliance with ambient air quality standards. All modeling results include PolyMet Plant Site sources plus background concentrations, but no other nearby sources. The ratios of the modeled air concentrations to ambient air quality standards for the criteria pollutants are not comparable to the estimated human health risks, as the HQs discussed in Section 7.2 of this AERA are based on a dose-response relationship. Therefore, the ratios in Large Table 5 cannot be added to the summed risks presented in Section 7.2.

### 9.4.5 Fine Particulate ($PM_{2.5}$)

Fine particulate emissions were estimated for the NorthMet Plant Site and modeled for compliance with the $PM_{2.5}$ ambient air quality standards (Large Table 5). Modeled air concentrations were below the respective most restrictive standard of 35 µg/$m^3$ for the 24-hour averaging period and 12 µg/$m^3$ for the annual averaging period.

A specific risk estimate for $PM_{2.5}$ direct emissions has not been calculated. Modeled compliance with the ambient air quality standards indicates that adverse health impacts are not expected to be associated with the Plant Site $PM_{2.5}$ emissions. However, the modeled air concentrations compared to the respective NAAQS (Large Table 5) are not an indicator of potential additive effects because the NAAQS are developed differently from the RfCs used in the quantitative risk estimate. The particulate emissions have been speciated to the individual metals but it is unknown whether the potential additional impacts, if any, from inhalation of $PM_{2.5}$ would be additive to, or possibly double counting of, potential health effects.

Secondary formation of $PM_{2.5}$ potentially associated with the facility's $SO_2$ and $NO_X$ emissions that may be transformed into sulfate and nitrate aerosol (typically as ammonium sulfate or ammonium nitrate) by atmospheric processes was addressed in this evaluation with the use of offset ratios. Secondary fine particle pollution is recognized as being a long-range transport issue (Reference (49)). For $SO_2$ conversion to sulfate aerosol, the conversion typically occurs over several days and during that time the emissions from a facility may have moved several hundred miles. Research is ongoing with regard to the conversion of NO/$NO_2$ to nitrate aerosol. Due to this long range transport of fine particles associated with $SO_2$ and $NO_x$ emissions, the extent the secondary formation of sulfate and nitrate aerosol affect air concentrations near an emission source is uncertain.

### 9.4.6 PBTs without Multipathway Screening Factors

All CFEs that are identified as PBTs have multipathway screening factors in the version of RASS (version 20120302) used in this AERA. The multipathway screening factors are based on inhalation toxicity values for PBT chemicals. Some PBT chemicals that may be emitted at the Plant Site only have oral reference doses, and are therefore not accounted for in the multipathway analysis. The status of all CFEs and risk-driver chemicals in terms of PBTs and multipathway screening factors is listed in Table 5-2.

## 9.5 Regulatory Requirements

### 9.5.1 State and Federal Control Requirements

PolyMet is proposing to obtain a Title V air emission permit for the Plant Site and Mine Site. The proposed facility will be a major Title V source, but not a major source under Prevention of Significant Deterioration (PSD) air permitting. The permit application will propose emission limitations based on air dispersion modeling inputs and the objective of being a minor source for PSD purposes. The permit application will also provide details on the applicability of state and federal requirements including New Source Performance Standards, Part 61 and Part 63 National

Emission Standards for Hazardous Air Pollutants (NESHAPS), and Minnesota Standards for Performance for Stationary Sources.

### 9.5.2 Air Permitting

Limitations will be proposed in the air emissions permit application to keep emissions below the PSD major source level. Therefore the project is not subject to PSD review. However, the following analyses have been, or will be, conducted to support the preparation of the SDEIS:

- control technology review (completed and approved)
- a Class II area air quality analysis, including modeled compliance with the applicable NAAQS for $SO_2$, NOx, $PM_{10}$ and $PM_{2.5}$ (Mine Site: completed and approved; Plant Site version 1 completed and reviewed, review of version 2 is underway)
- an air quality analysis of Class I area impacts as agreed upon with the Federal Land Managers (FLMs) has been completed. Details of the analysis are available in a separate report. (completed and approved)

### 9.5.3 Emergency Generators and Fire Pumps

The MPCA requests that a project proposer inventory and characterize emergency generators and fire pumps at the facility separately from the inventory of emission sources included in the risk estimate.

The Project will have three emergency diesel generators and two emergency diesel fire pumps for the Plant Site operations. The generators and fire pumps are expected to be operated sparingly and only in emergency situations. Testing of the generators and fire pumps will occur periodically to make sure they are in good operating condition. Due to the infrequent operations and the relatively short operating times when in use, potential emissions are expected to be small and they were not included in the risk analysis. Potential emissions from the emergency generators and fire pumps are not expected to significantly affect the quantitative risk estimates.

### 9.5.4 Accidental Releases

Minnesota's Notification of Deviations, Shutdowns and Breakdowns rule (Minnesota Rules, part 7019.1000) requires the owner or operator of an emission facility to notify the MPCA of shutdowns or breakdowns that cause any increase in emissions. The MPCA maintains a log of these notifications. In addition, the permit to be issued for the project may require the facility to maintain records of start-up, shutdown, breakdown or malfunctions of operating units and/or control equipment. The MPCA will generate a report from the Incident Management System that logs shutdown and breakdown reports for the previous five years.

# 10.0 Potential Incremental Risk from Mercury via the Fish Consumption Pathway

## 10.1 Introduction

For mercury, the non-inhalation routes of exposure are typically more significant than the inhalation pathway, with exposure through consumption of fish being the primary route of exposure. The July 2012 "Cumulative Impacts Analysis Local Mercury Deposition and Bioaccumulation in Fish report" (Reference (12)) provided results for the screening evaluation of potential cumulative local mercury deposition in the NorthMet Project area (Table 4 in the Cumulative Impacts Analysis Report). The Cumulative Impacts Analysis was conducted to address concerns regarding potential cumulative incremental increases in mercury fish concentration related to the proposed Plant Site and the only other "reasonable foreseeable" project within 25 kilometers (about 16 miles) of the Project area with appreciable mercury emissions.

During preparation of this Supplemental AERA Report, an error was found in the Cumulative Impacts Analysis report (Reference (12)) for the potential mercury contributions estimated for the Plant Site. The overall results in the Cumulative Impacts Analysis report do not change but the incremental change in fish mercury concentrations and incremental change in fisher risk (hazard quotients) attributed to the Plant Site have been updated in this Supplemental AERA report. An addendum to the cumulative mercury deposition report was prepared and submitted on January 15, 2013. Any inconsistencies between this report and the Cumulative Impacts Analysis report should be resolved in an addendum to the Cumulative Impacts Analysis report.

## 10.2 Methodology

The Minnesota Mercury Risk Estimation Method (MMREM) was used to assess the potential local deposition from only the Plant Site mercury emissions:

- Two emission speciation scenarios for the Plant Site (the same emission scenarios evaluated in the Cumulative Impacts Analysis)
    - Scenario 1: 25% elemental; 50% oxidized; 25% particle bound
    - Scenario 2: 80% elemental; 10% oxidized; 10% particle-bound
- Potential increases in mercury bioaccumulation in fish in five nearby lakes (Heikkilla Lake, Colby Lake, Whitewater Lake, Wynne Lake, and Sabin Lake)
- Potential increases in health risks via the chronic fish consumption pathway for recreational, subsistence/tribal, and subsistence anglers.

The forms of mercury estimated to be emitted from the plant site are elemental, oxidized, and particulate in the proportions shown in Scenarios 1 and 2 above. Once mercury in air is deposited into water bodies, it can be methylated by microorganisms to form methylmercury.

Methylmercury is toxic and bioaccumulates in food webs. Most of the mercury in the atmosphere is elemental mercury which is insoluble and does not readily deposit near its emissions source (Reference (12)). Oxidized mercury is water soluble and may be deposited more locally near emission sources, along with particulate bound mercury. This means the oxidized and particulate forms of mercury which are deposited are more likely to be methylated in water bodies near plant site emissions (Reference (12)).

### 10.2.1 Potential Plant Site Mercury Air Emissions

The modeling for the Cumulative Impacts Analysis (Reference (5)) included emissions from the Plant Site. The estimated potential mercury emissions from the Plant Site are approximately 4 pounds per year.

Because speciation from the autoclave at the Plant Site is uncertain, two speciation scenarios were used: a conservatively high estimate of mercury species that could deposit locally (Scenario 1) and a most likely estimate of mercury species (Scenario 2).

Scenario 2 is the estimated likely speciation of mercury emissions from the Plant Site based on engineering assumptions and limited data from other autoclaves (Reference (12)). The two-staged scrubbing system proposed for the autoclave will effectively control particle-bound and oxidized mercury, so that any emitted mercury is expected to be predominantly in an elemental form (Scenario 2).

**Table 10-1 Estimated Mercury Speciation for Autoclave Emissions from the Proposed Plant Site near Hoyt Lakes, Minnesota**

| Project<br>NorthMet, Plant Site | Mercury Speciation | Comments |
|---|---|---|
| Scenario 1 (1) | 25% elemental<br>50% oxidized<br>25% particle-bound | Conservative estimate for local deposition |
| Scenario 2 (1) | 80% elemental<br>10% oxidized<br>10% particle-bound | Estimated likely speciation |

(1) The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

### 10.2.2 Estimating Mercury Exposure from Fish Consumption

The assessment of incremental potential mercury exposure utilized the MPCA-developed screening approach known as the Minnesota Mercury Risk Estimation Method (MMREM) for assessing potential local mercury deposition impacts. The MMREM consists of using the air dispersion model AERMOD to estimate mercury air concentrations and a MPCA-developed

screening-level spreadsheet model to assess how much of this mercury might deposit and accumulate in fish in nearby lakes. The MMREM accounts for potential deposition from each species of mercury and incorporates the assumption of proportionality. The MMREM methodology assumes there is a linear relationship between the atmospheric mercury deposition rate to a given lake and fish tissue methyl-mercury concentrations. The linear relationship is used to estimate a potential incremental change in fish mercury concentrations and incremental hazard quotients for the following three separate fish consumption scenarios:

1. a recreational angler who eats 30 grams of fish per day (24 pounds per year)
2. a subsistence/tribal angler who eats 224 grams of fish per day (180 pounds per year)
3. a subsistence angler who eats 199 grams of fish per day (160 pounds per year)

The MMREM does not predict actual fish tissue concentrations, the actual expected change in fish tissue concentrations, or the health outcomes for any actual person consuming fish from the lakes considered, but is considered to be a conservative representation (i.e., over-prediction) of potential impacts.

### 10.2.3 Nearby Lakes Selected for Assessment in the St. Louis River Watershed

Five lakes nearby lakes were selected for analysis:

- Heikkilla Lake, part of Embarrass River watershed
- Sabin Lake, part of the Embarrass River watershed
- Wynne Lake, part of the Embarrass River watershed
- Colby Lake, part of the Partridge River watershed
- Whitewater lake, part of the Partridge River watershed

These 5 lakes are located within 12 kilometers (about 7 miles) of the Plant Site and all are located within the St. Louis River watershed (see Large Figure 7). Colby Lake and Whitewater Lake are closest to the Plant Site and are part of the Partridge River which is a tributary to the St. Louis River. Because these two lakes are the closest lakes to the Plant Site they would be potentially the most affected by deposition related to Plant Site operations. In other words, the incremental increase of mercury loading and the associated change in fish concentrations in other popular fishing lakes in the St. Louis River watershed such as Seven Beaver Lake (the headwaters of the St. Louis River) would be less than that modeled at the selected lakes because these other lakes are located further from the Plant Site.

## 10.3 Potential Change in Fish Mercury Concentration and Incremental Fisher Risk

Based on the MPCA screening-level MMREM spreadsheet model, the potential change in fish mercury concentrations from the Plant Site mercury emissions is estimated to be 0.0006 to 0.004

ppm for Scenario 2 to 0.002 to 0.016 ppm for Scenario 1, respectively. The potential changes estimated by the model correspond to an increase over background levels of 0.2 to 0.4% for Scenario 2 to 0.6 to 1.6% for Scenario 1, respectively. The incremental increases in mercury fish tissue concentrations under Scenario 2, which is the more likely emissions speciation scenario, only range from 0.0006 to 0.004 ppm (or 0.2% to 0.4% of background fish mercury concentrations). Although this potential change in fish mercury concentration is greater than zero, it is very small compared to the variability in background concentrations in the lakes and the current laboratory analytical methods. The modeled potential change under Scenario 2 or the more conservative Scenario 1 would also not change the current fish advisory status of any of the lakes studied.

The MPCA established a fish tissue mercury standard in 2008 of 0.2 mg/kg in edible fish tissue (Reference (50). The existing 95% UCL for fish tissue mercury concentration is above this level for all lakes considered with fish tissue data. The MDH has guidelines for meal advice levels regarding mercury levels in fish. Unrestricted fish consumption is only advised for fish with mercury concentrations less than 0.16 mg/kg for the general population and less than 0.05 mg/kg for pregnant women and children (Reference (51)). The data for existing ambient fish mercury concentrations in these lakes also indicate fish tissue mercury concentrations are above the MDH advisory levels. The modeled potential increases in fish mercury concentration, particularly for the more likely emissions Scenario 2, are also small when compared to the current fish advisory levels and are not expected to have any effect on the current advisories.

Table 10-2 summarizes the potential incremental increases in the estimated fish mercury concentrations from estimated increases in mercury emissions from the proposed NorthMet Project Plant Site in lakes within 12 kilometers (about 7 miles) of the proposed Plant Site. Additional details regarding incremental mercury deposition are available in Attachment F.

**Table 10-2 Summary of Potential Incremental Increases in Fish Mercury Concentrations Related to Estimated Mercury Deposition from the Proposed NorthMet Project Plant Site Near Hoyt Lakes, Minnesota**

| Lake | MN DNR # | Emissions Scenario (1) | Existing Ambient Fish Mercury Concentration (mg/kg Hg) (2) | Standard Deviation in Existing Fish Mercury Conc. | Potential Incremental Increase in Fish Mercury Concentration (mg/kg Hg) | Potential % Increase in Mercury in Fish (% of 95% UCL) |
|---|---|---|---|---|---|---|
| Heikkilla Lake | 69025300 | Scenario 1 | 95% UCL=0.65 (3) | 0.34 (3) | 0.010 | 1.6% |
| | | Scenario 2 | | | 0.003 | 0.4% |
| Colby Lake | 69024900 | Scenario 1 | 0.49 - 1.23<br>95% UCL=0.93 | 0.22 | 0.010 | 1.1% |
| | | Scenario 2 | | | 0.003 | 0.3% |
| White-water Lake | 69037600 | Scenario 1 | 0.12 - 0.90<br>95% UCL=0.35 | 0.13 | 0.002 | 0.6% |
| | | Scenario 2 | | | 0.0006 | 0.2% |
| Wynne Lake | 69043402 | Scenario 1 | 0.35 – 2.06<br>95% UCL=1.34 | 0.57 | 0.016 | 1.2% |
| | | Scenario 2 | | | 0.004 | 0.3% |
| Sabin Lake | 69043401 | Scenario 1 | 0.44 - 1.62<br>95% UCL=1.02 | 0.39 | 0.012 | 1.2% |
| | | Scenario 2 | | | 0.003 | 0.3% |

(1) Emissions Scenario 1: 25% elemental Hg, 50% oxidized Hg, 25% particle-bound Hg
Emissions Scenario 2: 80% elemental Hg, 10% oxidized Hg, 10% particle-bound Hg
(2) Current MPCA fish tissue mercury standard is set at 0.2 mg/kg Hg
(3) No fish tissue data available for Heikkilla Lake. The existing fish mercury concentration is assumed to be similar to that of the other four lakes evaluated. The 95% UCL includes the data from Colby, Whitewater, Wynne, Sabin, and Bear Island Lakes.

The current MPCA-estimated mercury deposition rate is 12.5 µg/m$^2$-year for northeast Minnesota. This means that about 250 pounds of mercury currently deposits onto the St. Louis Watershed (~ 150 square miles) every year due to background deposition. Even assuming that the maximum modeled deposition rate from Plant Site potential emissions (0.2 µg/m$^2$-yr at Heikkilla Lake for emissions scenario 1) occurred over the entire 150 square mile potentially affected area, the total annual deposition in the watershed from the Plant Site would be about 0.17 pounds per year. This is less than 0.1% of the estimated 250 pounds per year of mercury already landing onto the St. Louis River watershed due to background deposition. Because the change in mercury concentration in fish is thought to be ultimately proportional to the percent increase in mercury load, this potential 0.1% increase in annual mercury deposition is not likely to result in a measureable change in the mercury concentration in the fish in water bodies of the St. Louis River watershed or in the St. Louis River itself.

Table 10-3 summarizes the MMREM results for potential incremental increases in the fisher HQ for emissions Scenario 2 related to potential mercury emissions from the Plant Site. However, for all practical purposes, because the modeled potential change in fish mercury concentration is so

small compared to the existing concentrations, any associated increase in the hazard quotient is also overwhelmed by the existing hazard quotient and is not expected to change any expected health outcomes from consuming fish from these lakes.

**Table 10-3 Summary of Potential Incremental Increases in the Hazard Quotient (HQ) from Estimated Mercury Deposition from the Proposed NorthMet Project Plant Site Near Hoyt Lakes, Minnesota[1]**

| Lake | Scenario [2] | Recreational Angler | | Subsistence or Tribal Angler | | Subsistence Fisher | |
|---|---|---|---|---|---|---|---|
| | | Existing HQ | Modeled Increase in HQ[3] | Existing HQ | Modeled Increase in HQ[3] | Existing HQ | Modeled Increase in HQ[3] |
| Heikkilla Lake | #1 | 3.0 | 0.05 | 22.3 | 0.4 | 19.8 | 0.3 |
| | #2 | | 0.01 | | 0.1 | | 0.08 |
| Colby Lake | #1 | 4.3 | 0.05 | 32.0 | 0.4 | 28.4 | 0.3 |
| | #2 | | 0.01 | | 0.1 | | 0.08 |
| Whitewater Lake | #1 | 1.6 | 0.01 | 11.9 | 0.1 | 10.6 | 0.07 |
| | #2 | | 0.003 | | 0.02 | | 0.02 |
| Wynne Lake | #1 | 6.2 | 0.07 | 46.2 | 0.6 | 41.0 | 0.5 |
| | #2 | | 0.02 | | 0.1 | | 0.1 |
| Sabin Lake | #1 | 4.7 | 0.06 | 35.1 | 0.4 | 31.2 | 0.4 |
| | #2 | | 0.01 | | 0.1 | | 0.09 |

(1) Additional details regarding incremental risk from mercury deposition are in Attachment F
(2) Emissions Scenario 1: 25% elemental Hg, 50% oxidized Hg, 25% particle-bound Hg
Emissions Scenario 2: 80% elemental Hg, 10% oxidized Hg, 10% particle-bound Hg.
(3) Modeled incremental increase from the Plant Site using AERMOD dispersion modeling and MMREM model

The current levels of mercury in the fish of nearby lakes selected for this local deposition analysis (Colby, Whitewater, Wynne and Sabin Lakes), and other lakes in Minnesota, already exceed the State of Minnesota's health based target of 0.2 ppm and have fish-consumption advisories issued by Minnesota Department of Health (MDH) that recommend limits on the amount and types of fish that can be safely eaten. These fish consumption advisories, in turn, trigger federal regulatory requirements intended to reduce the mercury loading to these lakes. In Minnesota, the MPCA has developed a federally-approved long-term plan to help eliminate, or at least reduce, these mercury impairments. The MPCA plan is called a total maximum daily load (TMDL) plan. The USEPA approved the MPCA Statewide Mercury TMDL (TMDL) in March, 2007. The TMDL plan is focused on reducing overall state mercury emission rates and includes a statewide goal of reducing total statewide mercury emissions to 789 pounds per year by 2025 (Reference (52).

Overall, the maximum estimated increase in potential health risks from fish consumption related to potential Plant Site mercury emissions are very small when compared to existing fish consumption health risks. The potential incremental health risk due to increased mercury deposition at other area lakes, such as Seven Beaver Lake which forms the headwaters of the St. Louis River, would be even less than the estimates for the lakes assessed in this analysis because they are located further from the Plant Site. The MPCA Statewide Mercury total maximum daily load (TMDL) and Strategy Framework is intended to provide the long-term framework to reduce the mercury in fish in Minnesota lakes. PolyMet intends to comply with any applicable provisions of the Minnesota Mercury TMDL in order to help reduce long-term mercury concentrations in the fish in these lakes and other impaired lakes in Minnesota.

# 11.0 Cumulative Inhalation Risk Assessment

## 11.1 General Cumulative Risk Assessment Guidance

When determining the need for an environmental impact statement during the environmental review process, Minnesota Rules, part 4410.1700, subpart 7, item B, states that the Responsible Governmental Unit (RGU) must consider specific factors identified in the rule to decide whether a project has the potential for significant environmental effects. One of these factors is the "cumulative potential effects of related or anticipated future projects". Guidance and methodology for a cumulative inhalation risk analysis for the Plant Site and the Mine Site were provided by the MPCA and are summarized in the Plant Site and Mine Site Work Plans (References (13), (53)) and take into account potential cumulative effects from the proposed Mesabi Mining Project (Reference (54)), the Mesabi Nugget Large Scale Demonstration Plant (LSDP) and the Syl Laskin Energy Center power plant (located several kilometers southwest of the NorthMet Plant Site). Note: there is currently some uncertainty on the part of the regulatory agencies as to whether the Mesabi Mining Project is a reasonably foreseeable project. However, the Mesabi Mining Project is still included in this cumulative analysis as described in the work plans.

Separate cumulative assessments are described in Sections 11.2-11.5 below for the Mine Site and the Plant Site (Reference (13), (53)); however, one cumulative inhalation risk assessment that includes estimated air concentrations and risks from the Plant Site and the Mine Site is presented in this Supplemental AERA.

## 11.2 Receptors of Interest

The risk receptors of interest for the NorthMet Plant Site and Mine Site as outlined in the respective Work Plans are a potential resident at the following locations:

- Near the Plant Site at the ambient air boundary northwest of the Tailings Basin (receptor Plant NW),
- Southeast of the Plant Site at the former LTVSMC ambient air boundary (receptor Plant SE),
- Northwest of the Mine Site (Mine NW) at the mineral mining/industrial district boundary, and
- Southeast of the Mine Site (Mine SE) at the mineral mining/industrial district boundary.

Large Figure 1 identifies the locations of the Plant Site, Tailings Basin, Mine Site and the potential resident receptor locations.

## 11.3 Consideration of Nearby Sources/Projects

The inclusion or exclusion of nearby point sources in the cumulative risk evaluation is based on the likelihood of potential impact from the nearby point sources on the risk receptors of interest for the Project. The nearby projects/facilities that were initially assessed by the MPCA for their potential to impact the hypothetical risk receptors of interest are: 1) Mesabi Nugget Large Scale Demonstration Plant (LSDP); 2) the proposed Mesabi Mining Project; 3) Minnesota Power Laskin Energy Center power plant; 4) Cliffs Erie Pellet Yard; 5) the NorthMet Mine and Plant Sites. These facilities were evaluated for their distance and direction from the receptors of interest.

Because the construction permit for the pellet yard modification has expired and current permitted activities are minimal, the Cliffs Erie Pellet Yard is excluded from the cumulative inhalation risk assessment. There is currently some uncertainty on the part of regulatory agencies as to whether the Mesabi Mining Project is a reasonably foreseeable project. However, the Mesabi Mining Project is still included in this cumulative analysis.

Large Figure 1 shows the locations and distances of the facilities included in the analysis and their distance to the NorthMet Plant and Mine Sites.

## 11.4 Methodology for Estimating Potential Cumulative Inhalation Risks

The estimation of potential cumulative inhalation risks follows guidance and methodology provided by the MPCA which was summarized in the respective Mine Site and Plant Site Work Plans. The initial estimate of potential cumulative inhalation risks included the following components:

- Background Risks: calculated by the MPCA from ambient air monitoring data (e.g., particulate metals, VOCs, NO2) and the potential risk related to modeled NO2 emissions from the Laskin Energy Center;
- Incremental Risk from Nearby Non-NorthMet Emission Sources: modeled air concentrations and risk from Mesabi Mining Project and the Mesabi Nugget Large Scale Demonstration Plant;
- Incremental Risk from the Proposed Project: The NorthMet Plant Site and Mine Site represent an additional potential incremental risk above the estimated background risk.

### 11.4.1 Ambient Air Data/Monitoring

The estimates of potential cumulative inhalation background risks were calculated by MPCA staff using ambient air monitoring data from the 2008 to 2010 time period for the following locations: Virginia, MN, Ely, MN, and Cloquet, MN. Data from the Iron Range region is emphasized in the analysis (Virginia, particulate metals; Ely, VOCs and carbonyls; Cloquet, $NO_2$).

Because the intent of the cumulative risk analysis (per MPCA method) is to not underestimate potential background risks, the chronic exposure and the inhalation exposure concentration are high-end estimates. Background chronic risk estimates are considered near upper bound estimates because they incorporate the assumption of maximum outdoor exposure (24 hours per day, 365 days per year, for a 70-year lifetime). In addition, the specific air concentrations used to estimate the potential background risks are the 95% upper confidence limit of the arithmetic mean air concentration, which adds to the conservatism in the analysis.

For potential acute (one-hour) exposure, estimates of maximum one-hour air concentrations for the pollutants with acute inhalation health effects were calculated by the MPCA based on 24 hour (daily) maximum air concentrations multiplied by a factor of five. For NO2, monitored air concentrations from Cloquet, MN that reflect contributions from industrial and mobile sources were applied. Hourly maximum air concentrations from the Cloquet monitoring data were used directly for estimating background nitrogen dioxide risks. For this cumulative analysis, these maximum one-hour air concentrations are assumed to occur simultaneously, their potential risks are additive regardless of toxic endpoint, and that a hypothetical receptor would be outdoors at the time the one-hour maximum concentrations occurred.

In summary, the MPCA's intent for the cumulative risk evaluation is to not underestimate potential cumulative inhalation risks. In implementing the MPCA's preferred approach to the cumulative risk analysis, the potential background risks associated with ambient air monitoring data are overestimated and likely do not reflect any actual exposure to a receptor.

### 11.4.2 Inclusion of Nearby Facilities and Foreseeable Projects

Potential inhalation risks for selected chemicals potentially emitted from the existing Minnesota Power Laskin Energy Center power plant, the existing Mesabi Nugget Large Scale Demonstration Plant and proposed Mesabi Mining project were specifically included in this assessment because their emissions are not considered to be reflected in the background ambient air monitoring data used by MPCA to calculate the potential background inhalation risks. The selected chemicals potentially emitted from the Mesabi Mining project and the Mesabi Nugget LSDP and evaluated for incremental risks were manganese, crystalline silica and $NO_x$ (evaluated as $NO_2$). The selected chemical potentially emitted from Laskin Energy Center facility and evaluated for additional background risks was $NO_x$ (evaluated as $NO_2$). Table 11-1 lists the chemicals evaluated for each emission source included in the cumulative inhalation risk analysis.

Air concentrations and associated risk for manganese, crystalline silica and $NO_2$ from the Mesabi Mining Project (that included the Mesabi Nugget LSDP and the Laskin Energy Center) were obtained from the previous modeling conducted for that project. The Mesabi Mining Project was required to conduct a cumulative inhalation risk analysis that also included the toxic air pollutant emissions estimated for the Mesabi Nugget LSDP and selected toxic air pollutant emissions estimated for the Laskin Energy Center (included $NO_2$ emissions) (Reference (55)) (formerly the Mesabi Nugget Phase I and Phase 2 project). The detailed air dispersion modeling grid set up for the Mesabi Mining Project's cumulative inhalation risk analysis included the locations of the receptors of interest identified for this cumulative inhalation risk analysis. The modeled air

concentrations from the Mesabi Mining Project's cumulative inhalation risk analysis for the receptors of interest for this cumulative analysis were identified (from that project's AERMOD output files) and brought forward into this cumulative analysis. The AERMOD input/output files for the Mesabi Mining Project were provided to the MPCA as part of that project's required submittals (Reference (55)).

Specifically, the air concentrations (and estimated inhalation risk) from the Mesabi Mining Phase 1 and 2 AERA (Reference (55)) were combined with the modeling results from the NorthMet Mine Site and Plant Site for the specific locations of the receptors of interest.

For this analysis, the MPCA-approved Plant Site OLM protocol was used to model $NO_2$ emissions for the acute (1-hour) exposure. OLM modeling uses USEPA's very conservative assumption that 50% of the $NO_x$ emitted from the stack is already $NO_2$. More detail on the OLM protocol is provided in Section 5.3.2.

**Table 11-1 Potential Risk Driver Chemicals Assessed in the Cumulative Inhalation Risk Evaluation for the Mine Site and Plant Site Supplemental AERAs for the NorthMet Project near Hoyt Lakes, MN**

| Potential Risk Driver Chemical | Project/Facility | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|---|
| Arsenic Compounds | Plant Site | X | X | X |
| | Mine Site | X | X | X |
| Cobalt | Plant Site | X | X | |
| | Mine Site | X | X | |
| Crystalline Silica | Plant Site | | X | |
| | Mine Site | | X | |
| | Mesabi Mining | | X | |
| Diesel Particulate | Plant Site | | X | |
| | Mine Site | | X | |
| Dioxins/Furans | Plant Site | X | X | |
| | Mine Site | X | X | |
| Manganese Compounds | Plant Site | | X | |
| | Mine Site | | X | |
| | Mesabi Mining | | X | |
| Nickel Compounds | Plant Site | X | X | X |
| | Mine Site | X | X | X |
| $NO_2$ | Plant Site | | | X |
| | Mine Site | | | X |
| | Mesabi Mining | | | X |
| | Syl Laskin Energy Center | | | X |

| Potential Risk Driver Chemical | Project/Facility | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|---|
| PAHs | Mine Site | X | | |
| Acetaldehyde | Plant Site<br>Mine Site | X<br>X | X<br>X | X<br>X |
| Hydrochloric Acid | Plant Site | | X | X |

## 11.5 Estimated Cumulative Inhalation Risks

Table 11-2 provides a summary of the estimated potential cumulative inhalation risk from background (monitoring data + existing Laskin Energy Center) and the incremental increase from the Plant Site and Mine Site + Mesabi Mining + Mesabi Nugget LSDP. Detailed information regarding the cumulative risk at each of the receptors of interest is provided in Attachment G. Although there are no guideline values for cumulative risk, the estimated cumulative risk is compared below to the incremental risk guideline values for a single facility or project per MPCA risk guidance. Please note that the incremental risk guidelines were not developed for use in this manner and this comparison only provides a very broad context for the extent of cumulative risk.

Incremental risk from the PolyMet Mine and Plant Sites accounts for only 9% of the total cumulative cancer risk; 91% of the cumulative risk is from monitored background concentrations. Potential cumulative cancer risks are above the guideline value of 1E-05 for incremental risk; however, the estimated risks from monitored background air concentrations contribute the majority of the risk.

Incremental risk from the PolyMet Mine and Plant Sites accounts for only 7% of the total cumulative chronic noncancer hazard index. Cumulative noncancer chronic risks do not exceed the incremental hazard index guideline value of one and are predominately from risk estimated from monitored background air concentrations.

Monitored background concentrations and incremental risk from the Project each contribute about half of the cumulative acute hazard index. The existing Laskin Energy Center and the Mesabi Nugget LDSP and the Mesabi Mining Project contribute very little to the cumulative acute hazard index. Potential cumulative acute risks do not exceed the incremental hazard index guideline value of one. $NO_2$ is the largest contributor to incremental Project risk. As previously discussed, maximum permitted $NO_x$ emissions were evaluated for both the Mine and Plant Sites. The conservative assumption that 80% of the NO, the primary constituent of $NO_x$ emissions, converts to $NO_2$ instantaneously upon emission to air was used for the Mine Site and the OLM modeling protocol used to estimate the $NO_2$ concentrations due to the Plant Site sources. The OLM modeling protocol used the conservative 50% in-stack conversion ratio, which assumes 50% of the $NO_x$ emitted from the stack is in the form of $NO_2$ and conversion of the remaining

50% of the $NO_x$ emissions to $NO_2$ is calculated based on the estimated NO and ozone concentrations..

**Table 11-2 Maximum Calculated Potential Cumulative Inhalation Risks for the Receptors of Interest in the Supplemental AERAs for the NorthMet Mine Site and Plant Site**

| Estimated Potential Risk(1) | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background(2) | | | |
| Ambient air monitoring (calculated by MPCA) | $3x10^{-5}$ | 1 | 0.4 |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | NA | NA | 0.01 |
| Total Background(3) | $3x10^{-5}$ | 1 | 0.4 |
| | | | |
| Incremental | | | |
| NorthMet (Plant Site + Mine Site) | $3x10^{-6}$ | 0.1 | 0.6 |
| Mesabi Mining Project and Mesabi Nugget LSDP) [4] | NA | 0.1 | 0.03 |
| Total Incremental(3) | $3x10^{-6}$ | 0.2 | 0.6 |
| | | | |
| Total Cumulative Risk(3) | $4x10^{-5}$ | 1 | 1 |
| % of Cumulative Risk from PolyMet Projects | 9% | 7% | 57% |

(1) The maximum potential cumulative risk out of the 4 receptor locations evaluated is presented in Table 11-2 for cancer, chronic noncancer, and acute noncancer risk. The potential cumulative risk estimated at each of the 4 receptors is presented in Attachment G.
(2) Background risks based on monitoring data were calculated by the MPCA based on 2008-2010 monitoring data from Virginia, Ely and Cloquet.
(3) As per MPCA guidance, all reported risk values are rounded to one significant digit. Totals, however, are calculated from unrounded values and may differ from the value obtained by adding the rounded values shown in the table.
(4) LSDP = Large Scale Demonstration Plant; currently operating

## 12.0 Summary

Following the MPCA-accepted Work Plan for the Supplemental AERA, potential inhalation risks for an off-site worker at the Plant Site projected ownership boundary and multipathway risk (inhalation + ingestion) for a farmer and a resident receptor at the former LTVSMC ambient air boundary were estimated. The highest estimated risks are summarized below.

- Potential off-site worker at the Plant Site property ownership boundary (inhalation)
    - The estimated potential acute (1-hour) inhalation risk, summed for all chemicals using the maximum modeled air concentrations and regardless of toxic endpoint, is 1.
    - The acute inhalation risk driver pollutants using the maximum modeled air concentrations are $NO_2$, arsenic compounds, nickel compounds, and hydrochloric acid. For $NO_2$, the modeled air concentrations related to Plant Site emissions were calculated using the MPCA-approved OLM modeling protocol and air concentrations related to the Mine Site emissions were derived using the USEPA conversion factor of 0.8.
    - The acute inhalation risk driver pollutants are $NO_2$, arsenic compounds, nickel compounds, and hydrochloric acid.
    - The estimated maximum chronic inhalation risks (cancer = 1E-05 and noncancer = 1), summed for all chemicals regardless of toxic endpoint, do not exceed the respective guideline values of 1E-05 and 1.
    - Potential inhalation risks calculated for this supplemental AERA are similar to those calculated for the March 2007 AERA.
- Potential Farmer and Resident at the former LTVSMC ambient air boundary
    - The estimated potential acute (1-hour) inhalation risk, summed for all chemicals regardless of toxic endpoint is 0.5, which does not exceed the guideline value of 1.
    - For a potential resident, estimated potential multipathway cancer (5E-0-6) and noncancer chronic risks (0.2) are below the incremental risk guideline values of 1E-05 for cancer and 1 for noncancer chronic, respectively.
    - For a potential farmer, estimated potential cancer risks (1E-05) and noncancer multipathway chronic risks (0.2) do not exceed the incremental guideline values of 1E-05 and 1, respectively.
    - Age adjustment for early life exposures does not change the reported estimated cancer risks for the farmer or resident receptor.

- Fish pathway risk from mercury deposition
    - The modeled potential change in fish mercury concentration is estimated to range from about 0.0006 to 0.016 ppm. This change is small compared to the magnitude and variability in background concentrations.
    - Most of the nearby lakes considered in the MMREM have existing MDH fish consumption advisories for mercury to limit mercury exposure via the fish consumption pathway. Potential changes in mercury concentrations in fish from potential Plant Site mercury emissions are expected to be minimal and do not change these fish consumption advisories
- Cumulative inhalation risks
    - The Project is estimated to account for about 57% of the estimated potential cumulative acute risk. The estimated cumulative acute inhalation risk is 1 and does not exceed the incremental risk guideline value of 1.
    - The Project accounts for about 7% of the estimated potential cumulative chronic noncancer risk. The estimated cumulative chronic non cancer risk is 1 and does not exceed the incremental risk guideline value of 1.
    - The Project accounts for only 9% of estimated potential cumulative cancer risk. The estimated cumulative cancer risk is 4E-05, which is higher than the incremental risk guideline value is 1E-05. Background risk (3E-05) that is derived from monitored air concentrations already exceeds the incremental risk guideline value.

Conclusion: The MPCA AERA methodology ensures that a conservative approach is used to assess potential health risks and protect public health (including sensitive populations) with a suitable margin of safety. When potential health risks are assessed to be at or below acceptable guidelines using this methodology, adverse health effects, even in sensitive populations, are unlikely. When the estimated potential risks for the Plant Site are compared to guideline values, and accounting for conservatism in the risk analysis methodology, adverse impacts to human health are not expected to be associated with the potential air emissions from the proposed Plant Site operations.

For potential cumulative inhalation risk, potential background risks calculated by MPCA staff are intended to not underestimate those risks. The potential additional risk from the Project is small and considered to be conservatively overestimated for this screening analysis.

## 13.0 Certification

PolyMet hereby provides the following certification for the Plant Site Air Emissions Risk Analysis:

"I hereby certify under penalty of law that the enclosed documents and all attachments were prepared under my direction in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or the person directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true and accurate and complete."

_____

{responsible official}
Poly Met Mining Inc.

## Glossary of Terms Used in Air Emissions Risk Analysis

| Term | Definition |
|---|---|
| Acute exposure | Single or multiple exposures occurring within a short time (24 hours or less). For purpose of the AERA, acute exposure is a single event with a duration of one-hour |
| Acute toxicity | Adverse health effects that occur or develop rapidly after a single administration of a chemical |
| Additivity | Refers to a situation where the combined effect of exposure to two or more chemicals is equal to the sum of the effect of each of those chemicals given alone (e.g.10 + 10 = 20). |
| Algorithm | Systematic method for solving a problem. Usually refers to multiple step methods for performing complex mathematical calculations. |
| Antagonistic | Description of two or more chemicals which when given together interfere with each other's actions. |
| Bioaccessible | A value representing the availability of a metal for absorption when dissolved in in vitro surrogates of body fluids or juices. |
| Bioavailable | The fraction of a dose that becomes available for distribution to internal target tissues and organs. |
| Bioconcentration Factor (BCF) | The ratio of a contaminant concentration in biota to its concentration in the surrounding medium (e.g., water). |
| Biokinetic | Refers to the modeling and mathematical description of a chemicals distribution over time in a whole organism. |
| Biomagnification | The process of bioaccumulation and biotransfer by which tissue concentrations of chemicals in organisms at one trophic level exceed tissue concentrations in organisms at the next lower trophic level in a food chain. |
| Cancer induction | Chemical modification of the DNA in a cell which given the right conditions could allow the cell to begin to proliferate in an uncontrolled manner. |
| Carcinogen | A chemical that may be capable of causing cancer in mammals. For purposes of this risk assessment a carcinogen is a chemical that is defined by the USEPA as a carcinogen. |
| Central Tendency Exposure | A measure of the middle or the center of an exposure distribution. The mean is the most commonly used measure of central tendency (EPA Exposure Factors Handbook, Glossary) |
| Chemicals for Evaluation (CFE) | Chemicals which may be emitted to air as a result of this facility's operations and that have toxicity values in the MPCA RASS and have data available to estimate potential emissions |
| Chemicals for Potential Evaluation (CFPE) | Chemicals that may be emitted to air as a result of a facility's operations |

| Term | Definition |
|---|---|
| Chronic exposure | Prolonged or repeated exposure typically occurring over a period of several years. The assumed exposure periods used in this AERA vary between exposure scenarios. |
| Chronic toxicity | Adverse health effects that occur after a lapse of time between the initial exposure, or affects that persist over a long period of time whether or not they occurred immediately or are delayed. |
| Class I area | Federally mandatory Class I areas are wilderness areas and national parks. |
| Class II area | In Minnesota, Class II areas are all areas that are not designated as Class I areas. |
| Dose-response curve | Graphical representation of the relationship between chemical dose and response of the population to that dose (incidence of adverse effect). |
| Dosimetric | Corrections for differences in body weight, surface area and metabolic rate applied to dosage. |
| Epidemiological | Refers to the study of disease and its spread in people. |
| Genotoxic | Substance that can cause damage to cellular DNA. |
| Hazard Index (HI) | The sum of HQs for non-carcinogenic chemicals with similar modes of action and toxic endpoints. A HI of one or more indicates that there is a potential for adverse health effects. |
| Hazard Quotient (HQ) | The calculated or measured exposure to a given chemical divided by the RfC for that chemical. An HQ of one or greater indicates that there is a potential for adverse health effects. |
| Health Risk Value (HRV) or Inhalation Risk Value | A Health Risk Value is the concentration of a chemical (or defined mixture of chemicals) defined by the MDH that is likely to pose little or no risk to human health. For carcinogens, MDH defines significant risk as a risk of 1 in 100,000. For noncarcinogens, MDH defines significant risk as a Hazard Index greater than 1 (for an individual chemical) or a Hazard Quotient greater than 1 (for a mixture of chemicals. |
| MAAQS | Minnesota Ambient Air Quality Standards. |
| Maximum Exposed Individual (MEI) | An exposure concept is based upon the following assumptions: continuous lifetime exposure (365 days per year for 70 years), individual is outside 24-hours per day, individual is at the point of maximum estimated air concentration. The MEI represents the maximum or near maximum for potential risk from exposure to plant airborne emissions. |
| Modified Central Tendency Exposure (MCTE) | An exposure concept in which mean, or median exposure frequency and duration data are used in the calculation of risk. In this risk assessment upper value airborne concentrations were used in the MCTE concept. The resultant risk estimate would correspond to a 50th to 85th percentile range for chronic and sub-chronic exposure. |
| Multimedia factors | A term used in previous versions of MPCA AERA Guidance. See Multipathway Screening Factors for a current definition. |

| Term | Definition |
|---|---|
| Multipathway Screening Factors (MPSFs) | As defined by the MPCA, based on individual chemical information in the Industrial Risk Assessment Program (IRAP), it is the ratio of a chemical's total multipathway risk/a chemical's inhalation risk. |
| Non-carcinogen | For the purposes of this risk assessment, a non-carcinogen is a chemical, which is not included on the USEPA list of carcinogens. |
| Ozone Limiting Method (OLM) | A refined $NO_2$ modeling technique that determines if the conversion of NO to $NO_2$ is limited by the ambient ozone concentration and uses this to determine modeled $NO_2$ concentrations. A conservative default in-stack $NO_2$:NO ration of 1:1 was used in the Plant Site AERA modeling. |
| Particulate Matter | Small discrete masses of solid or liquid materials. Particles are often defined as having aerodynamic diameters (incorporates considerations of shape and density of the particle) from 0.001 to 100 microns (one micron equals one-millionth of a meter). |
| Persistent, bioaccumulative, toxic (PBT) chemicals | Persistent, bioaccumulative and/or toxic (PBT) chemicals are defined by the MPCA AERA-RASS. The MPCA AERA-RASS uses the "EPA PBT Profiler" to determine if a chemical is persistent and bioaccumulative. If the half-life in water, soil, and sediment is 60 days or more a substance is considered persistent, and if the half-life is more than 180 days, it is considered very persistent. If the BCF is 1000 or more, a substance is considered bioaccumulative, and if the BCF is 5000 or more, it is considered very bioaccumulative The MPCA considers a chemical persistent and bioaccumulative and carried the chemical through for further analyses if the percent partitioning to water was greater than 10%, the half- life in water was greater than 60 days, and the bioconcentration factor was greater than or equal to 1000. or the percent partitioning to soil was greater than 10%, the half-life in soil was greater than 60 days, and the BCF was greater than or equal to 1000; or the percent partitioning to sediment was greater than 10%, the half-life in sediment was greater than 60 days, and the BCF was greater than or equal to 1000. EPA has classified some metals as PBTs under the Community Right to Know Act.11 A more comprehensive list of metals with potential PBT characteristics was adopted by the European Union. Seven metals from the initial list of 315 substances were also included in the EU list were carried forward in subsequent analyses in the RASS. |
| $PM_{2.5}$ | Particulate matter with an aerodynamic diameter of 2.5 micrometers or less. |
| $PM_{10}$ | Particulate matter with an aerodynamic diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of human hair). |
| Reasonable Maximum Exposure (RME) | The exposure concept representing the highest exposure that is reasonably expected at the site. RME refers to people who are at the high end of the exposure distribution (approximately the 95th percentile). The RME scenario is intended to assess exposures that are higher than average, but are still within a realistic range of exposure (http://www.epa.gov/risk/exposure.htm). |

| Term | Definition |
|---|---|
| Receptor | For purposes of this risk assessment, a receptor is an individual living or working (outside of the facilities property boundary) that may be exposed to emissions from the facility. |
| Reference concentration (RfC) | An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse noncancer effects during a lifetime. |
| Reference Dose (RfD) | An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous ingestion exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse noncancer effects during a lifetime. |
| Reference Exposure Level (REL) | RELs are derived for the California Hot Spots program (by the Office of Environmental Health Hazard Assessment-OEHHA) in a manner similar to USEPA values and have undergone internal and external review. An REL represents an airborne concentration of a chemical at or below which no adverse effects are anticipated in individuals exposed to that level. RELs can apply to exposures for 1 hour, 8 hours, or up to a lifetime. http://oehha.ca.gov/air/allrels.html |
| Respirable | Particles that can be inhaled and deposited into the lungs and alveoli. Respirable particles are typically defined as having aerodynamic diameters of 10 microns or less. |
| Risk Driver | For non-carcinogens, this means a chemical with a Hazard Quotient greater than 0.1. For carcinogens, this means a chemical with an estimated risk greater than 1 in 1,000,000 (> 1E-06). |
| Semi-volatile organic compound (SVOC) | Organic compounds which may be present in both vapor and particulate phase within the atmosphere. These compounds tend to evaporate very slowly at normal temperatures and can be very persistent in the environment. SVOCs have vapor pressures ranging from $10^{-1}$ to $10^{-7}$ mmHg and boiling points that range from 120 to 300$^{o}$C. |
| Sensitive receptor | In general, a sensitive receptor refers to a person or group of people that may be more sensitive to chemical exposure. Examples include pregnant women, children, the elderly, or those who are immuno- compromised. |
| Settling velocity | The velocity at which a particle in still air at normal temperature and pressure will fall through the atmosphere. Settling velocity depends upon the particles size, shape and density. Heavy (dense) particles have higher settling velocities than light particles. |
| Significant impact levels (SILs) | Screening levels for incremental ambient air concentrations. Projects with incremental ambient air concentrations below the SIL for a given pollutant are not necessarily required to complete NAAQS modeling for that pollutant. |
| Slope factor | Used to define the potency of a carcinogen at low dose levels. The slope of the dose-response curve in the low-dose region. When low-dose linearity cannot be assumed, the slope factor is the slope of the straight line from 0 dose to the dose at 1% excess risk. (double check this) |

| Term | Definition |
|---|---|
| Synergistic | The combined effect of two or more chemicals given together is greater than the sum of the effects of those chemicals. |
| Toxicity | Measure or degree of adverse effect of a given chemical on a living organism. In the case of this risk assessment – humans. |
| Toxicity Equivalent (TEQ) | Toxicity Equivalents (TEQ) for dioxin and furan congeners is the toxicity weighted masses of mixtures of dioxins/furans. In practical terms, it is the summed concentration of dioxin/furan congeners expressed in terms of the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin. |
| Toxicity factor | Can refer to a toxicity value used to calculate a risk estimate (e.g., slope factor, unit risk, RfC, RfD, etc.) |
| Unit risk (UR) | The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 μg/L in water, or 1 $\mu g/m^3$ in air. |
| Volatile organic compound (VOC) | Organic compounds that evaporates easily and are usually found as a vapor in the air. VOCs have vapor pressures greater than $10^{-1}$ and boiling points less than $120^{o}C$. |
| Weight-of-evidence | Procedure for evaluating the toxicity, and in particular the carcinogenicity of a chemical using evidence from human (epidemiological) studies, and animal studies. Studies are weighted based upon their relevance to human exposure, and assessed quality of the study. Well-designed studies are given greater weight in the consideration of toxicity than poorly designed studies. Similarly human studies are given greater weight than animal studies. |

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## Revision History

| Date | Version | Description |
|---|---|---|
| 12/12/2012 | 1 | Initial release |
| 02/26/2013 | 2 | Report revised to address comments received on version 1. |
| 03/25/2013 | 3 | Report revised to address outstanding comment. |

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**Large Table 1 Exposure Parameters for the PolyMet Plant Site for Noncancer Effects**

| Exposure Information | | | Exposure Concentration Adjustments (note: if exposure is not adjusted the underlying assumptions in deriving the toxicity values and/or multipathway screening factors (MPSFs) continue to apply) | | | | MPCA- RASS Toxicity value or Multipathway screening factor (MPSF) assumptions | Classification of assessed risk |
|---|---|---|---|---|---|---|---|---|
| **Exposure Route** | **Exposure Conc. µg/m3** | **Receptor Location** | **Exp. Time (Hrs/day)** | **Exp. Freq. (days/year)** | **Exp. Duration (years)** | **Averaging time (years= exposure duration for non-carcinogens)** | **Assumptions and/or adjustments** | **Maximum Exposed Individual (MEI) or Reasonable Maximum Exposure (RME)** |
| Inhalation only - 1 hour | Maximum modeled 1- hour concentration | Off-site worker at the Plant-Site Property Boundary | NA | NA | NA | NA | Toxicity values assume one hour of exposure | Maximum exposed individual (MEI) |
| Inhalation only - 1 hour | Maximum modeled 1- hour concentration | Person at former LTVSMC ambient air boundary | NA | NA | NA | NA | Toxicity values assume one hour of exposure | Maximum exposed individual (MEI) |
| Chronic inhalation | Adjusted maximum modeled air concentration | Off-site worker at the Plant-Site Property Boundary | 8 hours/day | 250 days/year | 25 years | 25 years | None | Reasonable maximum exposure (RME) |
| Inhalation-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside of former LTVSMC mineral-mining boundary | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime | Maximum exposed individual (MEI) |
| Ingestion-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside of former LTVSMC mineral-mining boundary | None-see MPSF value assumptions | None-see MPSF value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | MPSFs assume exposure duration equals averaging time | Maximum exposed individual (MEI) |

NA=not applicable- maximum modeled air concentrations are not adjusted for acute exposures.

**Large Table 2 Exposure Parameters for the PolyMet Plant Site for Cancer Effects**

| Exposure Information | | | Exposure Concentration Adjustments (note: if exposure is not adjusted the underlying assumptions in deriving the toxicity values and/or multipathway screening factors (MPSFs) continue to apply) | | | | MPCA- RASS Toxicity value or Multipathway screening factor assumptions | Classification of assessed risk |
|---|---|---|---|---|---|---|---|---|
| **Exposure Route** | **Exposure Conc. µg/m3** | **Receptor** | **Exposure Time (hours/day)** | **Exposure Frequency (days/year)** | **Exposure Duration (years)** | **Averaging time (always 70 years for carcinogens)** | **Other adjustments** | **Maximum Exposed Individual (MEI) or Reasonable Maximum Exposure (RME)** |
| Chronic inhalation | Maximum modeled annual concentration | Off-site worker at the Plant-Site Property Boundary | 8 hours/day | 250 days/year | 25 years | 70 years | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime | Reasonable maximum exposure (RME) |
| Inhalation-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside of former LTVSMC mineral-mining boundary | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumption | None-see toxicity value assumptions | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime<br>MPSFs do not apply to inhalation risk | Maximum exposed individual (MEI) |
| Ingestion-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside of former LTVSMC mineral-mining boundary | None-see MPSF assumptions | None-see MPSF assumptions | None-see MPSF assumptions | None-see MPSF assumptions | The MPCA adjusts MPSFs in the RASS for exposure duration and averaging time<br>-Exposure duration is 30 years for a resident and 40 years for a farmer<br>-averaging time is 70 years | Reasonable maximum exposure (RME) |

NA=not applicable-acute exposures are not assessed for potential cancer effects nor are maximum modeled air concentrations adjusted for acute exposures.

**Large Table 3 Comparison of 2007 and 2012 Estimated Hourly and Annual Emissions of Chemicals for Potential Evaluation (CFPE) in the Supplemental Air Emissions Risk Analysis Conducted for the Proposed Plant Site**

| CFPE | 2007 Emissions tpy | 2012 Emissions tpy | % change tpy | 2007 Emissions lb/hr | 2012 Emissions lb/hr | % change lb/hr |
|---|---|---|---|---|---|---|
| Acetaldehyde | 3.62E-03 | 3.79E-04 | -90% | 1.01E-03 | 1.52E-03 | 50% |
| Acrolein | 2.31E-04 | 7.95E-05 | -66% | 1.10E-04 | 3.18E-04 | 189% |
| Acenaphthene | 1.30E-05 | 3.45E-04 | 2553% | 3.70E-05 | 4.52E-04 | 1120% |
| Acenaphthylene | 3.03E-05 | 6.87E-04 | 2171% | 7.41E-05 | 9.07E-04 | 1125% |
| Anthracene | 1.20E-05 | 9.77E-05 | 716% | 1.17E-05 | 1.30E-04 | 1013% |
| Antimony | 1.98E-03 | 1.35E-03 | -32% | 4.53E-04 | 2.44E-03 | 438% |
| Arsenic | 3.74E-03 | 2.69E-02 | 620% | 8.54E-04 | 2.40E-02 | 2713% |
| Barium | 9.65E-02 | 1.05E-01 | 9% | 2.20E-02 | 3.14E-02 | 42% |
| Benzene | 7.40E-03 | 7.27E-03 | -2% | 7.34E-03 | 2.30E-02 | 213% |
| Benzo(a)anthracene | 9.70E-06 | 5.26E-05 | 442% | 6.74E-06 | 7.12E-05 | 957% |
| Benzo(a)pyrene | 1.13E-06 | 2.02E-05 | 1688% | 1.19E-06 | 2.58E-05 | 2063% |
| Benzo(b)fluoranthene | 3.04E-06 | 8.20E-05 | 2599% | 8.77E-06 | 1.06E-04 | 1104% |
| Benzo(k)fluoranthene | 1.24E-06 | 1.77E-05 | 1333% | 1.08E-06 | 2.20E-05 | 1945% |
| Benzo(g,h,i)perylene | 2.12E-06 | 4.29E-05 | 1926% | 2.51E-06 | 5.62E-05 | 2141% |
| Beryllium | 2.14E-04 | 4.67E-04 | 119% | 4.88E-05 | 1.09E-03 | 2130% |
| Boron | 6.99E-02 | 5.87E-02 | -16% | 1.60E-02 | 6.18E-02 | 287% |
| 1,3-Butadiene | 9.11E-05 | 1.04E-05 | -89% | 2.08E-05 | 4.16E-05 | 100% |
| Cadmium | 2.21E-02 | 1.44E-03 | -93% | 5.05E-03 | 8.11E-04 | -84% |
| Carbon Disulfide | 3.75E+00 | 5.10E+00 | 36% | 8.57E-01 | 1.16E+00 | 36% |
| Chromium | 4.35E-02 | 1.07E-01 | 147% | 9.93E-03 | 6.77E-02 | 582% |
| Chromium (VI)[(1)] | 2.48E-04 | 0.00E+00 | -100% | 5.67E-05 | 0.00E+00 | -100% |
| Chrysene | 5.26E-06 | 1.13E-04 | 2053% | 1.23E-05 | 1.47E-04 | 1092% |
| Cobalt compounds | 4.69E-01 | 1.89E-01 | -60% | 1.07E-01 | 1.24E-01 | 16% |
| Copper | 8.14E+00 | 2.39E+00 | -71% | 1.86E+00 | 5.31E-01 | -71% |
| Crystalline Silica | 3.46E+00 | 4.54E+01 | 1213% | 7.89E-01 | 1.08E+02 | 13627% |
| Cumene[(2)] | | 0.00E+00 | | | 0.00E+00 | |
| Dibenzo(a,h)anthracene | 2.14E-06 | 2.81E-05 | 1216% | 1.75E-06 | 3.71E-05 | 2023% |
| Dichlorobenzene | 8.87E-04 | 9.28E-04 | 5% | 2.03E-04 | 2.12E-04 | 5% |
| Diesel Particulate Matter (DPM) | | 1.56E+00 | NEW | | 9.17E-01 | NEW |
| 7,12-Dimethylbenz(a)anthracene | 5.92E-06 | 1.24E-05 | 109% | 1.35E-06 | 2.82E-06 | 109% |
| Fluoranthene | 4.55E-05 | 3.22E-04 | 608% | 3.97E-05 | 4.36E-04 | 998% |
| Fluorene | 1.63E-04 | 1.04E-03 | 536% | 1.30E-04 | 1.42E-03 | 990% |
| Fluorides (as F) | 6.57E-02 | 1.22E-01 | 86% | 1.50E-02 | 1.72E-01 | 1048% |
| Formaldehyde | 6.11E-02 | 5.88E-02 | -4% | 1.45E-02 | 1.67E-02 | 15% |
| Hafnium | 5.96E-04 | 1.22E-03 | 105% | 1.36E-04 | 1.75E-03 | 1189% |
| Hexane | 1.33E+00 | 1.39E+00 | 5% | 3.04E-01 | 3.18E-01 | 5% |
| Hydrochloric Acid | 2.44E+00 | 1.01E+00 | -59% | 1.00E+01 | 1.94E+01 | 94% |
| Hydrogen Fluoride | 5.85E-03 | 6.78E-03 | 16% | 1.34E-03 | 1.55E-03 | 16% |
| Hydrogen Sulfide | 4.09E+00 | 1.88E+00 | -54% | 9.33E-01 | 4.29E-01 | -54% |
| Indeno(1,2,3-cd)pyrene | 1.94E-06 | 3.27E-05 | 1587% | 1.95E-06 | 4.21E-05 | 2059% |
| Isopropyl Alcohol | | 0.00E+00 | | | 0.00E+00 | |
| Lead | 1.17E-01 | 8.46E-02 | -28% | 2.67E-02 | 7.17E-03 | -73% |
| Manganese | 4.01E-01 | 2.05E+00 | 412% | 9.16E-02 | 4.61E+00 | 4930% |
| Mercury | 4.12E-03 | 2.35E-03 | -43% | 9.41E-04 | 6.15E-04 | -35% |
| 3-Methylchloranthrene | 6.65E-07 | 1.39E-06 | 109% | 1.52E-07 | 3.18E-07 | 109% |
| 2-Methylnaphthalene | 1.77E-05 | 1.86E-05 | 5% | 4.05E-06 | 4.24E-06 | 5% |
| MIBC | 1.27E+01 | 1.27E+01 | 0% | 3.62E+00 | 3.62E+00 | 0% |
| Naphthalene | 1.07E-02 | 1.02E-02 | -5% | 6.48E-03 | 1.30E-02 | 100% |
| Nickel | 5.18E+00 | 4.72E+00 | -9% | 1.18E+00 | 1.06E+00 | -11% |
| $NO_x$ | 1.37E+02 | 1.48E+02 | 7% | 5.47E+01 | 1.66E+02 | 204% |
| $N_2O$ | 2.44E+00 | 2.84E+00 | 16% | 5.58E-01 | 8.67E-01 | 55% |
| Phenanthrene | 2.28E-04 | 3.07E-03 | 1245% | 3.49E-04 | 4.06E-03 | 1064% |
| Phosphorus | 1.47E-01 | 7.69E-02 | -48% | 3.36E-02 | 1.76E-02 | -48% |
| Pyrene | 3.31E-05 | 2.90E-04 | 775% | 3.46E-05 | 3.86E-04 | 1015% |
| POM | 1.64E-03 | 2.02E-03 | 24% | 1.90E-03 | 6.13E-03 | 222% |

| CFPE | 2007 Emissions tpy | 2012 Emissions tpy | % change tpy | 2007 Emissions lb/hr | 2012 Emissions lb/hr | % change lb/hr |
|---|---|---|---|---|---|---|
| Propylene | 1.20E-02 | 6.86E-04 | -94% | 2.75E-03 | 2.75E-03 | 0% |
| Selenium | 2.32E-03 | 1.13E+00 | 48420% | 5.30E-04 | 2.59E-01 | 48864% |
| $H_2SO_4/SO_3$ | 1.15E+01 | 5.02E+00 | -56% | 2.73E+00 | 1.49E+00 | -45% |
| PCDD/PCDF (TEQ basis) | | 3.88E-09 | NEW | | 4.10E-09 | NEW |
| Tellurium | 1.39E-02 | 2.85E-02 | 105% | 3.17E-03 | 4.09E-02 | 1189% |
| Toluene | 4.96E-03 | 4.69E-03 | -5% | 3.18E-03 | 8.86E-03 | 179% |
| Vanadium | 4.43E-02 | 1.30E-01 | 193% | 1.01E-02 | 1.99E-01 | 1865% |
| Xylene | 1.70E-03 | 1.42E-03 | -17% | 1.79E-03 | 5.68E-03 | 217% |
| Zinc | 2.97E-01 | 1.98E-01 | -33% | 6.77E-02 | 3.33E-02 | -51% |

NA Not Applicable
(1) Previous emissions estimates of Chromium VI appear to have been in error. Upon further review of the process, emission of Chromium VI is not expected and therefore no emission of Chromium VI is expected.
(2) Cumene and isopropyl alcohol are no longer expected to be emitted due to changes in the process.

**Large Table 4 Revised Risk Estimates (RRE) for CFPE and Resulting CFE for the Supplemental Air Emissions Risk Analysis (AERA) Conducted for the Proposed NorthMet Project Plant Site Near Hoyt Lakes, Minnesota**

| CFPE (CFE are shaded) | Acute inhalation RRE | Noncancer inhalation RRE | Cancer inhalation RRE | Noncancer farmer RRE | Cancer farmer RRE | Noncancer resident RRE | Cancer resident RRE |
|---|---|---|---|---|---|---|---|
| Acetaldehyde [1,3,7] | | | | | | | |
| Acrolein | | | | | | | |
| Acenaphthene | | | | | | | |
| Acenaphthylene | | | | | | | |
| Anthracene | | | | | | | |
| Antimony | | 0.001 | | 0.000 | | 0.000 | |
| Arsenic [1,2,5] | 4.360 | 0.380 | 8.8E-06 | 0.986 | 1.1E-04 | 0.657 | 4.2E-05 |
| Barium [6] | | | | | | | |
| Benzene | 0.000 | 0.000 | 2.8E-10 | 0.000 | 1.0E-10 | 0.000 | 1.0E-10 |
| Benzo(a)anthracene [2] | | | 5.8E-12 | | 8.5E-10 | | 1.2E-11 |
| Benzo(a)pyrene [2] | | | 7.8E-11 | | 1.9E-08 | | 1.9E-10 |
| Benzo(b)fluoranthene [2] | | | 1.5E-11 | | 1.8E-10 | | 1.0E-11 |
| Benzo(k)fluoranthene [2] | | | 1.1E-11 | | 3.4E-09 | | 3.9E-11 |
| Benzo(g,h,i)perylene | | | | | | | |
| Beryllium [2] | | 0.003 | 5.6E-08 | 0.001 | 1.3E-07 | 0.001 | 6.3E-08 |
| Boron [6] | | | | | | | |
| 1,3-Butadiene | | | | | | | |
| Cadmium [2] | | 0.005 | 6.0E-08 | 3.29E-04 | 1.3E-07 | 3.29E-04 | 3.6E-08 |
| Carbon Disulfide | 2.65E-04 | 1.63E-05 | | 8.78E-06 | | 1.78E-06 | |
| Chromium | | | | | | | |
| Chromium (VI) | | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Chrysene [2] | | | 1.2E-12 | | 7.7E-11 | | 1.7E-12 |
| Cobalt compounds [3,7] | | | | | | | |
| Copper | 0.010 | | | | | | |
| Crystalline Silica [3] | | | | | | | |
| Cumene | | | | | | | |
| Dibenzo(a,h)anthracene [2] | | | 8.4E-11 | | 1.8E-07 | | 6.6E-10 |
| Dichlorobenzene | | 2.41E-08 | 7.6E-11 | 3.06E-09 | 2.7E-11 | 3.06E-09 | 2.7E-11 |
| Diesel Particulate Matter [3,7] | | | | | | | |
| 7,12-Dimethylbenz (a)anthracene [2] | | | 6.5E-09 | | 7.5E-07 | | 9.3E-09 |
| Fluoranthene | | | | | | | |
| Fluorene | | | | | | | |
| Fluorides (as F) | | | | | | | |
| Formaldehyde [1] | 0.003 | 1.47E-04 | 2.4E-09 | 5.60E-05 | 8.4E-10 | 5.60E-05 | 8.4E-10 |
| Hafnium | | | | | | | |
| Hexane | | 1.45E-05 | | 1.83E-06 | | 1.83E-06 | |
| Hydrochloric Acid [4] | 0.100 | 0.077 | | 0.016 | | 0.016 | |
| Hydrogen Fluoride [1] | 1.32E-05 | 1.41E-06 | | 6.36E-07 | | 6.36E-07 | |
| Hydrogen Sulfide | 0.020 | 0.003 | | 0.001 | | 0.001 | |
| Indeno(1,2,3-cd)pyrene [2] | | | 1.2E-11 | | 7.4E-09 | | 1.2E-10 |
| Isopropyl Alcohol | | | | | | | |
| Lead (2) | | | 3.2E-09 | | 9.5E-08 | | 2.4E-08 |
| Manganese [5] | | 0.945 | | 0.850 | | 0.850 | |
| Mercury (1) | 0.002 | 3.07E-05 | | 1.16E-05 | | 1.16E-05 | |
| 3-Methylchloranthrene [2] | | | 6.5E-11 | | 6.9E-09 | | 1.2E-10 |
| 2-Methylnaphthalene | | | | | | | |
| MIBC | | | | | | | |
| Naphthalene | 0.010 | 0.001 | 5.7E-08 | 0.000 | 7.7E-09 | 0.000 | 7.7E-09 |
| Nickel [5] | 0.193 | 0.259 | 2.2E-06 | 0.123 | 2.9E-06 | 0.123 | 2.9E-06 |
| $NO_x$ [5] | 1.697 | | | | | | |
| $N_2O$ | | | | | | | |
| Phenanthrene | | | | | | | |
| Phosphorus | | | | | | | |
| Pyrene | | | | | | | |
| POM [2] | | | 6.4E-10 | | 6.9E-08 | | 2.3E-10 |

| CFPE (CFE are shaded) | Acute inhalation RRE | Noncancer inhalation RRE | Cancer inhalation RRE | Noncancer farmer RRE | Cancer farmer RRE | Noncancer resident RRE | Cancer resident RRE |
|---|---|---|---|---|---|---|---|
| Propylene | | | | | | | |
| Selenium (2) | | 0.001 | | 0.004 | | 1.24E-04 | |
| H2SO4/SO3(8) | 0.026 | 0.035 | | 0.009 | | 0.009 | |
| Dioxins/Furans (2,3,7,8-TCDD TEQ basis) (2,4,7) | | | | | | | |
| Tellurium | | | | | | | |
| Toluene | 8.51E-07 | 3.65E-07 | | 4.62E-08 | | 4.62E-08 | |
| Vanadium | 0.053 | | | | | | |
| Zinc | | | | | | | |
| Risk Driver Threshold | 0.1 | 0.1 | 1 E-06 | 0.1 | 1 E-06 | 0.1 | 1 E-06 |

(1) Change in toxicity factor since 2007
(2) Change in multipathway screening factor (MPSF) since 2007 (called multimedia factors in 2007)
(3) CFE due to new toxicity factor that was not available in 2007
(4) CFE because is a potential risk driver based on changes since 2007
(5) CFE because was a risk driver in the March 2007 AERA
(6) Toxicity factor removed from RASS since 2007
(7) No RRE is calculated because March 2007 estimated risk was zero or not available
(8) 2007 modeled concentrations and 2012 toxicity factor used with percent change in emissions to determine acute RRE (See Section 0 for more information.)

**Large Table 5 Estimated Maximum Criteria Pollutant Air Concentrations from Air Emissions at the Plant Site at the Former LTVSMC Ambient Air Boundary Compared to Ambient Air Quality Standards**

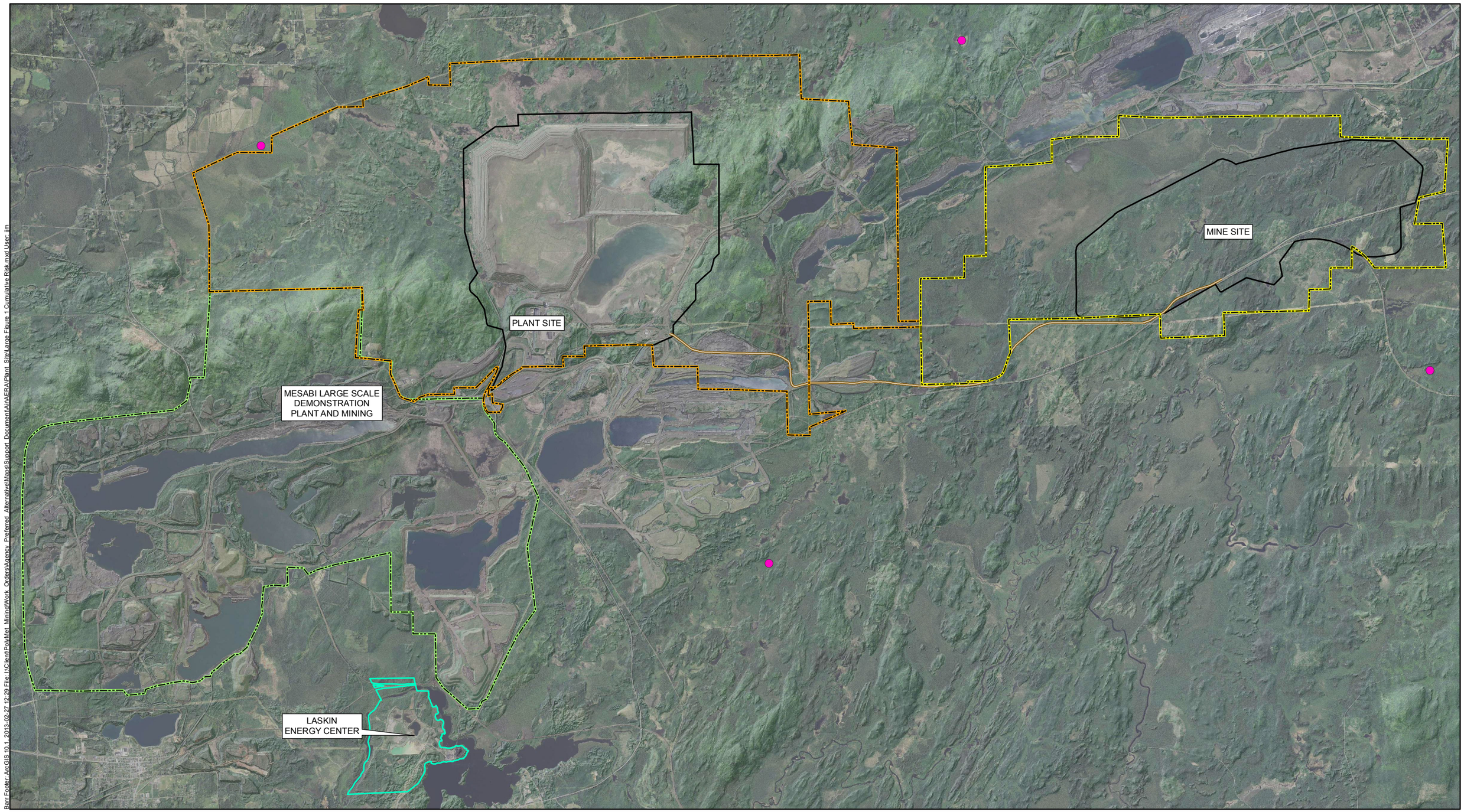
| Pollutant | Time Period | Estimated Ambient Air Concentrations ($\mu g/m^3$)(2) | Minnesota Ambient Air Quality Standard ($\mu g/m^3$) | National Ambient Air Quality Standard ($\mu g/m^3$) | Ratio of Modeled Air Concentration to the Minnesota Ambient Air Standard | Ratio of Modeled Air Concentration to the Federal Ambient Air Standard | Pollutant Toxic Endpoint |
|---|---|---|---|---|---|---|---|
| Particulate matter ($PM_{10}$) | 24 hour | 80 | 150 | 150 | 0.53 | 0.53 | Respiratory system |
| | Annual | 26 | 50 | | 0.53 | | |
| Particulate matter ($PM_{2.5}$) | 24 hour | 33 | 65 | 35 | 0.51 | 0.94 | Respiratory system |
| | Annual | 11 | 15 | 12 | 0.73 | 0.92 | |
| Sulfur dioxide ($SO_2$) | 1 hour | 109 | 1300 | 196 | 0.08 | 0.56 | Respiratory system |
| | 3 hour | 97 | 915 | | 0.11 | | |
| | 24 hour | 40 | 365 | | 0.11 | | |
| | annual | 7 | 60 | | 0.11 | | |
| Nitrogen oxides ($NO_x$) | 1 hour | 177 | | 188 | | 0.94 | Respiratory system |
| | Annual | 21 | 100 | 100 | 0.21 | 0.21 | |
| Carbon monoxide (CO)(1) | 1 hour | NM | 35,000 | 40,000 | NM | NM | Cardiovascular system |
| | 8 hour | NM | 10,000 | 10,000 | | | |

NM = Not modeled for environmental review purposes. See [1].

(1) CO was not identified as a pollutant of concern during the EIS scoping process. Exceedances of the ambient air quality standards are not expected.

(2) Final modeling results for all pollutants at the Plant Site ambient air boundary include PolyMet Plant Site emissions (fugitive emissions + stack emissions) and background concentration.

## Large Figures




Barr Footer:ArcGIS 10.1, 2013-02-27 12:29 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Support Documents\AirAERA\Plant Site\Large Figure 1 Cumulative Risk.mxd User: jim

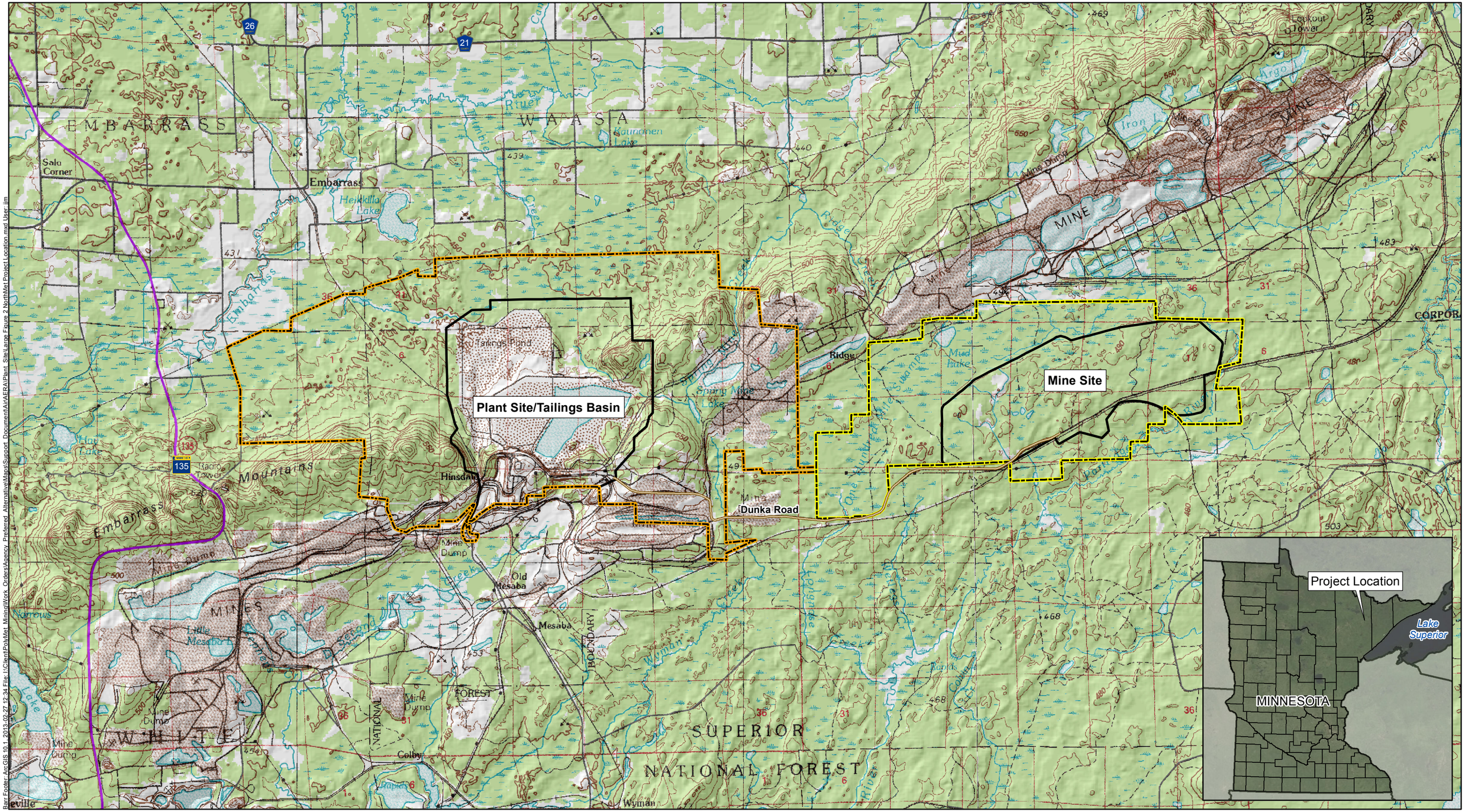
Receptors of Interest
Ambient Air Boundary - Mine Site
Ambient Air Boundary - Plant Site
Ambient Air Boundary - Mesabi Nugget
Laskin Energy Center - Approximate Boundary
Project Areas

N

1 0.5 0 1

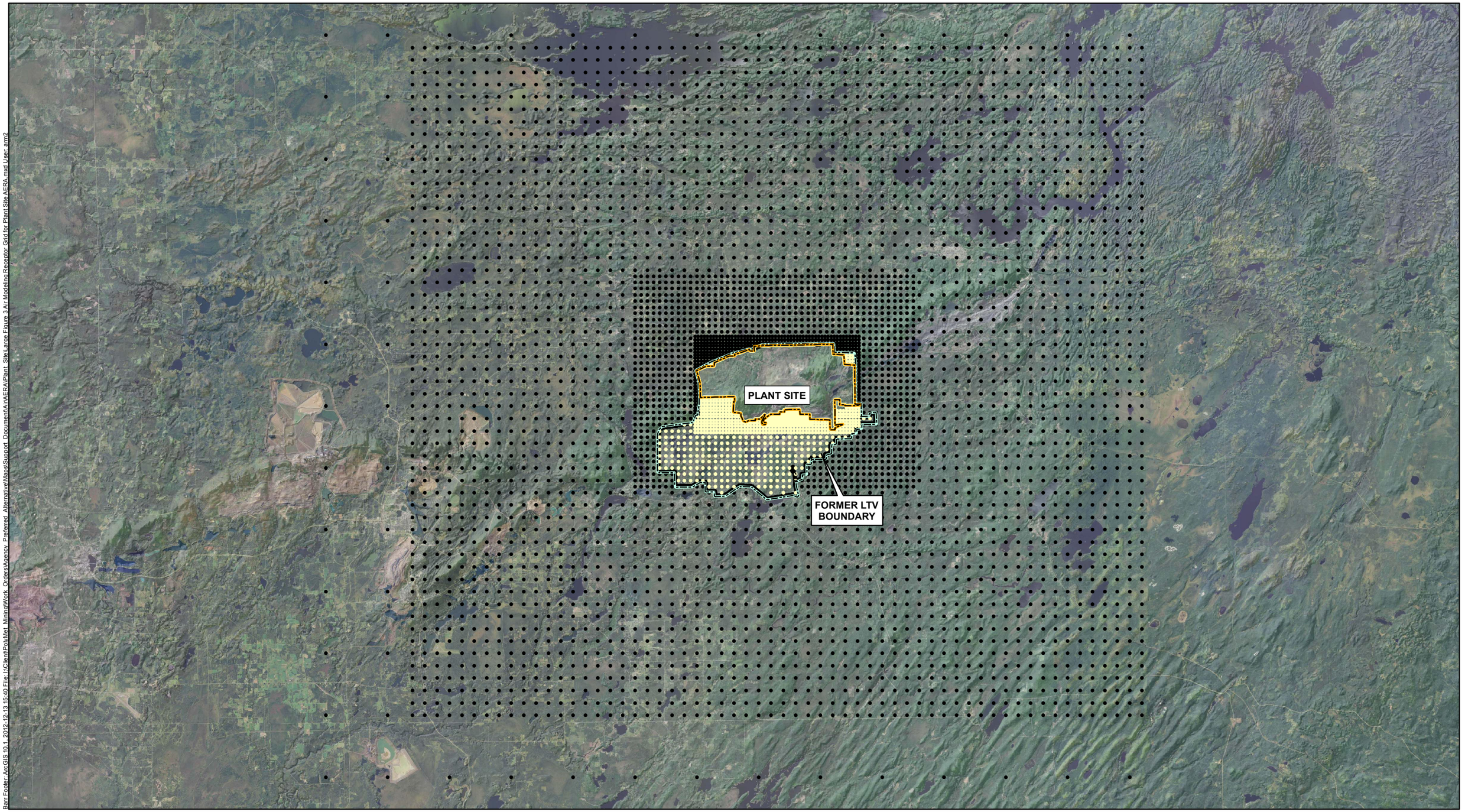
Miles

Large Figure 1
BOUNDARIES FOR PROJECTS AND RECEPTORS OF INTEREST
CONSIDERED IN THE CUMULATIVE RISK ASSESSMENT
FOR THE SUPPLEMENTAL PLANT AND MINE SITE AERAs
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota




Large Figure 2
NORTHMET PROJECT LOCATION IN THE HOYT LAKES AREA IN NORTHEAST MINNESOTA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

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Barr Footer: ArcGIS 10.1, 2012-12-13 15:40 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\AERA\Plant_Site\ Large Figure 3 Air Modeling Receptor Grid for Plant Site AERA.mxd User: am2

Ambient Air Boundary - Plant Site

Ambient Air Boundary - LTVSMC

Plant Site AERA Inhalation Receptors

Plant Site AERA Multipathway Resident/Farmer Receptors

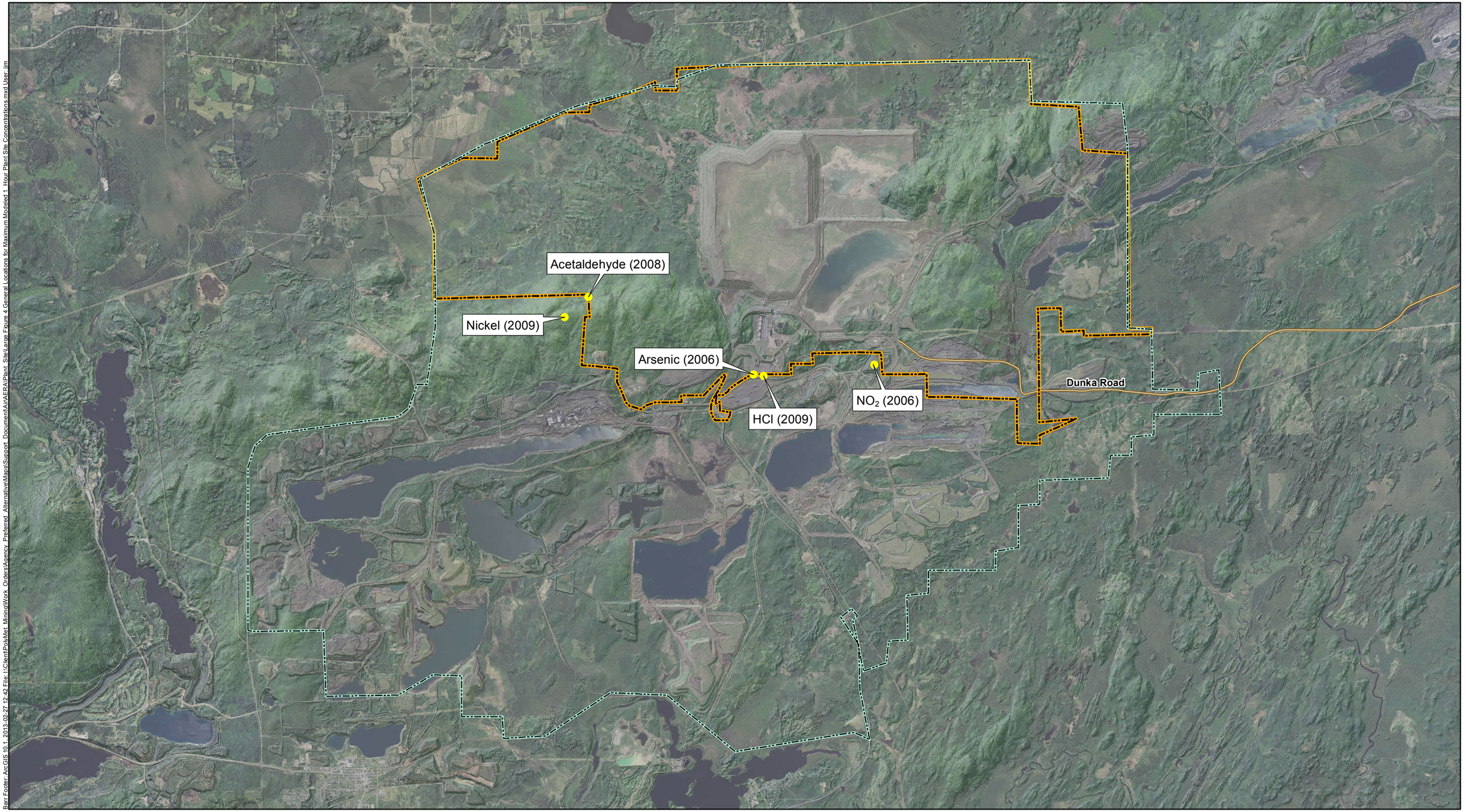
Note: All receptors shown are evaluated for Plant Site AERA Inhalation Risk.
Only those in black are evaluated for Plant Site AERA Multipathway Risk.

N

4.5 2.25 0 4.5

Miles

Large Figure 3
AIR MODELING RECEPTOR GRID FOR THE SUPPLEMENTAL PLANT SITE AERA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota




Barr Footer:ArcGIS 10.1, 2013-02-27 12:42 File: I:\Client\PolyMet\ MiningWork Orders\Agency Prefered Alternative\Maps\Support Document\Air\AERA\Plant Site\Large Figure 4 General Locations for Maximum Modeled 1 Hour Plant Site Concentrations.mxd User: jim

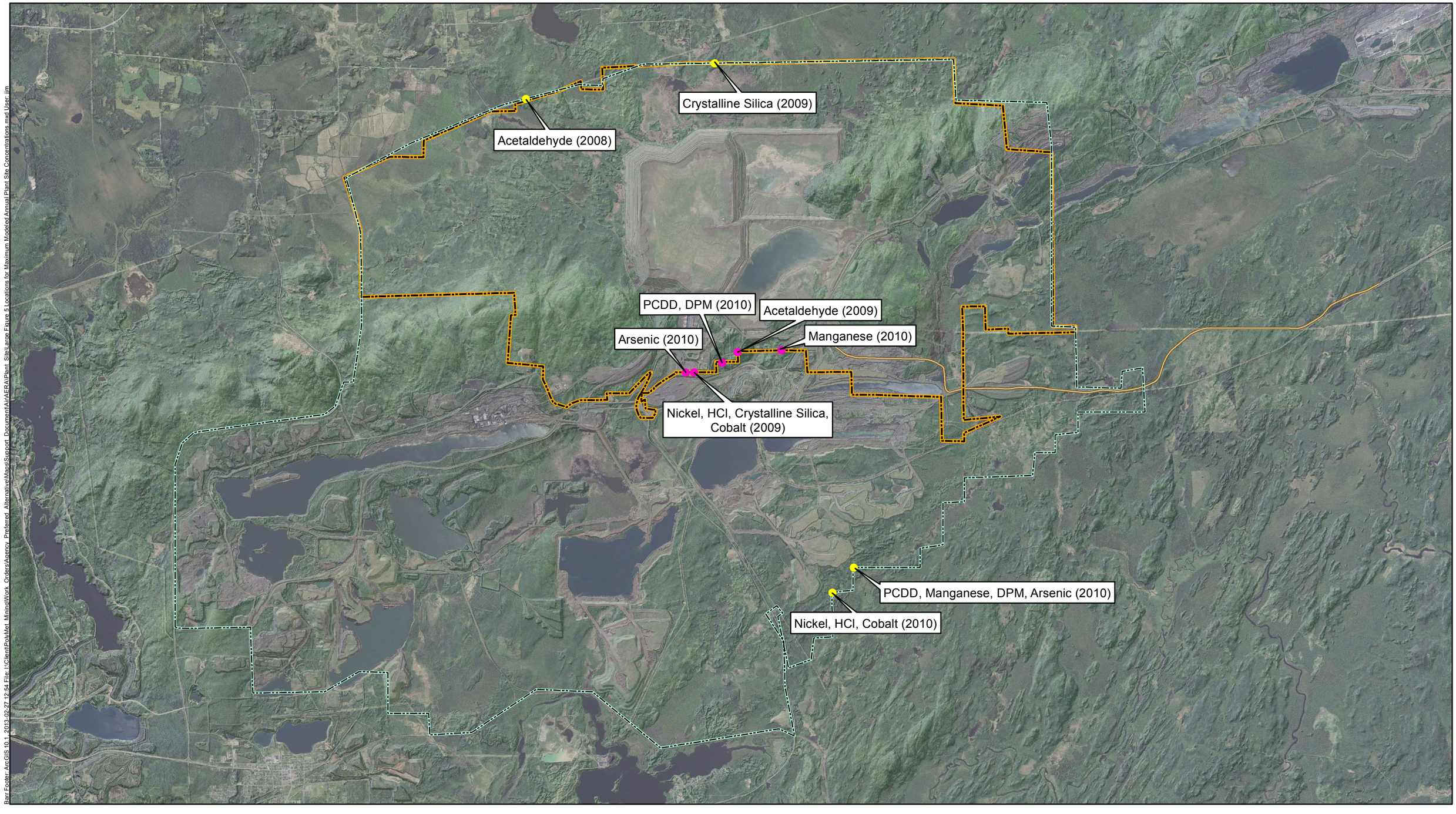
- Maximum 1-Hour Inhalation Concentration Receptors
- Ambient Air Boundary - LTVSMC (Multipathway Risk)
- Ambient Air Boundary - Plant Site (Inhalation Risk)

Note: Year noted in parentheses indicates the meteorological year data for which the maximum concentration was modeled.

1 0.5 0 1

Miles

Large Figure 4
LOCATIONS FOR MAXIMUM MODELED
1-HOUR AIR CONCENTRATIONS AT THE PLANT SITE
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota




Barr Foster ArcGIS 10.1 2013-02-27 12:54 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Support Document\Air\AERA\Plant Site\Large Figure 5 Locations for Maximum Modeled Annual Plant Site Concentrations.mxd User: jim

- Maximum Annual Inhalation Concentration
- Maximum Annual Multipathway Concentration
- Ambient Air Boundary - LTVSMC (Multipathway Risk)
- Ambient Air Boundary - Plant Site (Inhalation Risk)

Note: Year noted in parentheses indicates the meteorological year data for which the maximum concentration was modeled.

1 0.5 0 1
Miles

Large Figure 5
LOCATIONS FOR MAXIMUM MODELED
ANNUAL AIR CONCENTRATIONS AT THE PLANT SITE
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

10 km

3 km

Tailings Basin Area

Land Cover*

- Barren Land (Rock/Sand/Clay)
- Cultivated Crops
- Forest
- Developed
- Developed Open Space
- Wetlands
- Grassland/Herbaceous
- Open Water
- Pasture/Hay
- Shrub/Scrub

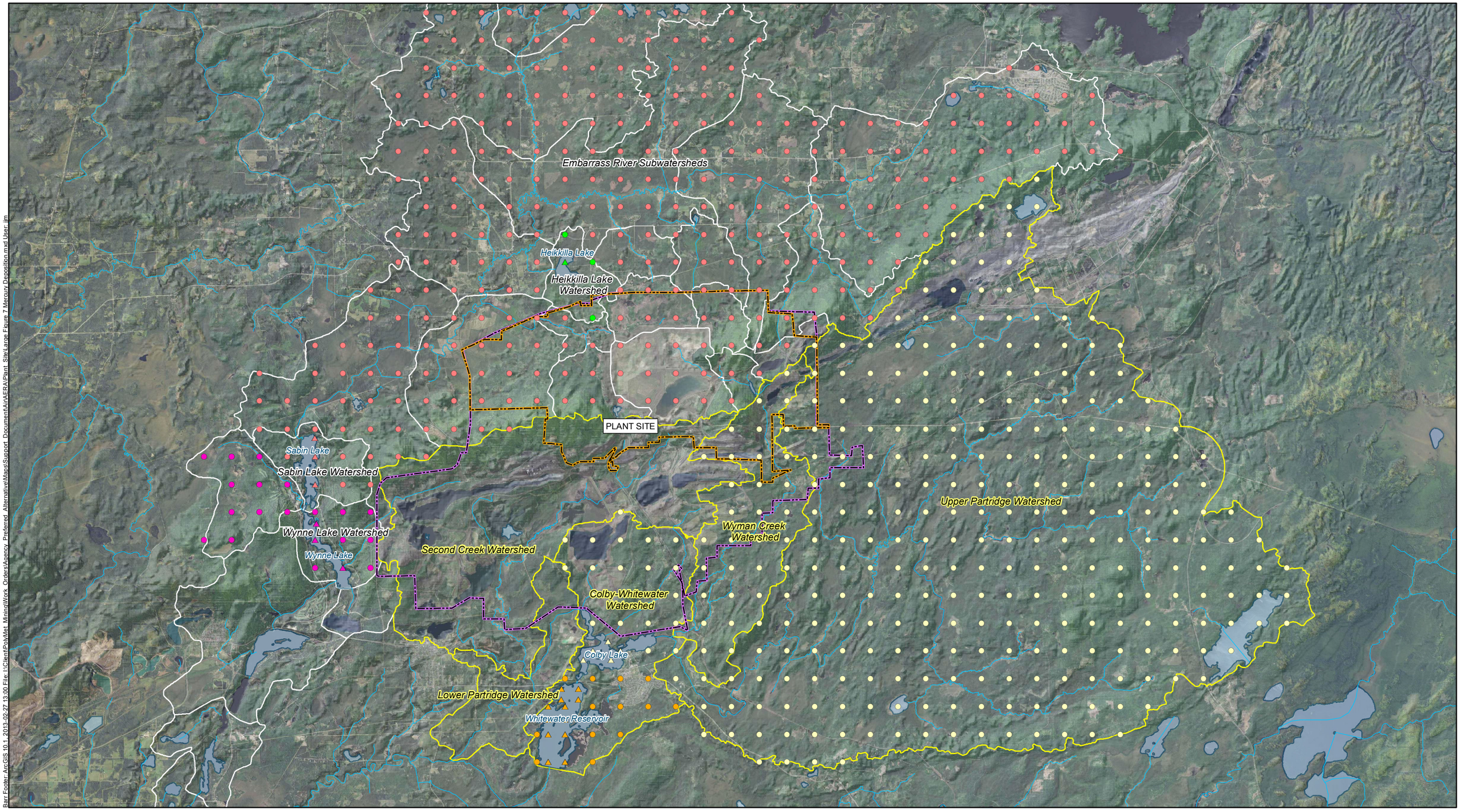
*National Land Cover Dataset, 2006.

1.75 0.875 0 1.75

Miles

Large Figure 6
LAND USE WITHIN 3 AND 10 KM OF
THE NORTHMET PROJECT PLANT SITE
NEAR HOYT LAKES, MN
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

Barr Footer: ArcGIS 10.1, 2013-02-27 12:57 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Support Documents\AirAERA\Plant Site\Large Figure 6 Land Use within 3 and 10km.mxd User: jlim




Barr Foster ArcGIS 10.1 2013-02-27 13:00 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Support Document\AirAERA\Plant Site\Large Figure 7 Mercury Deposition.mxd User: jlm

Mercury Receptors

- Colby Lake
- Colby WSHD
- Whitewater Lake
- Whitewater WSHD
- Heikkilla Lake
- Heikkilla WSHD
- Sabin Lake
- Wynne/Sabin WSHD
- Wynne Lake
- Wynne WSHD

- Ambient Air Boundary - Plant Site
- Ambient Air Boundary - LTVSMC
- Partridge River Subwatersheds
- Embarrass River Subwatersheds

2 1 0 2

Miles

Large Figure 7
LAKE AND WATERSHED RECEPTORS FOR POLYMET PLANT SITE PROJECT MERCURY ASSESSMENT FOR THE SUPPLEMENTAL PLANT SITE AERA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

## Attachments

**Attachment A**

**Multipathway Factors from the MPCA's Risk Assessment Screening Spreadsheet**

**Table A-1 Multipathway Factors from the MPCA's Risk Assessment Screening Spreadsheet**

| CAS number or MPCA number | Chemical Name | Farmer Noncancer | Farmer Cancer | Resident Noncancer | Resident Cancer |
|---|---|---|---|---|---|
| 75-07-0 | Acetaldehyde | 0 | 0 | 0 | 0 |
| 0-00-2 | Arsenic Compounds | 2 | 4 | 1 | 1 |
| 7440-48-4 | Cobalt | 0 | 0 | 0 | 0 |
| 0-02-4 | Diesel exhaust particulate | 0 | 0 | 0 | 0 |
| 7647-01-0 | Hydrochloric Acid | 0 | 0 | 0 | 0 |
| 0-01-4 | Manganese Compounds | 0 | 0 | 0 | 0 |
| 0-01-5 | Nickel Compounds | 0 | 0 | 0 | 0 |
| 10102-44-0 | Nitrogen oxide (NO2) | 0 | 0 | 0 | 0 |
| 1175.00 | Silica (crystalline, respirable) | 0 | 0 | 0 | 0 |
| 00-09-1 | TCDD Equivalents, 2,3,7,8- | 419 | 200 | 9 | 2 |

## Attachment B

## Toxicity Assessment for Risk Driver Chemicals

## B. Toxicity Assessment for Risk Driver Chemicals

### B.1 Sources of Toxicity Values Used in the MPCA-RASS

The sources for the toxicity values used in this Supplemental 2012 AERA and their hierarchy of use are shown in Table B-1.

**Table B-1 Sources of Toxicity Values used in the MPCA 20120302 RASS**

| Source of Toxicity Value | Comments |
|---|---|
| Minnesota Department of Health (MDH) Health Based Values (HBVs) | MDH may issue HBVs that are guidance, that have not yet been promulgated in Minnesota Rules through rulemaking. These values may be incorporated in the AERA. MDH and MPCA agree to use guidance values before HRVs. |
| Minnesota Department of Health (MDH) - Health Risk Values (HRVs), provisional and surrogate values | These are values that MDH has promulgated through rulemaking and have been incorporated into Minnesota Rules. Values are mainly based on USEPA RfCs with possible addition of an uncertainty factor(s).<br>Provisional, guidance, and surrogate values lack the same level of confidence as the HRVs adopted via rulemaking. |
| USEPA Integrated Risk Information System (IRIS) RfCs, RfDs, Unit Risk Estimates | IRIS values have undergone technical review by USEPA's internal workgroup and external peer review and public comment. |
| California EPA-Office of Environmental Health Assessment (OEHHA) - Reference Exposure Levels (RELs) | RELs are derived for the California Hot Spots program and are derived in a manner similar to USEPA and have undergone internal and external review. However, draft RELs do not have the same level of confidence as adopted RELs. |
| USEPA Superfund Health Risk Technical Support Center – Provisional Peer Reviewed Toxicity Values (PPRTVs)(1) | PPRTVs are derived using methods similar to the USEPA IRIS program and are internally reviewed by two USEPA experts and three external experts. They do not receive the same multi-program consensus as do the USEPA IRIS values. |

(1) In March 2012 the MPCA removed the USEPA's Health Effects Summary Tables (HEAST) database values and replaced them with the PPRTVs.

The methods used to derive the toxicity values (RELs, RfCs, RfDs, PPRTVs, and URs) use a dosimetric adjustment and generally assume exposure 24 hour/day, 365 days/year, for 70 years. This builds another level of conservatism into the health risk estimates.

### B.2 Toxicity Information for Selected CFE

Chemicals potentially emitted from the Plant Site are primarily associated with: ore processing operations, autoclave operations, hydrometallurgical process tank operations, process consumable handling sources, combustion sources and fuel tanks, fugitive dust emissions from tailings basin operations, and diesel combustion emissions from construction equipment used in ongoing operations at the Tailings basin. With few exceptions, conservative assumptions were

used in assessing chemicals potentially emitted from the Plant Site thereby overestimating potential inhalation and multipathway risks.

### B.2.1 Arsenic Compounds

Arsenic is a risk driver only for acute (one hour) inhalation at the Plant Site property boundary. The arsenic acute REL (0.2 µg/$m^3$) used in the AERA is for total inorganic arsenic (including arsine) and was derived by the California OEHHA Hot Spots program. The critical effects for one hour exposure are developmental toxicity (decreased fetal weight in mice), and effects to the cardiovascular and nervous systems.

Arsenic is assessed in the AERA as total arsenic. There are both organic and inorganic forms of arsenic. Most exposure to arsenic is from food (Reference (1)). Foods generally contain organic forms of arsenic which are less toxic than inorganic forms (Reference (1)). There are many forms of inorganic arsenic (e.g. metallic arsenic, arsenic trioxide (+3), arsenic pentoxide (+5)). Arsenic trioxide (+3) is one of the most toxic forms of inorganic arsenic and typically enters the environment from industrial processes such as ore smelting. Most studies assess arsenic toxicity by the administration of inorganic arsenic, arsenic trioxide (+3), or arsenic pentoxide (+5). Available data indicates that arsenic in geologic materials (soil, rock, coal, etc.), is predominantly in the form of arsenic pentoxide (+5). The predominant source of arsenic at the site is expected to be in the arsenic pentoxide (+5) (Reference (2)). Also, data from related industrial sources shows that arsenic pentoxide (+5) represents a large percent of the total arsenic while arsenic trioxide (+3) represents a much smaller percent of total arsenic. In terms of toxicity, only a small percentage of the arsenic trioxide (+3) is considered to be bioavailable (Reference (3)).

### B.2.2 Cobalt

Cobalt is a risk driver for cancer and chronic non cancer effects via inhalation at the Plant Site property boundary and cancer effects via multipathway risk at the former LTVSMC boundary. The calculated inhalation cancer risk is 4E-06, inhalation noncancer chronic risk is 0.2 and multipathway cancer risk for the farmer and resident is 2E-06. Cobalt is a new chemical for evaluation because a provisional value (PPRTV) was added to the RASS in March 2012. The toxicity values in the RASS are for cancer effects, and noncancer chronic effects

Cobalt naturally occurs in the environment in small amounts in rocks, soil, water, plants and animals. Small amounts of cobalt are necessary for the human body for the formation of vitamin $B_{12}$. Food is the largest source of cobalt intake for most people. Based on studies in occupational settings, inhalation of cobalt has been associated with adverse respiratory, cardiac, blood, and immunological effects (Reference (4)). Cobalt exposure in occupational settings may be associated with lung cancer.

The PPRTV unit risk number for cancer is of particular interest with regards to the PolyMet Plant Site. The development of this factor is based on a principal study of inhalation effects on rats and mice (References (5), (6)). Cobalt can exist in numerous forms (e.g. elemental cobalt, cobalt sulfate, cobalt ions, etc.). Cobalt metals and salts have been shown to be genotoxic in studies (Reference (7)). The study on which the PPRTV is based only investigated the soluble

form of cobalt, cobalt sulfate heptahydrate. The solubility of cobalt sulfate heptahydrate (used in the critical study) ranged from 82.8-100% (i.e. very soluble).

Stopford *et al.* evaluated the bioaccessibility of different cobalt compounds in surrogate body fluids (e.g. interstitial fluid, lysosomal fluid, alveolar fluid, serum, synovial fluid, gastric juice, and intestinal juice) by determining it solubility (Reference (8)). Among the compounds evaluated by Stopford *et al.*, the cobalt compound tested that is most similar to that most likely associated with ore crushing and handling operations and emissions at the Tailings Basin was cobalt aluminum spinel. When cobalt aluminum spinel was dissolved in the surrogate body fluids, solubilities ranged from 0.006-0095% (i.e., not very soluble). This information indicates that the assumption of 100% bioavailability for cobalt is very conservative.

Although there is information on the carcinogenic mode of action, the derivation of the unit risk value for cobalt uses a linear extrapolation non-threshold approach to a zero exposure level (References (5), (6)). This is generally accepted methodology and is considered to provide a conservative estimate of the potential toxicity of the chemical (Reference (9)).

Further study of the carcinogenicity of cobalt and cobalt compounds indicates that a distinction between different compounds is required to account for the mechanism of toxicity (reference (10)). Although soluble cobalt has been linked to carcinogenic activity in animals, there is insufficient evidence of any carcinogenic activity for other cobalt compounds and insufficient evidence without confounding factors of any carcinogenic activity in humans (references (6) (10)).

The International Agency for Research on Cancer (IARC, 2005) evaluated the carcinogenic hazards of cobalt and cobalt compounds and concluded that:

- there is inadequate evidence in humans for the carcinogenicity of cobalt metal without tungsten carbide
- there is sufficient evidence in experimental animals for the carcinogenicity of cobalt sulfate
- there is sufficient evidence in experimental animals for the carcinogenicity of cobalt metal powder

Based on this data and data for other cobalt compounds, IARC concluded that "cobalt and cobalt compounds are possibly carcinogenic to humans (Group 2B)." The IARC 2B classification means there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. IARC goes on to state the following about chemicals in the 2B classification:

> It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances, an agent for which there is *inadequate evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from

mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data.

These findings suggest that the PPRTV used for carcinogenic cobalt toxicity as applied to the form of cobalt most likely present in dusts at the Plant Site, is conservative and provides for an overestimation of potential risks.

### B.2.3 Diesel Engine Exhaust/Diesel Particulate

On June 12th, 2012, IARC classified diesel engine exhaust as a Group 1 carcinogen based on sufficient evidence in humans that exposure is associated with an increased risk for lung cancer. It had previously been classified as "probably carcinogenic to humans" (IARC Group 2A). Diesel particulate itself currently is not evaluated for carcinogenicity in the RASS. However, the constituents of diesel engine exhaust/diesel particulate such as arsenic, nickel, cobalt, dioxins/furans and PAHS are evaluated for potential health risks.

### B.2.4 Dioxins/furans

Dioxins/furans are only a risk driver for cancer risk to the farmer via multipathway exposure. The toxicity of dioxins/furans from the combustion of diesel fuel was evaluated on a Toxic Equivalency Quotient basis (TEQ) with 2,3,7,8 – TCDD as an index chemical. Emission factors were expressed on a grams Toxicity Equivalent Quotient (TEQ) per kilometer driven basis (g TEQ/km) (reference (11)).This means that in terms of toxicological effects, the toxicity of all dioxins/furans are weighted as compared to the toxicity of 2,3,7,8-TCDD.

### B.2.5 Hydrochloric acid

Hydrochloric acid is a risk driver only for acute (one hour) inhalation at the Plant site property boundary. The majority of the hourly HCl emissions are from tank filling activities and the maximum hourly emission rate assumes that both HCl tanks are filled simultaneously. A more likely scenario is that the tanks are filled sequentially, which would result in hourly emissions, and thus maximum air concentrations roughly half of the current results.

Hydrochloric acid as a liquid or concentrated gas is corrosive and can cause severe chemical burns to all tissues of contact (Reference (12)). Hydrochloric acid is so irritating to the upper respiratory tract workers have been reported to evacuate from the work place shortly after detecting its odor (References (13), (14). Exposure to the gas causes immediate coughing, burning of the throat, and a choking sensation (Reference (14)). Adverse effects are usually limited to inflammation and sometimes ulceration of the nose throat, and larynx (Reference (14)).

### B.2.6 Nickel compounds

Nickel compounds are a risk driver for all estimated risks at the Plant Site property boundary and at the former LTVSMC boundary. In the RASS, nickel compounds were evaluated using a cancer URE developed by the EPA-IRIS for nickel subsulfide in refinery dust. The carcinogenic potency of different nickel compounds varies significantly based on the solubility properties and

speciation (Reference (15)). The Office of Environmental Health Hazard Assessment (OEHHA) in California, under the Hot Spots program, has established Guideline Reference Exposure Levels (RELs) of 0.2 µg/m3 for acute exposure and 0.014 µg/m3 chronic exposures for nickel and compounds (http://www.oehha.ca.gov/air/allrels.html). The estimated total maximum one-hour (acute) concentration of nickel in air at the PolyMet Plant Site property ownership boundary is 2.9 $\mu g/m^3$ (0.0029 $mg/m^3$). The estimated total maximum annual (chronic) concentration of nickel in air at the PolyMet Mine Site property ownership boundary is 0.1643 $\mu g/m^3$ (0.0001643 $mg/m^3$).

### B.2.7 Nitrogen oxides ($NO_x$ and $NO_2$)

Nitrogen oxides ($NO_2$, $NO_x$) are a risk driver only for acute (one hour) inhalation at the Plant site property boundary. $NO_x$ emissions at the Plant Site are from both diesel engines and natural gas combustion. The Cal EPA-OEHHA 1 hour REL used in the AERA for $NO_2$ is 470 µg/m3. As a comparison, the 1-hr National Ambient Air Quality Standard (NAAQS) is 188 µg/m3. Facilities can model compliance with the NAAQS of 188 µg/m3, but have risks greater than acceptable guidelines when modeling the AERA with the higher toxicity value.

$NO_2$ is a respiratory irritant (Reference (14)). Short term exposures (30 minutes to 24 hours) have been linked to "…respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. Also, studies show a connection between breathing elevated short-term NO2 concentrations, and increased visits to emergency departments and hospital admissions for respiratory issues, especially asthma" (Reference (16)).For the AERA, the MPCA-approved OLM protocol was used to model $NO_2$ emissions for the acute (1-hour) exposure. OLM modeling used USEPA's conservative assumption that 50% of the $NO_x$ emitted from the stack is already $NO_2$. The conversion of the remaining 50% of the $NO_x$ emissions to $NO_2$ is calculated based on the estimated $NO_2$ and ozone concentrations. If the maximum NOx concentration is greater than the ozone concentration, the formation of $NO_2$ is limited by the ambient ozone concentration. If the maximum $NO_x$ concentration is less than the ozone concentration, the model assumes complete conversion of $NO_x$ to $NO_2$. Based on stack testing conducted at a variety of sources, typical ratios of $NO_2$: $NO_x$ from stack sources are less than 10%. There has been much less $NO_2$:$NO_x$ ratio testing conducted on exhaust emission from haul trucks, however the San Joaquin Valley Air Pollution Control District reports ratios ranging from 6 – 25% for trucks (Reference (17)).

Table B-2 summarizes the CFEs, their sources and the toxic effects they are assessed for in the MPCA-RASS.

**Table B-2 Summary Sources and Toxic Effects Evaluated of Compounds for Evaluation (CFEs) in the Supplemental AERA for the Plant Site.**

| Chemical | Potential Emission Source | Type of Chemical | Toxicity Effects to be Assessed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Inhalation | | | Multipathway | |
| | | | Acute | Non cancer chronic | Cancer | Non cancer chronic | Cancer |
| Acetaldehyde | Diesel Fuel burning engines (trucks, locomotive engines) | Volatile Organic Compound | X | X | X | | |
| Arsenic compounds | Diesel Fuel burning engines (trucks, locomotive engines); natural gas combustion, airborne ore and tailings particles, process gas from the Autoclave | Metal | X | X | X | X | X |
| Cobalt | Diesel Fuel burning engines (trucks, locomotive engines), natural gas combustion, airborne ore and tailings particles, process gas from the Autoclave | Metal | | X | X | | |
| Crystalline Silica | Crushing of ore and limestone and road dust. | Particulate | | X | | | |
| Diesel exhaust particulate | Diesel Fuel burning engines (trucks, locomotive engines) | Particulate | | X | | | |
| Dioxin/furans | Diesel Fuel burning engines (trucks, locomotive engines) | Dioxin/furans (Semi-volatile compound) | | X | X | X | X |
| Hydrochloric Acid | Tank emissions, process gas from the Autoclave | Inorganic compound | X | X | | | |

| Chemical | Potential Emission Source | Type of Chemical | Toxicity Effects to be Assessed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Inhalation | | | Multipathway | |
| | | | Acute | Non cancer chronic | Cancer | Non cancer chronic | Cancer |
| Manganese compounds | Diesel Fuel burning engines (trucks, locomotive engines), natural gas combustion, airborne ore and tailings particles, process gas from the Autoclave | Metal | | X | | | |
| Nickel compounds | Diesel Fuel burning engines (trucks, locomotive engines), natural gas combustion, airborne ore and tailings particles, process gas from the Autoclave | Metal | X | X | X | | |
| Nitrogen Oxides | Diesel Fuel burning engines (trucks, locomotive engines), natural gas combustion, process gas from the Autoclave | Gas | X | | | | |

**Attachment C**

**Methodology and Assumptions used in Calculating Risk Estimates (RASS 20120302)**

## C. Methodology and Assumptions used in Calculating Risk Estimates (RASS 20120302)

### C.1 Estimating Potential Incremental Inhalation Noncancer Risks

For each chemical to be evaluated, a noncancer risk is calculated in the MPCA-RASS by taking the ratio of the estimated dose (or the maximum modeled air concentration) to a toxicity reference value (TRV) for each chemical for evaluation. The resulting value is called the Hazard Quotient (HQ). The HQs for each chemical are then summed for all chemicals to calculate a Hazard Index (HI). The guideline value for comparison to estimated noncancer risks (HQ or HI) is one (1).

HQ = AIRc / TRV

Where: AIRc = modeled air concentration, typically the maximum 1-hour or annual value ($\mu g/m^3$)

TRV = Toxicity reference value (an HRV, REL, RfC or PPRTV) ($\mu g/m^3$)

$HI = HQ_{\text{chemical 1}} + HQ_{\text{chemical 2}} + HQ_{\text{chemical 3}} \ldots$

A conservative feature built into the RASS is that hazard quotients for noncarcinogens are summed regardless of toxic endpoint, with the resulting Hazard Index (HI) being reported in the RASS summary risk table. If the HQ or HI is greater than 1, there may be a greater concern for potential noncancer health effects and more refined analyses are needed. This does not mean that adverse effects will occur. Some factors to consider in a more refined analyses include determining the toxic endpoints for each chemical, the confidence level in the toxicity values (HRVs, RELs, RfCs, or PPRTVs), and any uncertainties in the derivation of the toxicity values. Most often the individual chemicals likely impact several different organs or systems and should not be summed together into one HI. The RASS does include a refined analysis that allow for summing the chemical HQs by specific target endpoints; an HI for each organ or system may be evaluated if the total noncancer risk is above the general guideline value. Typically when the HI is calculated by target endpoint, the individual target endpoint HI are lower than the when all HQs are summed regardless of toxic endpoint.

### C.2 Estimating Potential Incremental Inhalation Cancer Risks

Maximum modeled annual ambient air concentrations were used to estimate the dose. The estimated dose was multiplied by the unit risk estimate to estimate potential cancer risks to an individual. Use of maximum modeled annual air concentrations results in an estimated cancer risk that represents the maximum possible risk for that specific chemical. The MDH guideline for acceptable cancer risks is a risk level of 1 in 100,000 (1E-5).

Estimated Cancer Risk = Unit Risk (µg/m3)-1 * AIRc

Where: AIRc = modeled air concentration, typically the maximum annual value ($\mu g/m^3$)

To estimate chemical specific potential cancer risk under the MEI exposure concept, maximum values for exposure point concentrations and exposure conditions were used. The combination of maximum or high-end emissions, exposure, and toxicity parameters makes it extremely likely that quantitative risks are overestimated rather than underestimated. While such maximum exposure conditions are individually possible when considered alone, a combination of these conditions is not likely to occur in an actual population. The estimated potential cancer risk for the MEI exposure conditions developed in the AERA represents a theoretical upper-bound risk that would not likely occur in the actual population.

## C.3 Estimating Potential Incremental Non-Inhalation (Multipathway) Risks

Chemicals emitted to the atmosphere may be deposited on soils and surface water and may subsequently enter the terrestrial and aquatic food chain that may lead to indirect human exposures from eating contaminated food. The purpose of the screening level multipathway analysis is to evaluate the potential for adverse human health effects associated with indirect exposure (ingestion) to chemicals potentially emitted from the proposed project and from incidental ingestion of soil for the farmer and resident.

Multipathway Screening Factors (MPSF) were developed by the MPCA for chemicals identified as being persistent or bioaccumulative in the environment, or toxic (PBT). Within the MPCA-RASS spreadsheet, for each type of receptor (e.g. resident, farmer), ingestion risks (i.e., indirect risk by the non-inhalation pathway) are estimated by multiplying a chemical's chronic screening inhalation HQ and/or screening inhalation cancer risk by the MPSF.

Ingestion (non-inhalation) risk, $Chemical_A$ = Noncancer Chronic Inhalation risk * MPSF

Ingestion (non-inhalation) risk, $Chemical_A$ = Cancer Inhalation risk * MPSF

For each chemical and receptor type, inhalation and ingestion (non-inhalation) risks are then summed for a chemical (HQs for noncancer chronic; cancer risks) to derive a "total" noncancer and/or cancer risk (see the RiskCalcs worksheet in the RASS). The individual chemical risks are then summed to derive a TOTAL cancer risk (all chemicals) and a TOTAL HI for each receptor type.

The multipathway screening factors were derived by the MPCA with the Industrial Risk Assessment Protocol (IRAP; multipathway risk model) using generic input parameters to calculate inhalation and indirect exposure risk for specific chemicals (reference (18) (19)). The MPSF is the ratio of the maximum estimated risk from the ingestion exposure route to the maximum estimated risk from the inhalation exposure route (references (20) (21) (19)). The method used by the MPCA to derive the chemical-specific MPSF has not undergone widespread scientific review. The reliability and applicability of the method to site-specific analyses is uncertain. Therefore uncertainty is associated with the results of the multimedia analysis presented in this report. Based on the information available from the MPCA (reference (18) (19)) regarding the multipathway screening factors, it is highly likely that potential risks are conservative and overestimate any potential risks.

**Attachment D**

**Individual Pollutant Risk Estimates from the MPCA's Risk Assessment Screening Spreadsheet**

**Table D-1** **Off-Site Worker: Acute and Noncancer Chronic (Reasonable Maximum Exposure) Inhalation Risk at the Plant Site Ownership Boundary**

| cas # or MPCA # | Chemical Name | Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Acute | Subchronic Noncancer | Chronic Noncancer | Cancer |
| **Total** | | 1.2E+00 | | 1.1E+00 | |
| 75-07-0 | Acetaldehyde | 3.2E-06 | | 1.7E-08 | |
| 0-00-2 | Arsenic Compounds | 1.1E-01 | | 1.1E-02 | |
| 7440-48-4 | Cobalt | | | 2.2E-01 | |
| 0-02-4 | Diesel exhaust particulate | | | 2.4E-02 | |
| 7647-01-0 | Hydrochloric acid | 3.5E-01 | | 8.3E-04 | |
| 0-01-4 | Manganese Compounds | | | 6.3E-02 | |
| 0-01-5 | Nickel Compounds | 2.7E-01 | | 7.5E-01 | |
| 10102-44-0 | Nitrogen oxide (NO2) | 5.1E-01 | | | |
| 1175 | Silica (crystalline, respirable) | | | 1.9E-02 | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | | | 4.6E-06 | |

Highlighted values indicate risk drivers

**Table D-2** **Off-Site Worker: Acute and Cancer (Reasonable Maximum Exposure) Inhalation Risk at the Plant Site Ownership Boundary**

| cas # or MPCA # | Chemical Name | Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Acute | Subchronic Noncancer | Chronic Noncancer | Cancer |
| **Total** | | 1.2E+00 | | | 1.1E-05 |
| 75-07-0 | Acetaldehyde | 3.2E-06 | | | 1.2E-13 |
| 0-00-2 | Arsenic Compounds | 1.1E-01 | | | 2.6E-07 |
| 7440-48-4 | Cobalt | | | | 4.3E-06 |
| 0-02-4 | Diesel exhaust particulate | | | | |
| 7647-01-0 | Hydrochloric acid | 3.5E-01 | | | |
| 0-01-4 | Manganese Compounds | | | | |
| 0-01-5 | Nickel Compounds | 2.7E-01 | | | 6.4E-06 |
| 10102-44-0 | Nitrogen oxide (NO2) | 5.1E-01 | | | |
| 1175 | Silica (crystalline, respirable) | | | | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | | | | 2.7E-08 |

Highlighted values indicate risk drivers

**Table D-3** **Off-Site Worker: Acute and Chronic Noncancer (RME) Inhalation Risk by Endpoint at the Plant Site Ownership Boundary**

| Air Toxics Endpoint Refinement | | | |
|---|---|---|---|
| **Total Inhalation Screening Hazard Indices and Cancer Risks** | | | |
| **Endpoint** | **Acute** | **Subchronic Noncancer** | **Chronic Noncancer** |
| Respiratory/ Olfactory | 1.1E+00 | | 1.0E+00 |
| Developmental/Reproductive/ Endocrine/Fetotoxicity | 1.1E-01 | | 1.1E-02 |
| Hemetological (e.g. Hematopoietic, blood, lymphsystem, immune system) | | | 7.5E-01 |
| Neurological (e.g. central nervous system) | 1.1E-01 | | 7.4E-02 |
| Eyes | | | |
| Alimentary (e.g. digestive) | | | 4.6E-06 |
| Bone & teeth | | | |
| Cardiovascular | 1.1E-01 | | 1.1E-02 |
| Kidney (e.g. renal) | | | |
| Hepatic (e.g. liver) | | | 4.6E-06 |
| Skin | | | 1.1E-02 |
| Ethanol specific | | | |

**Table D-4** **Resident/Farmer Receptor: Acute Inhalation Risk at the Former LTVSMC Boundary**

| cas # or MPCA # | Chemical Name | Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Acute | Subchronic Noncancer | Chronic Noncancer | Cancer |
| **Total** | | 5.2E-01 | | | |
| 75-07-0 | Acetaldehyde | 1.4E-06 | | | |
| 0-00-2 | Arsenic Compounds | 3.0E-02 | | | |
| 7440-48-4 | Cobalt | | | | |
| 0-02-4 | Diesel exhaust particulate | | | | |
| 7647-01-0 | Hydrochloric acid | 4.8E-02 | | | |
| 0-01-4 | Manganese Compounds | | | | |
| 0-01-5 | Nickel Compounds | 6.2E-02 | | | |
| 10102-44-0 | Nitrogen oxide (NO2) | 3.8E-01 | | | |
| 1175 | Silica (crystalline, respirable) | | | | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | | | | |

Highlighted values indicate risk drivers

**Table D-5** **Multipathway Farmer and Resident Risk (Maximum Exposed Individual, MEI) at the Former LTVSMC Ambient Air Boundary**

| cas # or MPCA # | Chemical Name | Chronic Screening Total Hazard Quotients and Cancer Risks (Inhalation + Non-inhalation) for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Farmer Noncancer | Farmer Cancer | Resident Noncancer | Resident Cancer |
| **Total** | | **2.0E-01** | **1.1E-05** | **2.0E-01** | **5.4E-06** |
| 75-07-0 | Acetaldehyde | 1.3E-08 | 2.6E-13 | 1.3E-08 | 2.6E-13 |
| 0-00-2 | Arsenic Compounds | 6.5E-03 | 7.0E-07 | 4.4E-03 | 2.8E-07 |
| 7440-48-4 | Cobalt | 3.9E-02 | 2.1E-06 | 3.9E-02 | 2.1E-06 |
| 0-02-4 | Diesel exhaust particulate | 8.8E-03 | | 8.8E-03 | |
| 7647-01-0 | Hydrochloric acid | 3.6E-04 | | 3.6E-04 | |
| 0-01-4 | Manganese Compounds | 9.8E-03 | | 9.8E-03 | |
| 0-01-5 | Nickel Compounds | 1.2E-01 | 3.0E-06 | 1.2E-01 | 3.0E-06 |
| 10102-44-0 | Nitrogen oxide (NO2) | | | | |
| 1175 | Silica (crystalline, respirable) | 1.6E-02 | | 1.6E-02 | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | 7.2E-04 | 5.5E-06 | 1.7E-05 | 8.2E-08 |

Highlighted values indicate risk drivers

**Table D-6** **Multipathway Farmer and Resident Risk Adjusted for Early Life Exposure (Age Adjusted) at the Former LTVSMC Ambient Air Boundary**

| cas # or MPCA # | Chemical Name | Chronic Screening Total Hazard Quotients and Cancer Risks (Inhalation + Non-inhalation) for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Farmer Noncancer | Farmer Cancer | Resident Noncancer | Resident Cancer |
| **Total** | | | **1.3E-05** | | **7.2E-06** |
| 75-07-0 | Acetaldehyde | | 2.6E-13 | | 2.6E-13 |
| 0-00-2 | Arsenic Compounds | | 7.0E-07 | | 2.8E-07 |
| 7440-48-4 | Cobalt | | 2.1E-06 | | 2.1E-06 |
| 0-02-4 | Diesel exhaust particulate | | | | |
| 7647-01-0 | Hydrochloric acid | | | | |
| 0-01-4 | Manganese Compounds | | | | |
| 0-01-5 | Nickel Compounds | | 4.7E-06 | | 4.7E-06 |
| 10102-44-0 | Nitrogen oxide (NO2) | | | | |
| 1175 | Silica (crystalline, respirable) | | | | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | | 5.5E-06 | | 8.2E-08 |

Highlighted values indicate risk drivers

**Attachment E**

**Sources of Uncertainty for the Supplemental Plant Site AERA**

## E. Sources of Uncertainty for the Supplemental Plant Site AERA

### E.1 Uncertainty Specific to this Supplemental AERA

#### E.1.1 Emission Calculations

Numerous factors contribute to uncertainty in estimating emissions from the Mine Site.

- Use of EPA emission factor for dioxins/furans from tunnel studies performed in 1996-1998 (references (22) (23)).

- Lack of emission factors specifically for estimating dioxin/furan emissions from locomotives. The dioxin emission factors used for heavy duty diesel vehicles discussed above (references (22) (23)) were applied to locomotives on a fuel-usage basis. Locomotives are also subject to the same diesel fuel requirements as heavy duty off road vehicles.

- Metals emission from fugitive dust is based on total PM emissions, not an estimate of inhalable fraction.

#### E.1.2 Exposure Assessment

The following assumptions contribute to conservatism in the exposure assessment:

- Use of only the maximum modeled air concentrations as the chronic dose

- The assumption that the metal emissions (arsenic, cobalt, nickel, manganese) from fugitive sources are in a soluble form, are all respirable and 100% bioavailable by inhalation.

- The assumption that 80% of the NO emitted to air converts instantaneously to $NO_2$.

#### E.1.3 Toxicity Assessment

The following assumptions contribute to uncertainty in the toxicity assessment:

- Calculating risks using surrogate toxicity values to represent chemical mixtures. See Section 9.4.1 for a more complete discussion.

- Differences in the chemical species emitted from the proposed Plant Site operations, and the chemical species used in specific toxicity studies.

- See Sections C.1.3.1 and C.1.3.2 for additional sources uncertainty in deriving toxicity values.

There is a general lack of available information addressing synergism and/or antagonism. Toxicological interactions between multiple chemical exposures can occur. These potential interactions were not specifically addressed in the AERA. These interactions may result in

greater (synergistic) or lesser (antagonistic) effect than the effect of each individual chemical.

There is significant uncertainty inherent in the derivation of USEPA, MDH, Cal EPA-OEHHA, and Superfund toxicity values for chemicals (Reference (24)). This uncertainty is typically addressed by use of uncertainty factors or modifying factors in deriving a toxicity value and its use in estimating potential risks. It can be challenging to find toxicological data that is based on human exposures that can be appropriately used in a health risk assessment. Most toxicological data based on human exposures comes from epidemiological studies based on occupational exposures. Even though data from occupational human exposures is generally considered more relevant than animal data, occupational exposures are usually higher than environmental exposures. Given this lack of human data, toxicologists rely on data from animal studies or other *in vitro* tests. In developing these dose-response values, USEPA currently uses conservative assumptions to assure that the toxicity value is conservative and that the resultant risk estimate is more likely to overestimate risk than underestimate risk. USEPA applies these conservative assumptions for the development of both URs and RfCs.

### E.1.3.1 Non-Carcinogenic Toxicity Values-Uncertainty

Because appropriate human exposure data are rarely available, alternative methods are used to estimate dose-response values that are not likely to cause adverse health effects. The methods currently employed by the USEPA, Cal EPA-OEHHA, and the MDH to develop dose-response values do not allow for an assessment of the likelihood that effects will occur, nor allow an assessment of the severity of the effects in an exposed individual or population. Sources of uncertainty in the development of noncarcinogenic inhalation toxicity values (HRVs, RfCs, RELs, and PPRTVs) include:

- Extrapolation from high dose, short-term exposures in the experimental study to estimate effects following longer-term exposure encountered in the environment.
- Use of adverse effects data available for the most sensitive laboratory animal species.
- Extrapolation from animal studies to humans.
- The use of dose-response data from one route of exposure to estimate effects from exposure via different routes.
- The variability in the quality of the studies upon which the toxicity values are based.
- Lack of consideration of toxicological interactions (i.e. synergism, antagonism, potentiation, additivity) between multiple chemicals.

### E.1.3.2 Carcinogenic Toxicity Factors-Uncertainty

The toxicological database used for developing inhalation unit risk estimates is also a source of uncertainty. The USEPA outlined some of the sources of uncertainties in its *Guidelines for Carcinogen Risk Assessment* (references (25) (26)) and they include:

- Extrapolation from high to low doses and from animals to humans and species, gender age, and strain differences in uptake, metabolism, organ distribution and target site susceptibility.

- Assumption that cancer induction is a "non-threshold" event because it is believed that any level of exposure, however small, poses a finite probability of generating a carcinogenic response (22).

Other sources of uncertainty include:

- Classification of chemicals as either EPA Group A or B carcinogens even if there is just one positive finding of tumors in one laboratory experiment. This one finding is given more weight than any number of negative findings in studies of equal quality.

- The assumption that substances that have been found to be carcinogenic in some animal species means they are likely carcinogenic in humans.

- Cal EPA-OEHHA's use of oral studies to derive inhalation UR values for some chemicals. For example, the UR for dibenzo(a,h)anthracene is based on data derived from oral studies. The derived oral slope factor (SF) was then converted to a UR by assuming a body weight of 70 kg and an inhalation rate of 20 $m^3$ per day.

- Cal EPA-OEHHA's assumption that URs for inhalation have the same relative activities as cancer potencies for oral intake (reference (27)). The route of administration may have an impact on the absorption, distribution, metabolism, excretion, and mode of action of the chemical.

### E.1.4 Conservatism/Uncertainty in Risk Characterization

To develop a cancer risk estimate associated with exposure to multiple chemicals identified by USEPA as carcinogens, the chemical specific cancer risk estimates were summed in accordance with MPCA and USEPA guidance. USEPA recognizes that there are several limitations associated with this approach. For chemicals where the UR is based on the upper 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as risks from a number of carcinogens are summed (reference (24)). In addition, the following procedures and assumptions result in an additional level of conservatism in the cancer risk estimates:

- In summing the cancer risk, equal weight was given to all chemicals regardless of their classification (class A = known human carcinogen, class B = probable human carcinogen, class C = possible human carcinogen).

- Cancer risk values derived from animal studies were given equal weight to values based on human data.

- Carcinogenic responses arising in the same tissue should, according to USEPA, be considered additive unless the mechanism of carcinogenicity is unrelated. The chemicals identified by USEPA as potential carcinogens varied in target tissue. In the AERA, cancer risks were summed regardless of the difference in their mode of action or target tissue. In general, the assumption of additivity is expected to be conservative (reference (25)).

**Attachment F**

**Local Mercury Deposition Supporting Details**

**Table F-1 Data inputs to MMREM evaluations: Lake and Watershed Data**

| Lakes Evaluated | MN DNR # | Existing Ambient Fish Tissue Concentration (95% UCL) (mg/kg) | Area of Fishable Waterbody (acres) | Total Watershed Area (acres) | Area of Rest of Watershed (acres) | References |
|---|---|---|---|---|---|---|
| Colby Lake | 69024900 | 0.93 | 502 | 100,392 | 99,890 | 2,3 |
| Heikkilla Lake | 69025300 | 0.65 | 128 | 1,478 | 1,350 | 1,3 |
| Sabin Lake | 69043401 | 1.02 | 299 | 121,669 | 121,370 | 3 |
| Whitewater Lake | 69037600 | 0.35 | 1,215 | 4,265 | 3,050 | 4,5 |
| Wynne Lake | 69043402 | 1.34 | 289 | 123,889 | 123,600 | 2,3 |

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospatial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

**Table F-2 Data Inputs to MMREM: Modeled Air Concentrations: Average of Maximum Air Concentrations for Lake and Watershed Areas**

POLYMET MAXIMUM ANNUAL AIR CONCENTRATIONS, $\mu g/m^3$

| WATERBODIES | Oxidized Scenario 1 | Elemental Scenario 1 | Particle Bound Scenario 1 | Oxidized Scenario 2 | Elemental Scenario 2 | Particle Bound Scenario 2 |
|---|---|---|---|---|---|---|
| Colby Lake | 3.067E-07 | 1.534E-07 | 1.534E-07 | 8.862E-08 | 4.907E-07 | 6.136E-08 |
| Colby Lake Watershed | 3.952E-07 | 1.976E-07 | 1.976E-07 | 9.194E-08 | 6.322E-07 | 7.903E-08 |
| Heikkilla Lake | 4.743E-07 | 2.371E-07 | 2.371E-07 | 1.133E-07 | 7.587E-07 | 9.480E-08 |
| Heikkilla Lake Watershed | 6.014E-07 | 3.007E-07 | 3.007E-07 | 1.376E-07 | 9.620E-07 | 1.203E-07 |
| Sabin Lake | 1.861E-07 | 9.307E-08 | 9.307E-08 | 4.197E-08 | 2.977E-07 | 3.720E-08 |
| Sabin Lake Watershed | 4.225E-07 | 2.112E-07 | 2.112E-07 | 9.501E-08 | 6.758E-07 | 8.448E-08 |
| Whitewater Lake | 1.929E-07 | 9.645E-08 | 9.645E-08 | 5.421E-08 | 3.085E-07 | 3.855E-08 |
| Whitewater Lake Watershed | 2.675E-07 | 1.337E-07 | 1.337E-07 | 7.382E-08 | 4.279E-07 | 5.350E-08 |
| Wynne Lake | 1.487E-07 | 7.433E-08 | 7.433E-08 | 3.293E-08 | 2.379E-07 | 2.977E-08 |
| Wynne Lake Watershed | 4.225E-07 | 2.112E-07 | 2.112E-07 | 9.501E-08 | 6.758E-07 | 8.448E-08 |

# Table F-3 MMREM Output for Colby Lake, Scenario 1

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 1**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Colby Lake** | **St. Louis** | **69024900** | **0.93** | **502** | **99890** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **3.07E-07** | 50.0% | 1.10 | 0.1 | 502 | 4046.9 | 2.2E+05 | 0.22 | 1.00 | 0.22 |
| Hg(0) | **1.53E-07** | 25.0% | 0.01 | 0.0 | 502 | 4046.9 | 9.8E+02 | 0.00 | 1.00 | 0.00 |
| Hg-p | **1.53E-07** | 25.0% | 0.05 | 0.00 | 502 | 4046.9 | 4.9E+03 | 0.00 | 1.00 | 0.0049 |
| Total | 6.13E-07 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **3.95E-07** | 50.0% | 1.10 | 0.14 | 99,890 | 4046.9 | 5.54E+07 | 55.42 | 0.26 | 14.41 |
| Hg(0) | **1.98E-07** | 25.0% | 0.01 | 0.0 | 99,890 | 4046.9 | 2.5E+05 | 0.25 | 0.26 | 0.07 |
| Hg-p | **1.98E-07** | 25.0% | 0.05 | 0.00 | 99,890 | 4046.9 | 1.3E+06 | 1.26 | 0.26 | 0.327 |
| Total | 7.90E-07 | 100.0% | | 0.1 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 15.02 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 502 | 4046.9 | 2.5E+07 | 25.39 | 1.00 | 25.39 |
| Total deposition for the rest of the watershed | 12.5 | 99,890 | 4046.9 | 5.1E+09 | 5053.06 | 0.26 | 1313.80 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1339.19 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 15.0 | 1339.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.010 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 4.7 | 0.05 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0021 | 0.0022 | 70 | 2.84E-03 | 3.19E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 28.4 | 0.32 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0023 | 0.0025 | 70 | 3.20E-03 | 3.59E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 32.0 | 0.36 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0003 | 0.0003 | 70 | 4.28E-04 | 4.81E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.3 | 0.05 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).

Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-4 MMREM Output for Colby Lake, Scenario 2

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 2**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Colby Lake** | **St. Louis** | **69024900** | **0.93** | **502** | **99890** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **8.86E-08** | 13.8% | 1.10 | 0.0 | 502 | 4046.9 | 6.2E+04 | 0.06 | 1.00 | 0.06 |
| Hg(0) | **4.91E-07** | 76.6% | 0.01 | 0.0 | 502 | 4046.9 | 3.1E+03 | 0.00 | 1.00 | 0.00 |
| Hg-p | **6.14E-08** | 9.6% | 0.05 | 0.00 | 502 | 4046.9 | 2.0E+03 | 0.00 | 1.00 | 0.0020 |
| Total | 6.41E-07 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **9.19E-08** | 11.4% | 1.10 | 0.0 | 99,890 | 4046.9 | 1.3E+07 | 12.89 | 0.26 | 3.35 |
| Hg(0) | **6.32E-07** | 78.7% | 0.01 | 0.0 | 99,890 | 4046.9 | 8.1E+05 | 0.81 | 0.26 | 0.21 |
| Hg-p | **7.90E-08** | 9.8% | 0.05 | 0.00 | 99,890 | 4046.9 | 5.0E+05 | 0.50 | 0.26 | 0.131 |
| Total | 8.03E-07 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 3.76 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 502 | 4046.9 | 2.5E+07 | 25.39 | 1.00 | 25.39 |
| Total deposition for the rest of the watershed | 12.5 | 99,890 | 4046.9 | 5.1E+09 | 5053.06 | 0.26 | 1313.80 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1339.19 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 3.8 | 1339.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.003 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 4.7 | 0.01 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0005 | 0.0006 | 70 | 2.84E-03 | 7.98E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 28.4 | 0.08 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0006 | 0.0006 | 70 | 3.20E-03 | 8.98E-06 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 32.0 | 0.09 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 4.28E-04 | 1.20E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.3 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-5 MMREM Output for Heikkilla Lake, Scenario 1

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 1**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Heikkilla Lake** | **St. Louis** | **69025300** | **0.65** | **128** | **1350** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **4.74E-07** | 50.0% | 1.10 | 0.2 | 128 | 4046.9 | 8.5E+04 | 0.09 | 1.00 | 0.09 |
| Hg(0) | **2.37E-07** | 25.0% | 0.01 | 0.0 | 128 | 4046.9 | 3.9E+02 | 0.00 | 1.00 | 0.00 |
| Hg-p | **2.37E-07** | 25.0% | 0.05 | 0.00 | 128 | 4046.9 | 1.9E+03 | 0.00 | 1.00 | 0.0019 |
| Total | 9.49E-07 | 100.0% | | 0.2 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **6.01E-07** | 50.0% | 1.10 | 0.21 | 1,350 | 4046.9 | 1.14E+06 | 1.14 | 0.26 | 0.30 |
| Hg(0) | **3.01E-07** | 25.0% | 0.01 | 0.0 | 1,350 | 4046.9 | 5.2E+03 | 0.01 | 0.26 | 0.00 |
| Hg-p | **3.01E-07** | 25.0% | 0.05 | 0.00 | 1,350 | 4046.9 | 2.6E+04 | 0.03 | 0.26 | 0.007 |
| Total | 1.20E-06 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.39 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 128 | 4046.9 | 6.5E+06 | 6.48 | 1.00 | 6.48 |
| Total deposition for the rest of the watershed | 12.5 | 1,350 | 4046.9 | 6.8E+07 | 68.29 | 0.26 | 17.76 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 24.23 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.4 | 24.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.010 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 3.2 | 0.05 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0021 | 0.0022 | 70 | 1.98E-03 | 3.20E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 19.8 | 0.32 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0023 | 0.0025 | 70 | 2.23E-03 | 3.61E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 22.3 | 0.36 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0003 | 0.0003 | 70 | 2.99E-04 | 4.83E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 3.0 | 0.05 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-6 MMREM Output for Heikkilla Lake, Scenario 2

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 2**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Heikkilla Lake** | **St. Louis** | **69025300** | **0.65** | **128** | **1350** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **1.13E-07** | 11.7% | 1.10 | 0.0 | 128 | 4046.9 | 2.0E+04 | 0.02 | 1.00 | 0.02 |
| Hg(0) | **7.59E-07** | 78.5% | 0.01 | 0.0 | 128 | 4046.9 | 1.2E+03 | 0.00 | 1.00 | 0.00 |
| Hg-p | **9.48E-08** | 9.8% | 0.05 | 0.00 | 128 | 4046.9 | 7.7E+02 | 0.00 | 1.00 | 0.0008 |
| Total | 9.67E-07 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **1.38E-07** | 11.3% | 1.10 | 0.05 | 1,350 | 4046.9 | 2.61E+05 | 0.26 | 0.26 | 0.07 |
| Hg(0) | **9.62E-07** | 78.9% | 0.01 | 0.0 | 1,350 | 4046.9 | 1.7E+04 | 0.02 | 0.26 | 0.00 |
| Hg-p | **1.20E-07** | 9.9% | 0.05 | 0.00 | 1,350 | 4046.9 | 1.0E+04 | 0.01 | 0.26 | 0.003 |
| Total | 1.22E-06 | 100.0% | | 0.1 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.10 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 128 | 4046.9 | 6.5E+06 | 6.48 | 1.00 | 6.48 |
| Total deposition for the rest of the watershed | 12.5 | 1,350 | 4046.9 | 6.8E+07 | 68.29 | 0.26 | 17.76 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 24.23 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.1 | 24.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.003 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 3.2 | 0.01 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0005 | 0.0006 | 70 | 1.98E-03 | 7.94E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 19.8 | 0.08 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0006 | 0.0006 | 70 | 2.23E-03 | 8.94E-06 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 22.3 | 0.09 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 2.99E-04 | 1.20E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 3.0 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-7 MMREM Output for Sabin Lake, Scenario 1

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 1**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Sabin Lake** | **St. Louis** | **69043401** | **1.02** | **299** | **121370** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **1.86E-07** | 50.0% | 1.10 | 0.1 | 299 | 4046.9 | 7.8E+04 | 0.08 | 1.00 | 0.08 |
| Hg(0) | **9.31E-08** | 25.0% | 0.01 | 0.0 | 299 | 4046.9 | 3.6E+02 | 0.00 | 1.00 | 0.00 |
| Hg-p | **9.31E-08** | 25.0% | 0.05 | 0.00 | 299 | 4046.9 | 1.8E+03 | 0.00 | 1.00 | 0.0018 |
| Total | 3.72E-07 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **4.22E-07** | 50.0% | 1.10 | 0.15 | 121,370 | 4046.9 | 7.20E+07 | 71.98 | 0.26 | 18.72 |
| Hg(0) | **2.11E-07** | 25.0% | 0.01 | 0.0 | 121,370 | 4046.9 | 3.3E+05 | 0.33 | 0.26 | 0.09 |
| Hg-p | **2.11E-07** | 25.0% | 0.05 | 0.00 | 121,370 | 4046.9 | 1.6E+06 | 1.64 | 0.26 | 0.425 |
| Total | 8.45E-07 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 19.31 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 299 | 4046.9 | 1.5E+07 | 15.13 | 1.00 | 15.13 |
| Total deposition for the rest of the watershed | 12.5 | 121,370 | 4046.9 | 6.1E+09 | 6139.65 | 0.26 | 1596.31 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1611.44 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 19.3 | 1611.4 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.012 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 5.1 | 0.06 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0024 | 0.0026 | 70 | 3.12E-03 | 3.74E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 31.2 | 0.37 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0027 | 0.0029 | 70 | 3.51E-03 | 4.21E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 35.1 | 0.42 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0004 | 0.0004 | 70 | 4.70E-04 | 5.64E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.7 | 0.06 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-8 MMREM Output for Sabin Lake, Scenario 2

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 2**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Sabin Lake** | **St. Louis** | **69043401** | **1.02** | **299** | **121370** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **4.20E-08** | 11.1% | 1.10 | 0.0 | 299 | 4046.9 | 1.8E+04 | 0.02 | 1.00 | 0.02 |
| Hg(0) | **2.98E-07** | 79.0% | 0.01 | 0.0 | 299 | 4046.9 | 1.1E+03 | 0.00 | 1.00 | 0.00 |
| Hg-p | **3.72E-08** | 9.9% | 0.05 | 0.00 | 299 | 4046.9 | 7.1E+02 | 0.00 | 1.00 | 0.0007 |
| Total | 3.77E-07 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **9.50E-08** | 11.1% | 1.10 | 0.03 | 121,370 | 4046.9 | 1.62E+07 | 16.19 | 0.26 | 4.21 |
| Hg(0) | **6.76E-07** | 79.0% | 0.01 | 0.0 | 121,370 | 4046.9 | 1.0E+06 | 1.05 | 0.26 | 0.27 |
| Hg-p | **8.45E-08** | 9.9% | 0.05 | 0.00 | 121,370 | 4046.9 | 6.5E+05 | 0.65 | 0.26 | 0.170 |
| Total | 8.55E-07 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 4.67 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 299 | 4046.9 | 1.5E+07 | 15.13 | 1.00 | 15.13 |
| Total deposition for the rest of the watershed | 12.5 | 121,370 | 4046.9 | 6.1E+09 | 6139.65 | 0.26 | 1596.31 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1611.44 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 4.7 | 1611.4 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.003 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 5.1 | 0.01 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0006 | 0.0006 | 70 | 3.12E-03 | 9.04E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 31.2 | 0.09 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0007 | 0.0007 | 70 | 3.51E-03 | 1.02E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 35.1 | 0.10 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 4.70E-04 | 1.36E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.7 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-9 MMREM Output for Whitewater Lake, Scenario 1

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 1**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Whitewater Lake** | **St. Louis** | **69037600** | **0.35** | **1215** | **3050** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **1.93E-07** | 50.0% | 1.10 | 0.1 | 1,215 | 4046.9 | 3.3E+05 | 0.33 | 1.00 | 0.33 |
| Hg(0) | **9.65E-08** | 25.0% | 0.01 | 0.0 | 1,215 | 4046.9 | 1.5E+03 | 0.00 | 1.00 | 0.00 |
| Hg-p | **9.65E-08** | 25.0% | 0.05 | 0.00 | 1,215 | 4046.9 | 7.5E+03 | 0.01 | 1.00 | 0.0075 |
| Total | 3.86E-07 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **2.68E-07** | 50.0% | 1.10 | 0.09 | 3,050 | 4046.9 | 1.15E+06 | 1.15 | 0.26 | 0.30 |
| Hg(0) | **1.34E-07** | 25.0% | 0.01 | 0.0 | 3,050 | 4046.9 | 5.2E+03 | 0.01 | 0.26 | 0.00 |
| Hg-p | **1.34E-07** | 25.0% | 0.05 | 0.00 | 3,050 | 4046.9 | 2.6E+04 | 0.03 | 0.26 | 0.007 |
| Total | 5.35E-07 | 100.0% | | 0.1 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.64 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 1,215 | 4046.9 | 6.1E+07 | 61.46 | 1.00 | 61.46 |
| Total deposition for the rest of the watershed | 12.5 | 3,050 | 4046.9 | 1.5E+08 | 154.29 | 0.26 | 40.11 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 101.58 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.6 | 101.6 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.002 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 1.7 | 0.01 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0004 | 0.0005 | 70 | 1.06E-03 | 6.70E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 10.6 | 0.07 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0005 | 0.0005 | 70 | 1.19E-03 | 7.54E-06 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 11.9 | 0.08 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 1.59E-04 | 1.01E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 1.6 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-10 MMREM Output for Whitewater Lake, Scenario 2

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 2**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Whitewater Lake** | **St. Louis** | **69037600** | **0.35** | **1215** | **3050** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **5.42E-08** | 13.5% | 1.10 | 0.0 | 1,215 | 4046.9 | 9.2E+04 | 0.09 | 1.00 | 0.09 |
| Hg(0) | **3.09E-07** | 76.9% | 0.01 | 0.0 | 1,215 | 4046.9 | 4.8E+03 | 0.00 | 1.00 | 0.00 |
| Hg-p | **3.86E-08** | 9.6% | 0.05 | 0.00 | 1,215 | 4046.9 | 3.0E+03 | 0.00 | 1.00 | 0.0030 |
| Total | 4.01E-07 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **7.38E-08** | 13.3% | 1.10 | 0.03 | 3,050 | 4046.9 | 3.16E+05 | 0.32 | 0.26 | 0.08 |
| Hg(0) | **4.28E-07** | 77.1% | 0.01 | 0.0 | 3,050 | 4046.9 | 1.7E+04 | 0.02 | 0.26 | 0.00 |
| Hg-p | **5.35E-08** | 9.6% | 0.05 | 0.00 | 3,050 | 4046.9 | 1.0E+04 | 0.01 | 0.26 | 0.003 |
| Total | 5.55E-07 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.19 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 1,215 | 4046.9 | 6.1E+07 | 61.46 | 1.00 | 61.46 |
| Total deposition for the rest of the watershed | 12.5 | 3,050 | 4046.9 | 1.5E+08 | 154.29 | 0.26 | 40.11 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 101.58 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.2 | 101.6 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.001 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 1.7 | 0.00 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0001 | 0.0001 | 70 | 1.06E-03 | 1.97E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 10.6 | 0.02 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0001 | 0.0002 | 70 | 1.19E-03 | 2.22E-06 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 11.9 | 0.02 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0000 | 0.0000 | 70 | 1.59E-04 | 2.97E-07 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 1.6 | 0.00 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).

Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-11 MMREM Output for Wynne Lake, Scenario 1

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 1**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Wynne Lake** | **St. Louis** | **69043402** | **1.34** | **289** | **123600** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **1.49E-07** | 50.0% | 1.10 | 0.1 | 289 | 4046.9 | 6.0E+04 | 0.06 | 1.00 | 0.06 |
| Hg(0) | **7.43E-08** | 25.0% | 0.01 | 0.0 | 289 | 4046.9 | 2.7E+02 | 0.00 | 1.00 | 0.00 |
| Hg-p | **7.43E-08** | 25.0% | 0.05 | 0.00 | 289 | 4046.9 | 1.4E+03 | 0.00 | 1.00 | 0.0014 |
| Total | 2.97E-07 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **4.22E-07** | 50.0% | 1.10 | 0.15 | 123,600 | 4046.9 | 7.33E+07 | 73.30 | 0.26 | 19.06 |
| Hg(0) | **2.11E-07** | 25.0% | 0.01 | 0.0 | 123,600 | 4046.9 | 3.3E+05 | 0.33 | 0.26 | 0.09 |
| Hg-p | **2.11E-07** | 25.0% | 0.05 | 0.00 | 123,600 | 4046.9 | 1.7E+06 | 1.67 | 0.26 | 0.433 |
| Total | 8.45E-07 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 19.64 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 289 | 4046.9 | 1.5E+07 | 14.62 | 1.00 | 14.62 |
| Total deposition for the rest of the watershed | 12.5 | 123,600 | 4046.9 | 6.3E+09 | 6252.46 | 0.26 | 1625.64 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1640.26 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 19.6 | 1640.3 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.016 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 6.7 | 0.08 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0032 | 0.0034 | 70 | 4.10E-03 | 4.91E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 41.0 | 0.49 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0036 | 0.0039 | 70 | 4.62E-03 | 5.53E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 46.2 | 0.55 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0005 | 0.0005 | 70 | 6.18E-04 | 7.40E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 6.2 | 0.07 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

# Table F-12 MMREM Output for Wynne Lake, Scenario 2

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008

**Inputs are in blue and bold** | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** **Polymet Mining, Northmet Project Scenario 2**

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Wynne Lake** | **St. Louis** | **69043402** | **1.34** | **289** | **123600** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **3.29E-08** | 11.0% | 1.10 | 0.0 | 289 | 4046.9 | 1.3E+04 | 0.01 | 1.00 | 0.01 |
| Hg(0) | **2.38E-07** | 79.1% | 0.01 | 0.0 | 289 | 4046.9 | 8.8E+02 | 0.00 | 1.00 | 0.00 |
| Hg-p | **2.98E-08** | 9.9% | 0.05 | 0.00 | 289 | 4046.9 | 5.5E+02 | 0.00 | 1.00 | 0.0005 |
| Total | 3.01E-07 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **9.50E-08** | 11.1% | 1.10 | 0.03 | 123,600 | 4046.9 | 1.65E+07 | 16.49 | 0.26 | 4.29 |
| Hg(0) | **6.76E-07** | 79.0% | 0.01 | 0.0 | 123,600 | 4046.9 | 1.1E+06 | 1.07 | 0.26 | 0.28 |
| Hg-p | **8.45E-08** | 9.9% | 0.05 | 0.00 | 123,600 | 4046.9 | 6.7E+05 | 0.67 | 0.26 | 0.173 |
| Total | 8.55E-07 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 4.75 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 289 | 4046.9 | 1.5E+07 | 14.62 | 1.00 | 14.62 |
| Total deposition for the rest of the watershed | 12.5 | 123,600 | 4046.9 | 6.3E+09 | 6252.46 | 0.26 | 1625.64 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1640.26 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 4.8 | 1640.3 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.004 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 6.7 | 0.02 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0008 | 0.0008 | 70 | 4.10E-03 | 1.19E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 41.0 | 0.12 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0009 | 0.0009 | 70 | 4.62E-03 | 1.34E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 46.2 | 0.13 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 6.18E-04 | 1.79E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 6.2 | 0.02 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

Subsistence Fisher #1 HQ based on consuption rate = 95th percentile of general population (USEPA, 1997 Exposure Factors Handbook).
Subsistence Fisher #2 HQ based on consuption rate assuming Treaty protected catch rate of 180 pounds per year per member.

**Attachment G**

**Detailed Risk Estimates for Cumulative Risk Receptors**

**Table G-1 Coordinates used for Receptors of Interest and Maximum 1-hour concentrations in µg/m$^3$ from Plant Site Emissions (2006-2010 Met-Data) used for Cumulative Risk Assessment**

| | NW of Plant Site | SE of Plant Site | NW of Mine Site | SE of Mine Site | Acute Toxicity Reference Values |
|---|---|---|---|---|---|
| X | 559558.3 | 568819 | 572447.4 | 580447.4 | |
| Y | 5275557 | 5267998 | 5277680 | 5271180 | |
| Acetaldehyde | 0.000168 | 0.000181 | 0.000117 | 8.17E-05 | 470 |
| Arsenic | 0.003611 | 0.003093 | 0.001143 | 0.001586 | 0.2 |
| HCL | 67.398 | 67.988 | 47.887 | 29.144 | 2700 |
| Nickel | 0.3036 | 0.3577 | 0.16956 | 0.083723 | 11 |
| $NO_2$[1] | 121.0864 | 101.1896 | 59.40423 | 49.737 | 470 |

[1] $NO_2$ concentrations as modeled using PVMRM-OLM modeling in AERMOD

**Table G-2 Coordinates used for Receptors of Interest and Maximum annual concentrations in µg/m$^3$ from Plant Site Emissions (2006-2010 Met-Data) used for Cumulative Risk Assessment**

| | NW of Plant Site | SE of Plant Site | NW of Mine Site | SE of Mine Site | Toxicity Reference Values | Cancer Unit Risk |
|---|---|---|---|---|---|---|
| X | 559558.3 | 568819 | 572447.4 | 580447.4 | | |
| Y | 5275557 | 5267998 | 5277680 | 5271180 | | |
| Acetaldehyde | 4.69E-08 | 9.21E-08 | 2.41E-08 | 1.63E-08 | 9 | 2.20E-06 |
| Arsenic | 1.01E-05 | 2.25E-05 | 2.97E-06 | 2.1E-06 | 0.015 | 4.30E-03 |
| Cobalt | 9.44E-05 | 0.000143 | 2.33E-05 | 2.16E-05 | 0.006 | 9.00E-03 |
| Silica, Crystalline | 0.018804 | 0.021786 | 0.008933 | 0.005036 | 3 | na |
| HCl | 0.002601 | 0.00423 | 0.000948 | 0.000753 | 20 | na |
| Diesel Particulate Matter | 0.014151 | 0.024244 | 0.004462 | 0.002304 | 5 | na |
| Manganese | 0.000675 | 0.001236 | 0.000192 | 0.000118 | 0.2 | na |
| Nickel | 0.00266 | 0.003826 | 0.000641 | 0.000606 | 0.05 | 4.80E-04 |
| Dioxins/Furans | 2.24E-11 | 3.82E-11 | 7.23E-12 | 3.75E-12 | 0.00004 | 400 |

**Table G-3 Coordinates used for Receptors of Interest and Maximum 1-hour concentrations in µg/m3 from Mine Site Emissions (2006-2010 Met-Data) used for Cumulative Risk Assessment**

| | NW of Plant Site | SE of Plant Site | NW of Mine Site | SE of Mine Site | Acute Toxicity Reference Values |
|---|---|---|---|---|---|
| X | 559653.1 | 568875.8 | 572375.8 | 580875.8 | |
| Y | 5275536 | 5267954 | 5277454 | 5271454 | |
| Acetaldehyde | 8.21E-05 | 0.000117 | 0.000155 | 0.000208 | 470 |
| Arsenic | 0.00213 | 0.001141 | 0.001367 | 0.003379 | 0.2 |
| Nickel | 0.022258 | 0.008669 | 0.009414 | 0.030515 | 11 |
| $NO_X$[1] | 152.56 | 92.393 | 112.55 | 247.23 | 470 |

[1] $NO_X$ concentrations as modeled by AERMOD are shown. An estimated $NO_2$ concentration was used in risk calculations using the USEPA recommended NO to $NO_2$ conversion rate of 80%.

**Table G-4 Coordinates used for Receptors of Interest and Maximum annual concentrations in µg/m3 from Mine Site Emissions (2006-2010 Met-Data) used for Cumulative Risk Assessment**

| | NW of Plant Site | SE of Plant Site | NW of Mine Site | SE of Mine Site | Toxicity Reference Values | Cancer Unit Risk |
|---|---|---|---|---|---|---|
| X | 559653.1 | 568875.8 | 572375.8 | 580875.8 | | |
| Y | 5275536 | 5267954 | 5277454 | 5271454 | | |
| Acetaldehyde | 1.67E-08 | 1.16E-08 | 6.54E-08 | 9.44E-08 | 9 | 2.20E-06 |
| Arsenic | 4.06E-06 | 5.1E-06 | 1.94E-05 | 2.82E-05 | 0.015 | 4.30E-03 |
| Cobalt | 3.84E-06 | 4.67E-06 | 2.04E-05 | 3.59E-05 | 0.006 | 9.00E-03 |
| Silica, Crystalline | 0.000629 | 0.000762 | 0.003349 | 0.006544 | 3 | na |
| Dibenzo(a,h)anthracene | 1.13E-07 | 1.43E-07 | 5.31E-07 | 7.19E-07 | na | 1.20E-03 |
| Diesel Particulate Matter | 0.00921 | 0.011143 | 0.043072 | 0.052252 | 5 | na |
| Indeno(1,2,3-c,d)pyrene | 1.32E-07 | 1.67E-07 | 6.22E-07 | 8.45E-07 | na | 1.10E-04 |
| Manganese | 0.000315 | 0.000395 | 0.001522 | 0.002265 | 0.2 | na |
| Nickel | 2.61E-05 | 3.06E-05 | 0.000128 | 0.000271 | 0.05 | 4.80E-04 |
| Dioxins/Furans | 1.57E-11 | 1.91E-11 | 7.38E-11 | 8.83E-11 | 0.00004 | 400 |

**Table G-5 Coordinates used for Receptors of Interest and Maximum concentrations in µg/m3 from Mesabi Mining and LSDP Emissions (2001-2005 Met-Data) used for Cumulative Risk Assessment**

| | NW of Plant Site | SE of Plant Site | NW of Mine Site | SE of Mine Site | Acute RfC | Chronic RfC |
|---|---|---|---|---|---|---|
| X | 559423.8 | 568819 | 571838.4 | 573580.1 | | |
| Y | 5275566 | 5267998 | 5276981 | 5270481 | | |
| MN - annual | 0.011702 | 0.00929 | 0.003347 | 0.004268 | na | 0.2 |
| Crystalline Silica - annual | 0.10828 | 0.10431 | 0.028041 | 0.038005 | na | 3 |
| $NO_X$[1] - hourly | 9.912 | 11.9816 | 4.89288 | 12.384 | 470 | Na |

[1] $NO_X$ concentrations as modeled by AERMOD are shown. An estimated $NO_2$ concentration was used in risk calculations using the USEPA recommended NO to $NO_2$ conversion rate of 80%.

**Table G-6 Coordinates used for Receptors of Interest and Maximum 1-hour concentrations in µg/m3 from Syl Laskin Emissions (2006-2010 Met-Data) used for Cumulative Risk Assessment**

| | NW of Plant Site | SE of Plant Site | NW of Mine Site | SE of Mine Site | Acute Toxicity Reference Values |
|---|---|---|---|---|---|
| X | 559423.8 | 568819 | 571838.4 | 573580.1 | |
| Y | 5275566 | 5267998 | 5276981 | 5270481 | |
| $NO_X$[1] | 7.49 | 10.7 | 6.68 | 7.66 | 470 |

[1] $NO_X$ concentrations as modeled by AERMOD are shown. An estimated $NO_2$ concentration was used in risk calculations using the USEPA recommended NO to $NO_2$ conversion rate of 80%.

**Table G-7 Potential Cumulative Inhalation Risks at the Receptor of Interest Northwest of the Tailings Basin at the Plant Site Boundary for the Supplemental AERAs for the NorthMet Mine Site and Plant Site**

| Estimated Potential Risk | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background (1) | | | |
| Ambient air monitoring (calculated by MPCA) | $3x10^{-5}$ | 1 | 0.4 |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | NA | NA | 0.01 |
| Total Background (2) | $3x10^{-5}$ | 1 | 0.4 |
| | | | |
| Incremental | | | |
| Plant Site | $2x10^{-6}$ | 0.1 | 0.3 |
| Mine Site | $4x10^{-8}$ | 0.004 | 0.3 |
| Mesabi Mining Project (Includes LSDP) (3) | NA | 0.1 | 0.02 |
| Total Incremental (2) | $2x10^{-6}$ | 0.2 | 0.6 |
| | | | |
| Total Cumulative Risk (2) | $3x10^{-5}$ | 1 | 1 |
| % of Cumulative Risk from PolyMet Projects | 6% | 7% | 57% |

[1] Background risks based on monitoring data were calculated by the MPCA based on 2008-2010 monitoring data from Virginia, Ely and Cloquet.
[2] As per MPCA guidance, all reported risk values are rounded to one significant digit. Totals, however, are calculated from unrounded values and may differ from the value obtained by adding the rounded values shown in the table.
[3] LSDP = Large Scale Demonstration Plant; currently operating

**Table G-8 Potential Cumulative Inhalation Risks at the Receptor of Interest Southeast of the Plant Site at the Former LTVSMC Ambient Air Boundary for the Supplemental AERAs for the NorthMet Mine Site and Plant Site**

| Estimated Potential Risk | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background (1) | | | |
| Ambient air monitoring (calculated by MPCA) | $3x10^{-5}$ | 1 | 0.4 |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | NA | NA | 0.02 |
| Total Background (2) | $3x10^{-5}$ | 1 | 0.4 |
| | | | |
| Incremental | | | |
| Plant Site | $3x10^{-6}$ | 0.1 | 0.3 |
| Mine Site | $4x10^{-8}$ | 0.005 | 0.2 |
| Mesabi Mining Project (Includes Mesabi Nugget LSDP) (3) | NA | 0.1 | 0.03 |
| Total Incremental (2) | $3x10^{-6}$ | 0.2 | 0.5 |
| | | | |
| Total Cumulative Risk (2) | $4x10^{-5}$ | 1 | 0.9 |
| % of Cumulative Risk from PolyMet Projects | 9% | 8% | 49% |

[1] Background risks based on monitoring data were calculated by the MPCA based on 2008-2010 monitoring data from Virginia, Ely and Cloquet.
[2] As per MPCA guidance, all reported risk values are rounded to one significant digit. Totals, however, are calculated from unrounded values and may differ from the value obtained by adding the rounded values shown in the table.
[3] LSDP = Large Scale Demonstration Plant; currently operating

**Table G-9 Potential Cumulative Inhalation Risks at the Receptor of Interest Northwest of the Mine Site at the Mineral Mining/Industrial District Boundary for the Supplemental AERAs for the NorthMet Mine Site and Plant Site**

| Estimated Potential Risk | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background (1) | | | |
| Ambient air monitoring (calculated by MPCA) | $3x10^{-5}$ | 1 | 0.4 |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | NA | NA | 0.01 |
| Total Background (2) | $3x10^{-5}$ | 1 | 0.4 |
| | | | |
| Incremental | | | |
| Plant Site | $5x10^{-7}$ | 0.04 | 0.2 |
| Mine Site | $2x10^{-7}$ | 0.02 | 0.2 |
| Mesabi Mining Project (Includes LSDP) (3) | NA | 0.03 | 0.01 |
| Total Incremental (2) | $7x10^{-7}$ | 0.1 | 0.4 |
| | | | |
| Total Cumulative Risk (2) | $3x10^{-5}$ | 1 | 0.8 |
| % of Cumulative Risk from PolyMet Projects | 2% | 5% | 45% |

[1] Background risks based on monitoring data were calculated by the MPCA based on 2008-2010 monitoring data from Virginia, Ely and Cloquet.
[2] As per MPCA guidance, all reported risk values are rounded to one significant digit. Totals, however, are calculated from unrounded values and may differ from the value obtained by adding the rounded values shown in the table.
[3] LSDP = Large Scale Demonstration Plant; currently operating

**Table G-10 Potential Cumulative Inhalation Risks at the Receptor of Interest Southeast of the Mine Site as the Mineral Mining/Industrial District Boundary for the Supplemental AERAs for the NorthMet Mine Site and Plant Site**

| Estimated Potential Risk | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background (1) | | | |
| Ambient air monitoring (calculated by MPCA) | $3x10^{-5}$ | 1 | 0.4 |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | NA | NA | 0.01 |
| Total Background (2) | $3x10^{-5}$ | 1 | 0.4 |
| | | | |
| Incremental | | | |
| Plant Site | $5x10^{-7}$ | 0.03 | 0.1 |
| Mine Site | $3x10^{-7}$ | 0.03 | 0.4 |
| Mesabi Mining Project (Includes LSDP) (3) | NA | 0.03 | 0.03 |
| Total Incremental (2) | $8x10^{-7}$ | 0.1 | 0.6 |
| | | | |
| Total Cumulative Risk (2) | $3x10^{-5}$ | 1 | 1 |
| % of Cumulative Risk from PolyMet Projects | 2% | 5% | 55% |

[1] Background risks based on monitoring data were calculated by the MPCA based on 2008-2010 monitoring data from Virginia, Ely and Cloquet.
[2] As per MPCA guidance, all reported risk values are rounded to one significant digit. Totals, however, are calculated from unrounded values and may differ from the value obtained by adding the rounded values shown in the table.
[3] LSDP = Large Scale Demonstration Plant; currently operating

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## Attachment Q

## Emissions from Trucks used to Haul Products

**NorthMet Project**
**Maximum Estimated emissions from product trucks Table Q-1 Maximum Truck Trips**

| Product | Estimated Annual Max Production (tons) | Loaded Truck Weight (tons) | Empty Truck Weight (tons) | Truck Payload (tons) | Potential Maximum Trucks per Year | Potential Maximum Trucks per Day (1) | Potential Maximum Trucks per Hour | Frequency of Truck Shipping |
|---|---|---|---|---|---|---|---|---|
| PGM Concentrate | 462 | 40 | 16 | 24 | 19 | 1 | 1 | Always |
| MHP (Ni/Co) | 21199 | 40 | 16 | 24 | 883 | 9 | 2 | Possibly Frequent |
| Total | 21661 | | | | 903 | 10 | 3 | |

Note:

See NorthMet Project Air Data Package; Version 3B - max only; March 11, 2011 for further information on potential truck hauling of products.

(1) Assumes a winter storm or similar event that would back up shipments for 3 days.

**NorthMet Project**
**Maximum Estimated emissions from product trucks**
**Table Q-2 Emission Calculations**

| | Per trip data | | | Max Fuel Use, gal | | | | | | | Maximum Emissions | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | km | Max idling hours | fuel use, gal | hourly | daily | year | Pollutant | EF | units | reference | lb/hour | lb/day | tpy |
| Product trucks | 4.51 | 0.25 | 0.42 | 1.25 | 4.16 | 376 | NOx | 5 | g/bhp-hr | [1] | 2.73E-01 | 9.11E-01 | 4.11E-02 |
| | | | | | | | Arsenic | 0.000011 | lb/MMbtu | [3] | 1.91E-06 | 6.37E-06 | 2.87E-07 |
| | | | | | | | Beryllium | 0.00000031 | lb/MMbtu | [3] | 5.38E-08 | 1.79E-07 | 8.10E-09 |
| | | | | | | | Cadmium | 0.0000048 | lb/MMbtu | [3] | 8.33E-07 | 2.78E-06 | 1.25E-07 |
| | | | | | | | Chromium | 0.000011 | lb/MMbtu | [3] | 1.91E-06 | 6.37E-06 | 2.87E-07 |
| | | | | | | | Lead | 0.000014 | lb/MMbtu | [3] | 2.43E-06 | 8.10E-06 | 3.66E-07 |
| | | | | | | | Manganese | 0.00079 | lb/MMbtu | [3] | 1.37E-04 | 4.57E-04 | 2.06E-05 |
| | | | | | | | Mercury | 0.0000012 | lb/MMbtu | [3] | 2.08E-07 | 6.95E-07 | 3.13E-08 |
| | | | | | | | Nickel | 0.0000046 | lb/MMbtu | [3] | 7.99E-07 | 2.66E-06 | 1.20E-07 |
| | | | | | | | Selenium | 0.000025 | lb/MMbtu | [3] | 4.34E-06 | 1.45E-05 | 6.53E-07 |
| | | | | | | | PCDD/PCDF | 1.32E-11 | lb/gal | [4] | 1.65E-11 | 5.50E-11 | 2.48E-12 |
| | | | | | | | Acenaphthene | 0.00000468 | lb/MMbtu | [2] | 8.13E-07 | 2.71E-06 | 1.22E-07 |
| | | | | | | | Acenaphthylene | 0.00000923 | lb/MMbtu | [2] | 1.60E-06 | 5.34E-06 | 2.41E-07 |
| | | | | | | | Anthracene | 0.00000123 | lb/MMbtu | [2] | 2.14E-07 | 7.12E-07 | 3.21E-08 |
| | | | | | | | Benzo(a)anthracene | 0.000000622 | lb/MMbtu | [2] | 1.08E-07 | 3.60E-07 | 1.62E-08 |
| | | | | | | | Benzo(a)pyrene | 0.000000257 | lb/MMbtu | [2] | 4.46E-08 | 1.49E-07 | 6.71E-09 |
| | | | | | | | Benzo(b)fluoranthene | 0.00000111 | lb/MMbtu | [2] | 1.93E-07 | 6.42E-07 | 2.90E-08 |
| | | | | | | | Benzo(g,h,i)perylene | 0.000000556 | lb/MMbtu | [2] | 9.65E-08 | 3.22E-07 | 1.45E-08 |
| | | | | | | | Benzo(k)fluoranthene | 0.000000218 | lb/MMbtu | [2] | 3.79E-08 | 1.26E-07 | 5.69E-09 |
| | | | | | | | Chrysene | 0.00000153 | lb/MMbtu | [2] | 2.66E-07 | 8.86E-07 | 4.00E-08 |
| | | | | | | | Dibenzo(a,h)anthracene | 0.000000346 | lb/MMbtu | [2] | 6.01E-08 | 2.00E-07 | 9.04E-09 |
| | | | | | | | Fluoranthene | 0.00000403 | lb/MMbtu | [2] | 7.00E-07 | 2.33E-06 | 1.05E-07 |
| | | | | | | | Fluorene | 0.0000128 | lb/MMbtu | [2] | 2.22E-06 | 7.41E-06 | 3.34E-07 |
| | | | | | | | Indeno(1,2,3-cd)pyrene | 0.000000414 | lb/MMbtu | [2] | 7.19E-08 | 2.40E-07 | 1.08E-08 |
| | | | | | | | Naphthalene | 0.00013 | lb/MMbtu | [2] | 2.26E-05 | 7.52E-05 | 3.40E-06 |
| | | | | | | | Phenanthrene | 0.0000408 | lb/MMbtu | [2] | 7.08E-06 | 2.36E-05 | 1.07E-06 |
| | | | | | | | Pyrene | 0.00000371 | lb/MMbtu | [2] | 6.44E-07 | 2.15E-06 | 9.69E-08 |

[1] Emission factors for NOx based on standard for model years 1991 and later for on-road heavy duty vehicles.
EPA Health Assessment for Diesel Engine Exhaust, 2002 (Table 2-4)

[2] Emission factors from AP-42 Chapter 3.4 Table 3.4-4 "PAH Emission Factors for Large Uncontrolled Stationary Diesel Engines"

[3] Emission factors from AP-42 Chapter 3.1 Table 3.1-5 "Emission Factors for Metallic Hazardous Air Pollutants From Distillate Oil-Fired Stationary Gas Turbines"

[4] PCDD/PCDF - TEQ = 2,3,7,8 TCDD equivalents. Emission factor for Dioxins is the average of all US studies from 1996-1998 cited in Table 2-11 of the EPA 2002 report "Health Assessment Document for Diesel Engine Exhaust". Emission factors of 2,3,7,8 TCDD equivalents (TEQs) in pg/km were used as cited and represent the TEQ methodology at the time of the study.

| | | |
|---|---|---|
| 663 | pg TEQ/km | CARB, 1987; Lew, 1996 |
| 172 | pg TEQ/km | Gertler et al., 1996 (tunnel study) |
| 29 | pg TEQ/km | Gullett and Ryan, 1997 |
| 288 | pg TEQ/km | |
| 1.32E-11 | lb/gal | |

Assumptions:

| | | | |
|---|---|---|---|
| BSFC = | 7000 | Btu/hp-hr | AP-42 Chapter 3.3 Table 3.3-1 footnote a |
| diesel heating value | 19300 | BTU/lb | AP-42 sections 3.3 |
| diesel heating value | 0.139 | MMbtu/gal | AP-42 sections 3.1 |
| HD diesel mileage | 5.5 | km/L | EPA Health Assessment for Diesel Engine Exhaust, 2002 (Table 2-11 footnote "a") |
| HD diesel idling | 0.8 | gal/hour | L. Gaines et al., 2002. "Estimation of Fuel Use by Idling Commercial Trucks", Center for Transportation Research, Argonne National Laboratory. |

Conversions:

| | |
|---|---|
| 3.785 | L per gal |
| 1.609 | km per mile |
| 453.59 | g per pound |

**Attachment R**

**Supplemental Air Emissions Risk Analysis (AERA) - Mine Site**




# NorthMet Project

# Supplemental Air Emissions Risk Analysis (AERA) – Mine Site

**Version 3**

**Issue Date: February 21, 2013**

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## 1.0 Executive Summary

The initial Mine Site Air Emission Risk Analysis (AERA) Report was submitted to the Minnesota Pollution Control Agency (MPCA) in January 2008 (Reference (1)) in support of the October 2009 Draft Environmental Impact Statement (DEIS) for the NorthMet Project (Project) (Reference (2)). Because of proposed changes to the Project, Poly Met Mining Inc. (PolyMet) was requested to provide a supplemental AERA to reflect the proposed changes to the Project to support preparation of a Supplemental Draft Environmental Impact Statement (SDEIS). This Supplemental AERA evaluated the current Project and the associated changes in estimated emissions. This screening human health risk analysis followed the MPCA-accepted November 2011 Work Plan (as amended in August 2012) (Reference (3)). This analysis was conducted similarly to the 2008 Mine Site AERA with some exceptions (Section 5.5). This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Air Data Package will be resolved in favor of this document.

### 1.1 Chemicals for Evaluation (CFE)

Following the methodology described in the November 2011 Work Plan (Reference (3)), eleven chemicals for evaluation (CFE) were identified. These CFE included the risk driver chemicals identified in the 2008 AERA (asterisked below) and specific chemicals from the 2008 AERA that now have toxicity values and were not previously evaluated (chemicals with no asterisk).

The CFE for this Supplemental AERA are as follows: acetaldehyde, arsenic compounds*, cobalt and compounds, crystalline silica, dibenzo(a,h)anthracene* (PAH), diesel particulate, indeno(1,2,3-cd)pyrene* (PAH), manganese compounds*, nickel compounds*, nitrogen oxides ($NO_x$)* and dioxins/furans (2,3,7,8-TCDD toxicity equivalent basis, TEQ)*.

In addition, due to an oversight, the addition of an acute toxicity value for sulfuric acid was not considered in previous versions of the Supplemental AERA report. An evaluation of potential acute risk from sulfuric acid emissions has been added in this document. Sulfuric acid emissions at the Mine Site are minimal and therefore, potential risk due to these emissions is minimal as well.

### 1.2 Exposure Assessment

Exposure assumptions for this 2012 Supplemental AERA are the same as those used for the 2008 AERA. Potential chronic (more than one year) and acute (one hour) exposure were evaluated for the two Mine Site operating scenarios as represented by the Mine Year with the greatest emissions for that scenario: Mine Year 8 represents the scenario in which materials will be stockpiled and Mine Year 13 represents the scenarios in which materials will be disposed of in pits and some stockpiled material transferred to the pits. A receptor's assumed exposure is to the maximum modeled air concentration and is identified by U.S. Environmental Protection Agency (USEPA) as assessing the Maximum Exposed Individual (MEI) (Reference (4)). Assessing potential health risks to an MEI can be used in calculating a Theoretical Upper Bounding

Estimate (TUBE). The TUBE "...is easily calculated and designed to estimate exposure, dose and risk levels that are expected to exceed the levels experienced by all individuals in the actual distribution" (Reference (5)).

For this Supplemental AERA, a deposition algorithm was used for particulate emissions that utilized the half-life modeling in the AERMOD model (version 12060) to better represent potential air concentrations related to fugitive dust emissions and transport (Section 5.3.2). The algorithm was previously described in the Class II Modeling Protocol (Reference (6)) and the amended AERA work plan.

Potential health risks were assessed for two routes of exposure; direct via inhalation and indirect (ingestion exposure) via food consumption. Multi-pathway exposure evaluates concurrent exposure to contaminants by both inhalation and food consumption. Potential inhalation health risks were estimated for a maximum exposed (24 hours/day, 365 days/year) individual at the Mine Site property ownership boundary (i.e. Mine Site ambient air boundary). Potential resident and farmer multipathway risks were estimated for receptor locations approximately one kilometer from the Mine Site property ownership boundary because current zoning (as Mineral Mining by the City of Babbitt or Industrial by St. Louis County) does not allow residential/farming development on the lands within the mining/industrial district nor are there existing residents in this area. See Large Table 1 and Large Table 2 for details regarding exposure, receptor location, toxicity, and type of exposure assumptions.

## 1.3 Estimated Potential Incremental Human Health Risks and Conclusions

Maximum modeled air concentrations for the 11 CFE were input to the MPCA's Risk Assessment Screening Spreadsheet (RASS; version 20120302). Table 1-1 identifies that the summed potential incremental health risks at the projected Mine Site ownership boundary and at the mineral mining boundary were at or below the Minnesota Department of Health (MDH) guideline values of 1E-05 for carcinogens and 1.0 for non-cancer chronic and acute endpoints (References (7) and (8)). Risk driver chemicals (chemicals having potential non-cancer risks of 0.1 or greater or carcinogenic risk of 1E-06 or greater) included the following:

- Adult maximum exposed individual (inhalation only)
  - $NO_2$ from diesel fuel combustion: potential non-cancer acute HQ = 0.8
  - cobalt from fugitive dust: potential carcinogenic risk = 3E-06
  - nickel from fugitive dust: potential carcinogenic risk = 1E-06
- farmer receptor (multipathway)
  - dibenzo(a,h)anthracene from fuel combustion: indirect cancer risks = 5E-06
  - dioxins/furans (TEQ) from fuel combustion: indirect cancer risks = 8E-06

Table 1-1 also provides a comparison of risks estimated for this Supplemental AERA to those previously estimated in the 2008 Mine Site AERA. Overall, the estimated incremental health risks for this Supplemental AERA are considered to be similar (i.e. in the same range) to those estimated in the 2008 AERA.

Table 1-2 summarizes conservatism and uncertainty in the risk analysis.

Overall, when following the regulatory agency risk assessment methodology, estimated risks are considered to be conservative and likely meet the intent of a screening assessment to not underestimate risks.

Based on the estimated potential incremental risks estimated for the Project (current and previous Project Description), adverse effects to human health are not expected to be associated with potential air emissions from Mine Site activities.

**Table 1-1 Summary of Potential Incremental Human Health Risks for the NorthMet Project Mine Site Proposed to be Located Near Babbitt, Minnesota**

| Exposure Route | Exposure Scenario | Receptor (MEI) | Potential noncancer effects (Hazard Index)[1] | | Potential cancer effects (Risk Estimate)[2] | |
|---|---|---|---|---|---|---|
| | | | 2008[3] | 2012[4] | 2008[3] | 2012[4] |
| Inhalation Only Exposure | Acute (1 hour)[5] | Mine-Site property ownership boundary | 0.2 | 0.8 | N/A | N/A |
| | Chronic (greater than 1 year) | Mine-Site property ownership boundary | 0.3 | 0.2 | 4E-06 | 5E-06 |
| Multipathway Exposure (inhalation + food consumption) | Chronic (greater than 1 year) | Farmer[6] | 0.04 | 0.04 | 3E-05 | 1E-05 |
| | | Resident[6] | 0.04 | 0.04 | 7E-07 | 8E-07 |

MEI = Maximum Exposed Individual; for chronic risk, exposure to the maximum modeled air concentration is assumed to occur 24 hours per day for 365 days per year

N/A = not applicable and not assessed

(1) Hazard Index is the sum of individual non-cancer chemical risks for acute or chronic exposure. Risks were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version as current at the time the analysis was conducted). Incremental non-cancer (chronic and acute) guideline value is 1.0.

(2) Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version as current at the time the analysis was conducted). Incremental cancer risk guideline value is 1E-05, MDH.

(3) Risk estimates are as presented in the 2008 Mine Site AERA. The highest estimated risks for the highest estimated emission years (either the stockpile storage mine phase (Mine Year 8) or in-pit disposal phase (Mine Year 16)) are presented here.

(4) Risk estimates for the revised Project Description as of October 2012. The highest estimated risks from the highest estimated emission years (either the stockpile storage mine phase (Mine Year 8) or in-pit disposal mine phase (Mine Year 13)) are presented here. See section 5.3.1 for Mine Years 8 and 13 rationale.

(5) For the current risk analysis and the 2008 AERA, the HI for Acute risk includes the risks estimated for $NO_x$ emissions (evaluated as $NO_2$). The USEPA factor of 80% was applied to the maximum modeled one-hour $NO_x$ air concentration as a conservative estimate of the conversion of $NO_x$ to $NO_2$.

(6) PolyMet' s land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the Mine Site ownership boundary. Therefore, resident and farmer multipathway risks were not calculated at the Mine Site ownership boundary. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer from the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated controlled potential emissions and for both stockpile storage and in-pit disposal mine layout. ~ 95% of the estimated potential farmer and resident risk is from potential indirect exposure (food consumption) related to estimated emissions of PAHs and dioxins/furans from diesel fuel combustion.

**Table 1-2 Summary of Uncertainty and Conservatism in the Air Emissions Risk Analysis Conducted for the NorthMet Project Mine Site, Minnesota**

| Risk Component | Effect on 2008 Risk Estimates[1] | Effect on 2012 Risk Estimates[1] |
|---|---|---|
| **Emission Estimates** | | |
| Use of controlled potential emission rates in all standard calculations including AERMOD inputs and the following assumptions:<br>-operations continue 24 hours/day, 7 days/week, 365 days/year, except for the Portable Crushing Plant and Overburden Screening activities[2]<br>- highest projected fuel usage in any year for on-site vehicles and worst case fleet for emissions<br>- emissions from locomotives were based on loading and idling time of locomotives at the Mine Site<br>- emissions from on-site vehicles are based on worst case years with maximum vehicle miles travelled. | Overestimates potential risk | Overestimates potential risk |
| Use of the USEPA factor that assumes 80% of the $NO_X$ emissions are instantly converted to $NO_2$. $NO_2$ is the sole risk-driver chemical for acute inhalation risk. The primary source of $NO_X$ is diesel fuel emissions. This is a conservative estimate because typically this conversion of NO to $NO_2$ is on the order of several hours to days (Reference (9)). | Overestimates potential acute inhalation risk | Overestimates potential acute inhalation risk |
| Estimating dioxin emissions from haul trucks. For the 2008 analysis, Barr Engineering calculated a factor (using several data sets provided by USEPA (Reference (10)) from the 1996 – 1998 time period) that was accepted by the MPCA for use in dioxin emission calculations. For the 2012 analysis, USEPA's factor (derived from data from the 1996 – 1998 time period) was used in the dioxin emission calculations. Both emission factors result in high end estimates of potential emissions (References (11) (12)). | Overestimates potential risk | Overestimates potential risk |
| All sources of emissions were modeled except those that did not emit the pollutants included in the supplemental AERA or sources that were excluded per MPCA Guidance | Likely no effect on estimated risks | Likely no effect on estimated risks |
| **Exposure and Bioavailability of Chemicals** | | |
| For inhalation exposure, the maximum modeled air concentration for an averaging time period was used to estimate potential risks. USEPA guidance identifies this as a Maximum Exposed Individual. | Overestimates potential risk | Overestimates potential risk |

| Risk Component | Effect on 2008 Risk Estimates[1] | Effect on 2012 Risk Estimates[1] |
|---|---|---|
| MEI Concept, chronic risk. It is very unlikely that an individual would be living near the boundary of the facility or at the Mineral Mining/Industrial District. An individual would not be outside 24 hours/day, 7 days/week, for 365 days/year in Minnesota. | Overestimates potential risk | Overestimates potential risk |
| Air dispersion modeling was conducted with the AERMOD model. For the 2008 analysis, AERMOD was run in regulatory mode. For the 2012 analysis, a deposition algorithm utilizing the half-life modeling in AERMOD was used to better represent fugitive dust emissions. | Overestimates potential risk | Overestimates risk |
| Assumption that all metals exist in a physical form that makes them 100% bioavailable and in a respirable size range. About 97% of the metal emissions for the Mine Site are associated with rock handling operations. This means the metals are much more likely to be inherent to the mineral structure of the rocks and present as compounds- they are not likely present in ionic forms. Therefore, it is very unlikely that 100% of the metals will be in a respirable size range and be bioavailable by inhalation. In terms of multipathway exposure, it is unlikely that 100% of the metals will be bioavailable by ingestion. | Overestimates potential risk | Overestimates potential risk |
| **Toxicity Values** | | |
| Use of provisional toxicity value (a PPRTVs) in the RASS for cobalt (a worker exposure value) to assess potential risks. | Likely overestimates potential risk | Likely overestimates potential risk |
| Use of PAH toxicity values that are derived by extrapolation and are considered to be highly uncertain. | Likely overestimates potential risk | Likely overestimates potential risk |
| 2008: Some persistent chemicals did not have Multipathway Screening Factors and were excluded from the indirect pathway risk estimates.<br>2012: All chemicals for evaluation considered PBT had Multipathway Screening Factors. | May underestimate potential risk | May underestimate potential risk |
| The RASS only evaluates chemicals with inhalation benchmarks for potential ingestion risk (multipathway exposure). Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks and are not evaluated for multipathway exposure (ingestion plus inhalation). | May underestimate potential risk | May underestimate potential risk |

| Risk Component | Effect on 2008 Risk Estimates(1) | Effect on 2012 Risk Estimates(1) |
|---|---|---|
| **Risk Characterization (Risk Estimates)** | | |
| In terms of risk characterization the following assumptions were made:<br>- all chemicals have an additive effect<br>- assumed all non-carcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects.<br>- Cancer risks summed across modes/mechanisms of action; carcinogenic unit risks have the same weight of evidence for human carcinogenicity | Likely overestimates potential risk | Likely overestimates potential risk |
| Synergism/antagonism was not considered | May under- or over- estimate potential risk | May under- or over- estimate potential risk |
| For carcinogens when the Unit Risk is based on the 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as the risks from a number of carcinogens are summed (Reference (13)). | Overestimates potential risk | Overestimates potential risk |
| For non-carcinogens, the Hazard Index was summed across all toxicity endpoints. This is not realistic because different chemicals can have different toxicity endpoints. | Overestimates potential risk | Overestimates potential risk |

(1) Key for Effects Determination:
- Overestimates potential risk: A value or assumption intentionally chosen to provide high risk estimates
- Likely Overestimates potential risk: A value or assumption intentionally chosen that is expected to provide high risk estimates
- May overestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a high risk estimate
- Underestimates potential risk: A gap in information or an available value that is known to provide a low risk estimate
- Likely underestimates potential risk: A gap in information or an available value that may provide a low risk estimate
- May underestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a low risk estimate.
- Likely no effect on estimated risk: Value or assumption that is known or suspected to have very little, if any, effect on potential risk

(2) The Portable Crushing Plant and Overburden Screening operations were assumed to operate 24 hours/day from April through October.

## 2.0 Introduction

In January 2008, PolyMet submitted an Air Emissions Risk Analysis (AERA) in support of the Draft Environmental Impact Statement (DEIS) to the MPCA (Reference (1)). Because of the conservatism in the risk analysis, all incremental potential health risks calculated in the 2008 AERA were considered to be acceptable and it was concluded that no adverse human health risks were expected to be associated with the Project's air emissions. Since preparation of the DEIS, PolyMet has proposed changes to mine operations and a Supplemental Draft EIS (SDEIS) is currently being prepared to evaluate the revised Project. PolyMet has been requested to submit a supplemental AERA to re-assess the potential human health risks associated with the Project. A Work Plan for the Supplemental AERA was accepted by the MPCA in November 2011 (Reference (3)). In August 2012 the Work Plan was amended for modeling of fugitive dust emissions (described in Section 5.3.2).

This supplemental 2012 AERA reflects the design and operations for the Mine Site as characterized by the NorthMet Mine Site Emission Inventory version 10 submitted October 27, 2012. This report includes:

- a list of chemicals potentially emitted from Mine Site activities
- a summary of estimated emissions for the individual chemicals
- a list of chemicals for quantitative risk evaluation
- air dispersion modeling results for all relevant emission sources at the Mine Site (including vehicle and locomotive emissions and fugitive emissions from haul roads)
- chemical-specific inhalation and total multipathway (inhalation + indirect pathway) incremental health risks based on potential emissions from mine operations
- a qualitative screening analysis (Uncertainty Discussion)

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Air Data Package will be resolved in favor of this document.

### 2.1 Purpose of the Supplemental 2012 AERA

The primary objectives of this Supplemental 2012 AERA are to:

- conduct a conservative assessment of potential incremental human health risks that may be associated with air emissions with the Project as reflected in the Mine Site Emission Inventory

- compare the estimated potential risks for the current Project emissions with the risks estimated in the 2008 AERA and assess the differences or similarities in risk estimates

- provide supplemental risk information to be used in the SDEIS and the air permitting process

## 2.2 Approach to the AERA

PolyMet has followed the November 2011 Work Plan (as amended in August 2012 for air dispersion modeling of fugitive dust) and the MPCA's most current AERA guidance (Reference (14)) in conducting this risk analysis.

The MPCA's AERA process (Reference (14)) is designed to determine whether or not controlled potential chemical emissions from sources and/or source groups are a potential health risk via inhalation and/or from indirect (multipathway) exposure. As defined by the MPCA, the term "risk" generally refers to estimated cancer risks (risk estimate) and the potential for noncancer health effects. Noncancer health effects are described using a Hazard Quotient (HQ) (for a single chemical) or a Hazard Index (HI) as the sum of HQs. In the AERA process, "quantitative analysis" specifically refers to the estimation of cancer risks and hazard indices using the MPCA's Risk Assessment Screening Spreadsheet (RASS, version 20120302). The AERA process additionally includes a "qualitative analysis," which identifies and discusses issues for which public health impacts cannot be easily quantified.

It is important to note that because of the limitations inherent in the risk assessment process, the risk characterization in this AERA or any health risk assessment cannot predict actual health outcomes, such as cancer. In other words, this or any health risk assessment does not provide an estimate of actual risk to a real person.

The 2012 Supplemental AERA was based on the following risk assessment guidance documents:

**State of Minnesota**

- Air Emissions Risk Analysis (AERA) Guidance. Version 1.1. MPCA, September 2007 (Reference (14))

**USEPA**

- Guidelines for the Health Risk Assessment of Chemical Mixtures. USEPA, 1986 (Reference (15))

- Risk Assessment Guidance for Superfund Volume 1 – Human Health Evaluation Manual Part A. USEPA, 1989 (Reference (16))

- Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. USEPA, 2009 (Reference (17))

- Guidelines for Developmental Toxicity Risk Assessment. USEPA, 1991 (Reference (18))

- Guidelines for Exposure Assessment. USEPA, 1992 (Reference (5))

- Guidance for Data Usability in Risk Assessment. USEPA, 1992 (Reference (19))

- Exposure Factors Handbook, USEPA, 2011 (Reference (20))

- Risk Assessment for the Waste Technologies Industries (WTI) Hazardous Waste Incinerator Facility – Volume V. Human Health Risk Assessment. USEPA, 1997 (Reference (21))

- Guidelines for Carcinogenic Risk Assessment. USEPA, 1986, 1996, 2005 (References (22) (23) (24)).

- Residual Risk Report to Congress. USEPA, 1999 (Reference (25))

## 3.0 Site Characterization

### 3.1 Facility Description

PolyMet plans to construct and operate a mine area six miles south of the town of Babbitt, in northeastern Minnesota (Mine Site) (Large Figure 1). In addition, PolyMet plans to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant MN and to build an ore processing facility at the former LTVSMC site near Hoyt Lakes, MN (referred to as the Plant Site) about eight miles to the west of the Mine Site. The locations of these two facilities are shown in Large Figure 1. A detailed description of the Project is provided in the March 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement (EIS) (Reference (26)) and the NorthMet Project Description Version 3 submitted September 13, 2011. An updated Project Description, version 4, is scheduled to be submitted by October 31, 2012.

### 3.2 Site Environment Description

The Mine Site is located six miles south of the city of Babbitt in northern Minnesota, within the corporate boundaries of the city (occupying parts of Sections 1-4 and 9-12, Township 59 North, Range 13 West, St. Louis County). PolyMet's land holdings at the Mine Site are within an area zoned as Mineral Mining by the city of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary (Large Figure 2).

Lands immediately adjacent to the Mine Site are primarily undeveloped and dominated by extensive forests and large wetlands (peatlands), except for the northern boundary where another industrial mine site is located.

The Project site lies within the Nashwauk Uplands of the Northern Superior Uplands in the Laurentian Mixed Forest Province (Reference (27)). Landforms within the Nashwauk Uplands include end moraines, outwash plains, and lake plains. Soils vary from medium to coarse texture. Forestry and mining are the most important land uses presently. The surface relief of the Nashwauk Uplands is generally gently rolling, with local relief ranging from about 10 to 30 feet. In some locations, the local relief can range up to 200+ feet (e.g., Embarrass Mountains). Slopes are mostly short and irregular. The landscape includes many closed depressions, most of which contain peat-lands.

## 4.0 Identifying Chemicals for Quantitative Evaluation

As described in the November 2011 Work Plan, the chemicals for evaluation (CFE) in this Supplemental 2012 AERA include:

- risk driver chemicals from the January 2008 Mine Site AERA
- chemicals with new toxicity values which were not evaluated in the 2008 Mine Site AERA
- chemicals for which either an increase in emissions and /or a change in or addition of a toxicity value suggests the chemical would now be considered a risk driver chemical (2008 adjusted risk is now greater than 1E-06 for cancer or noncancer risk greater than 0.1)

### 4.1 Risk Driver Chemicals from the 2008 AERA

Chemicals for Potential Evaluation (CFPE) were identified for the January 2008 AERA using a variety of sources of emission information (e.g., concentrations of metals in rock and ore to estimate potential fugitive dust emissions, emissions associated with diesel fuel combustion, etc.). The focus of that effort was to identify those chemicals that may be emitted to air from Mine Site operations that may be of potential human health concern if exposure to those chemicals occurs at levels above thresholds that are generally considered safe.

The quantitative risks from the 2008 AERA are used as the basis for determining potential risk-driver chemicals. A chemical is considered a "risk driver" if the hazard quotient for an individual chemical is above 0.1 or the cancer risk for an individual chemical is greater than 1E-06.

Of the 32 chemicals that were quantitatively evaluated for inhalation and multipathway health risks in the January 2008 AERA, six were identified as "risk drivers:" dioxins/furans, manganese compounds, nickel compounds, nitrogen oxides ($NO_X$ as $NO_2$), dibenzo(a,h)anthracene (PAH), and indeno(1,2,3-cd)pyrene (PAH).

These six chemicals were quantitatively evaluated in this Supplemental AERA.

### 4.2 Chemicals That Now Have Toxicity Values

Chemicals that were listed as CFPE in the 2008 Mine Site AERA without a toxicity value, but that now have a toxicity value in the MPCA's Risk Assessment Screening Spreadsheet (RASS), include the following: acetaldehyde (for acute toxicity), cobalt, crystalline silica and diesel particulate matter (DPM).

These chemicals were added to the list of chemicals for quantitative evaluation for this Supplemental AERA.

In addition, an acute benchmark concentration for sulfuric acid was added to the RASS since the 2007 version. In a scoping oversight the emissions from sulfuric acid were not considered with the other chemicals for evaluation. Instead, a semi-quantitative Revised Risk Estimate (RRE- See Section 4.3) for sulfuric acid is included in the total acute hazard index for the Plant Site. Note that the RRE for sulfuric acid does not indicate that it would be a risk driver chemical.

### 4.3 Additional Chemicals to Evaluate Due to Changes in Emissions or Toxicity

Emission estimates for Mine Site sources, including fugitive dust (from haul roads, loading/unloading of waste rock and ore, crushing and screening of construction rocks) and diesel combustion emissions (from haul trucks and locomotives) have been updated to reflect changes in proposed operations since submittal of the 2008 AERA as represented by the latest emission inventory (version 10).

Large Table 3 presents the comprehensive list of 54 pollutants in the AERA inventory identified to be potentially emitted from the proposed Mine Site activities. Estimated emissions of these chemicals from 2008 and current emissions estimates are compared for the worst-case year of stockpile waste rock storage (i.e., year 8) and in-pit waste rock storage and stockpile reclamation (year 16 for the 2008 AERA and year 13 for the 2012 Supplemental AERA).

Potential emissions of metals in fugitive dust were conservatively estimated based on total particulate matter (PM) and the concentration of a metal in specific types of mineral material (ore, lean ore, waste rock). Potential emissions of metals from natural gas combustion (based on AP-42 listings) and mobile source diesel fuel (fuel oil) combustion were also calculated.

Details regarding emissions calculations are available in the NorthMet Mine Site Emissions Inventory Version 10 submitted October 27, 2012. The emission inventory also provides the model inputs used for the pollutants evaluated in the AERA.

Because both emission changes and toxicity value changes may have occurred since 2008, CFPE were reassessed for potential importance to the overall risk estimates. As identified in the November 2011 Work Plan, the following methodology to calculate a "revised risk estimate" (RRE) was used to determine whether any changes were significant with regard to emissions or toxicity values.

- For chemicals that only have emission changes since 2008

  RRE = Jan 2008 risk x (1 + %change in emissions)

- For chemicals that only have changes to toxicity value since 2008

  RRE = Jan 2008 risk x (1 + %change in toxicity value)

- For chemicals that have both changes in emissions and toxicity value since 2008

RRE = Jan 2008 risk x (1 + % change in emissions)(1 + % change in toxicity value)

Any chemical with an RRE greater than or equal to risk driver levels (0.1 for noncancer risks and 1E-06 for cancer risks) would be included in the quantitative risk assessment for the Supplemental AERA. Large Table 4 identifies the revised risk estimates for all CFPEs with toxicity factors. The analysis of changes in emissions and toxicity factors identifies that arsenic is an additional chemical to be evaluated quantitatively for human health risks. Therefore, arsenic was included as a CFE for this Supplemental AERA.

The RRE for sulfuric acid is calculated even though an acute reference concentration was not available in 2008. The Jan 2008 risk was estimated using the current acute reference concentration value for sulfuric acid (RASS version 20120302) and the maximum modeled 1-hour concentration from the 2008 analysis. The percent change in emissions was then applied to the estimated Jan 2008 risk value as shown below and in Large Table 2.

RRE (sulfuric acid) = Est. Jan 2008 risk x (1 + % change in emissions)

RRE (sulfuric acid) = 0.00017 x (1+1232%) = 0.0023

## 4.4 Chemicals for Evaluation (CFE)

The following chemicals have been identified as CFE for this Supplemental AERA:

- acetaldehyde
- arsenic compounds
- cobalt compounds
- diesel particulate
- dioxins/furans (2,3,7,8-TCDD toxic equivalents, TEQ basis)
- manganese compounds
- nickel compounds
- nitrogen oxides (evaluated as $NO_2$)
- PAHs (dibenzo(a,h)anthracene; Indeno(1,2,3-cd)pyrene)
- silica, crystalline
- In addition sulfuric acid was evaluated as a Revised Risk Estimate (RRE).

## 4.5 Chemicals Screened out of the Quantitative Evaluation

Chemicals not identified in Section 4.4 were not quantitatively evaluated for the Supplemental AERA. These chemicals were screened out of evaluation based on estimated low risks as determined in both the 2008 AERA, as per the work plan, and in the determination of RREs (see Section 4.3). For comparison, the estimated risks for the chemicals screened out of quantitative evaluation, as determined in the 2008 AREA and as RREs, are presented in Table 4-1. These estimated risks would not likely change the final determination of risk estimates presented in this Supplemental AERA within the reporting values of one significant digit.

**Table 4-1 Potential Risk Estimates of Chemicals Screened Out of the Supplemental Mine Site AERA using both 2008 Risk Results and Revised Risk Estimates (RREs) Based on Changes in Emission Estimates and/or Toxicity Values**

| Source or Location of Estimated Potential Risks | Potential Risks from Chemicals in the 2008 AERA with Insignificant Risk[1] | Revised Risk Estimates (RREs) for Chemicals with Insignificant Risk in the 2008 AERA[2] |
|---|---|---|
| Inhalation Risks at the PolyMet Mine Site Operating Boundary | | |
| Acute | 0.0058 | 0.0038 |
| Chronic Noncancer | 0.016 | 0.0097 |
| Cancer | 2.4E-07 | 1.2E-07 |
| Multipathway Risks at the Mineral Mining/Industrial District Boundary | | |
| Farmer Noncancer | 0.0041 | 0.0050 |
| Farmer Cancer | 5.2E-07 | 4.1E-07 |
| Resident Noncancer | 0.0041 | 0.0050 |
| Resident Cancer | 5.3E-08 | 1.9E-08 |

(1) Estimates reflect the risk of screened out chemicals as evaluated in the 2008 AERA i.e. the RASS is the 20070904 version and emission estimates are those evaluated in 2008.
(2) Estimates reflect the risk of screened out chemicals as calculated as RREs for the 2012 supplemental AERA i.e., updated emissions and toxicity values from the 20120302 RASS are used.

Note that iron is not considered a chemical for potential evaluation. Although iron is present in the ore, it is not in high enough concentrations to be extracted economically as a product as part of the Project. Previous mining projects, such as Essar and the Keetac Expansion, that have evaluated iron through the oral pathway have not shown iron to be a risk driver chemical and iron therefore was not considered to be an issue for human health risk. The relatively lower iron

concentrations in the Project ore compared to the iron ore processed in the Essar and Keetac projects indicate that iron is highly unlikely to be a risk driver chemical for the Project.

## 5.0 Exposure Assessment and Estimating Exposure Point Concentrations

### 5.1 Exposure Assessment Concepts

Exposure assessment is the process of evaluating how people are potentially exposed to chemicals from their environments. For this analysis, maximum modeled air concentrations were used to assess potential inhalation risks. The USEPA (Reference (4)) considers the use of maximum modeled air concentrations in a risk analysis to assess a Maximum Exposed Individual (MEI) and defines the MEI as an exposure scenario based on using the *"...modeling node where the maximum ambient air concentration occurs, regardless of whether there is a person there or not...."*. In general, the MEI analysis assumes that a hypothetical receptor would live in the area of the estimated maximum concentration and be outdoors 24 hours per day, 365 days per year for their lifetime.

This exposure concept uses the maximum point estimate for ambient air concentrations as the potential dose and compares this concentration to toxicity values to generate near maximum risk estimates. Factors such as typical (or central tendency) exposure frequency and duration (as applied to the maximum concentration), bioavailability, variability in exposure point concentrations, and chemical speciation are not considered. Assessing health risks to an MEI is a high end estimate and similar to calculating the theoretical upper bound estimate (maximum exposure that is expected to exceed the levels experienced by all individuals in the actual distribution).

Important considerations for the MEI concept are as follows:

- according to USEPA (Reference (28)), the theoretical upper bound estimate "...is easily calculated and designed to estimate exposure, dose and risk levels that are expected to exceed the levels experienced by all individuals in the actual distribution...."
- the estimated risk presented under the MEI concept should not be used to draw conclusions regarding potential public health impacts or be used as an indicator of actual risks
- the MEI scenario is a useful screening tool to determine if more detailed analyses or the inclusion of other exposure concepts (such as the central tendency exposure) are warranted
- Risk management decisions should be based on realistic exposure scenarios rather than the hypothetical MEI (Reference (25)).

Assessing the MEI using the MPCA AERA methodology ensures that a conservative approach is used to assess potential health risks and protect public health (including sensitive populations) with a suitable margin of safety. Although presentation of potential risks using more plausible assumptions can assist in risk management decisions, when potential health

risks are assessed to be at or below acceptable guidelines using the MPCA AERA methodology, adverse health effects, even in sensitive populations, are not expected.

## 5.2 Exposure and Dose

### 5.2.1 Inhalation Exposure (Direct Exposure)

Following MPCA guidance, the RASS is used to calculate potential inhalation risks to receptors located at the area of the highest modeled air concentration (typically at the property boundary). The location of hypothetical receptors for this analysis is a person at the Mine Site property boundary, and a person at the distant Mineral Mining/Industrial zoning boundary. The RASS is designed to assess potential inhalation health risks for ~~from~~ the following durations of inhalation exposures:

- short-term, acute, (exposure to maximum concentration of a chemical in ambient air for the one hour averaging time), and
- long-term, chronic (exposure to maximum concentration of a chemical in ambient air for the annual averaging time).

The AERA methodology, as integrated into the MPCA's Risk Assessment Screening Spreadsheet (RASS), uses simple generic equations to calculate potential chemical exposure to a hypothetical receptor through inhalation. In this application the maximum modeled air concentration is synonymous with the potential dose for all acute and chronic durations. In actuality, real exposure occurs during uptake of the chemical through the respiratory tract after inhalation. Once the chemical is absorbed from the respiratory tract a certain amount becomes available to interact with specific organs or cells within the body (i.e. the delivered dose). For the analysis presented in this report, assuming that 100% of the maximum modeled air concentration is absorbed and accounts for the delivered dose is an overestimation of potential incremental risk, especially for chronic exposure.

### 5.2.2 Multipathway Exposure (Indirect; Ingestion)

Multipathway exposure assessment is an important part of risk assessment for chemicals that are emitted into air. Chemicals that are persistent, bioaccumulative, and/or toxic (PBT) can deposit to water, soil, and sediment and be present for long periods of time. Some particles settle onto soil and vegetation surfaces (farm crops and gardens) and into surface water (lakes, rivers, streams) and are persistent in the environment. Particles that settle into surface waters can deposit in the sediment and bioaccumulate in aquatic ecosystems. PBT chemicals have the potential to become part of the food chain by being deposited on plants (and/or incorporated into plants) and subsequently eaten by animals (e.g. cattle, poultry) and incorporated into food products. Potential exposure to PBT chemicals from food along with incidental ingestion of soil is part of the multipathway assessment for the resident and farmer. Using the maximum estimated air concentrations for the annual averaging time period, potential multipathway exposures are accounted for in the AERA methodology for two generic receptor types:

- a resident who consumes vegetables grown in his or her own garden, which are all assumed to receive deposition from the Project

- a farmer who, in addition to consuming homegrown vegetables, regularly eats home-grown meat, eggs, and dairy products which are all assumed to be affected by deposition from the Project

As previously discussed, the Mine Site is within Mineral Mining/Industrial zoning areas, which prohibit residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Currently there are no residents living in the area between the Mine Site boundary and the Mineral Mining/Industrial District boundary. There are also no residents or farmers at the Mineral Mining/Industrial District boundary, however, it is possible for a hypothetical resident or farmer to be at this boundary without violating zoning requirements. Therefore, potential multipathway risks for a potential resident and farmer receptor were calculated for areas at or outside the Mineral Mining/Industrial Districts boundary, with the nearest point of this boundary being approximately one kilometer from the Mine Site ownership boundary. Risks were calculated based on estimated potential to emit emissions for Mine Year 8 and Mine Year 13, per the current emission inventory (see Section 5.3.1 for Mine Years 8 and 13 rationale). Exposure scenarios evaluated in the Supplemental AERA are summarized in Table 5-1. See Large Table 1 and Large Table 2 for a summary of exposure, dose and toxicity endpoint information.

**Table 5-1 Summary of Exposure Scenarios and Receptors Evaluated for the Supplemental Air Emissions Risk Analysis for the Mine Site**

| Receptor(s) | Type of Exposure |
|---|---|
| Person (off-site worker) at the Mine Site Property Boundary | Inhalation<br>Short-term, acute inhalation: breathing maximum 1 hour modeled concentration of a chemical in ambient air<br>Long-term, chronic inhalation: breathing maximum annual modeled concentration of a chemical in ambient air |
| Resident who eats vegetables from his/her garden just outside of the Mining/Industrial boundary | Total Multipathway Exposure (Inhalation + Ingestion)<br>Long-term, chronic ingestion of vegetables from the garden (including incidental soil ingestion) + breathing maximum annual air concentration |
| Farmer who eats vegetables from his/her garden and meat and dairy products from his/her farm just outside the Mining/Industrial boundary | Total Multipathway Exposure (Inhalation + Ingestion)<br>Long-term, chronic ingestion of vegetables, meat, and dairy products from the farm (including incidental soil ingestion) + breathing maximum annual air concentration |

All CFEs that are identified as PBTs have multipathway screening factors in the version of RASS (20120302) used in this AERA (see Attachment A). The status of all CFEs and risk-driver chemicals in terms of PBTs and multipathway screening factors is listed in Table 5-2. The CFE from the Mine Site that are persistent and/or bioaccumulative are associated either with diesel fuel combustion from trucks and locomotive engines (dioxins/furans, PAHs and metals) or fugitive dust from haul roads (metals associated with particulate matter).

**Table 5-2 Multipathway Screening Factors for the Chemicals for Evaluation in the Supplemental AERA Conducted for the Mine Site**

| Chemical Name | Risk Driver In the 2008 AERA? | RASS-Multipathway Screening Factor? | RASS-PBT |
|---|---|---|---|
| Acetaldehyde | No | No | No |
| Arsenic Compounds | Yes | Yes | Yes |
| Cobalt | No | No | No |
| Crystalline Silica | No | No | No |
| Dibenzo(a,h)anthracene (PAH) | Yes | Yes | Yes |
| Diesel Particulate | No | No | No |
| Dioxins/Furans (2,3,7,8-TCDD equivalents) | Yes | Yes | Yes |
| Indeno(1,2,3-cd)pyrene (PAH) | Yes | Yes | Yes |
| Manganese Compounds | No | No | No |
| Nickel Compounds | No | No | No |
| Nitrogen oxides/$NO_2$ | Yes | No | No |

## 5.3 Estimating Exposure Point Concentrations

Maximum modeled air concentrations are used as exposure concentrations to estimate potential incremental inhalation risk. These exposure concentrations (i.e., air concentrations), are derived through the use of air dispersion models and estimates of controlled potential chemical emissions from version 10 of the Mine Site Emission Inventory. Maximum modeled air concentrations were derived using AERMOD (version 12060).

### 5.3.1 Estimating Emissions

Emission estimates were summarized in Section 4.3. The discussion here provides additional information on the emission estimates in the current Mine Site operations emission inventory.

The Potential to Emit (PTE) was primarily based on emission factors from AP-42, mass balance information, engineering calculations, block models, and whole rock or geology data. The emission calculations include the assumption that all operations will occur 24 hours/day 365 days/year except for operation of the Portable Crushing Plant and Overburden Screening activities. Operations of the Portable Crushing Plant and Overburden screening activities were assumed to occur 24 hours/day throughout the construction season which was defined as April through October. Hourly and annual emission rates were calculated and these have been summarized in Table 5-3. For sources directly related to the mining operation, the annual emissions are based on mining rates during the years with the highest emissions (worst case) for each of the two primary modes of mine operation:

- stockpile disposal of all waste rock (Year 8)
- disposal of waste rock in the Central/East Pit (Year 13) and reclamation of Category 2/3 and Category 4 Stockpiles.

The most recent emission calculations for the NorthMet Project Mine Site were submitted in an emissions inventory on August 29, 2012.

Additional discussion for selected categories of emission calculations is provided in the following subsections: fugitive sources, mobile sources, and point sources.

#### 5.3.1.1 Fugitive Emissions

The majority of sources associated with the Mine Site activities are fugitive emission sources. The fugitive sources associated with Mine Site activities have been divided into six categories that tend to be similar in nature. The categories are as follows:

- truck and railcar loading and unloading of overburden, waste rock and ore
- fugitive dust emissions from trucks travelling on unpaved roads in the mine area, along Dunka road and the fueling facility circle
- contractor operations including crushing to produce rock for construction purposes
- wind erosion of stockpiles
- blast-hole drilling
- combustion emissions from trucks and locomotives

#### 5.3.1.2 Mobile Sources

Emission calculations for mine vehicles (diesel fuel combustion) include VOCs, speciated PAHs, diesel particulate, dioxins/furans, and metals. These vehicle emissions calculations were based on the following assumptions:

- all vehicles operate at the highest projected annual fuel usage for any year of mine operation
- worst case fleet assumed for vehicle emissions over life of Project (mix of Tier 2, Tier 3 and Tier 4 vehicles)

Emission calculations for locomotives (diesel fuel combustion) include VOCs, speciated PAHs and metals. These emissions are based on the loading and idling time of the locomotives at the Mine Site. For dioxins/furans, there are no emission factors for locomotives. The dioxin/furans emission factor for heavy duty vehicles (Reference (29) and Reference (30)), however, was applied to locomotives on a fuel usage basis.

#### 5.3.1.3 Point Sources

The point sources at the Mine Site consist of three diesel tanks, a mobile generator used to temporarily power large electric mining vehicles, the backup generator at the Wastewater Treatment Facility (WWTF) and space heaters at the WWTF.

A mobile diesel generator will be located at the Mine Site to provide temporary power to electric-powered large excavators and drill rigs used in the mine pits to move this equipment from one location to another. This generator is only sized to provide locomotion to the equipment, not to operate it for its primary function (drilling or loading haul trucks). This generator will be operated infrequently, and when it is operated, one of the large pieces of electrical mining equipment will be out of service, effectively limiting emissions from normal mining activities. Because this generator does not meet the definition of an emergency generator, emissions from this source have been included in the evaluations in the AERA.

#### 5.3.1.4 Small Sources Not Modeled

A few small emission sources were not modeled for the AERA. One is the emergency diesel generator for the WWTF to be located at the Mine Site. This diesel powered backup generator (Emission Units 332) will be used at the Mine Site to provide backup in case of a power failure at the WWTP. The major pollutant to be emitted from this generator is $NO_x$. Some particulate metals may also be emitted. Due to the infrequent use, relatively short operating time expected for EU 332 and defined use as an emergency generator, potential emissions from this diesel generator were not modeled in the AERA following MPCA AERA guidance (Reference (14)).

The other small sources of potential emissions are the diesel fuel tanks. The potential emissions from these tanks are VOCs. Due to the very small potential VOC emissions likely associated

with these tanks they were eliminated from quantitative analysis according to the AERA guidance.

#### 5.3.1.5 Particulate Metal Emission Estimates

For the 2008 Mine Site AERA, particulate metal emission estimates were based on total particulate with a diameter cut-point of approximately 30 microns (approx. $PM_{30}$). The same approach was used for this Supplemental AERA.

### 5.3.2 Air Dispersion Modeling

The fate and transport of chemicals, after being emitted from the various Mine Site activities to ambient air, is dependent on the source release characteristics, meteorological conditions, terrain characteristics, atmospheric physical and chemical processes (pollutant scavenging, wet and dry deposition rates, etc.), physical and chemical characteristics of the compounds, and land use. For this risk analysis the AERMOD model (version 12060) was used to estimate maximum modeled air concentrations. Meteorological data used in the modeling are from Hibbing, MN (2001-2005) and they were processed using AERMET (version 11059). Large Figure 3 shows the air dispersion modeling receptor grid.

For this AERA, and consistent with the compliance modeling conducted for Class II areas, a site-specific deposition algorithm was developed for the Mine Site to better represent potential fugitive dust emissions transport and air concentrations. For the AERA modeling, the particulate depletion half-life time step was changed from 1,100 seconds ($PM_{10}$ gravitational settling basis used for Class II modeling) to 370 seconds ($PM_{30}$ gravitational settling basis) (Reference (31)). This algorithm is discussed in detail in the addendum to the Mine Site Class II Modeling Protocol submitted to the Minnesota State agencies on March 12, 2012 (Reference (6)) and the AERA Work Plan as amended in August of 2012.

The total Mine Site emission rates that were modeled are presented in Table 5-3 and the maximum modeled air concentrations are provided in Table 5-4. Electronic versions of the input and output files (post-processing files) for the chemicals that were modeled are included with the AERA report submitted to the MPCA.

The maximum modeled air concentrations occur at the PolyMet Mine Site property ownership boundary (Large Figure 4 and Large Figure 5) and are used to assess potential inhalation risks (acute and chronic) for an individual. Potential multipathway chronic risks were also assessed for a potential resident and a potential farmer receptor, but only for those receptors located outside the area zoned as Mineral Mining/Industrial District (zoning boundary shown in Large Figure 2). Large Figure 3 identifies the two receptors outside the Mineral Mining/Industrial District boundary that are closest to the Mine Site.

**Table 5-3 Estimated total mine-related annual emission rates modeled for the Supplemental Air Emissions Risk Analysis conducted for the proposed Mine Site**

| Chemical Name | Total Mine Site Emission Rate (g/s) | | | |
|---|---|---|---|---|
| | Year 8 hourly rate | Year 8 annual rate | Year 13 hourly rate | Year 13 annual rate |
| Acetaldehyde | 2.44E-05 | 1.40E-06 | 2.44E-05 | 1.40E-06 |
| Arsenic Compounds | 0.0013 | 0.0004 | 0.0014 | 0.0005 |
| Cobalt | 0.0036 | 0.0025 | 0.0040 | 0.0027 |
| Crystalline Silica | 0.5820 | 0.3952 | 0.6467 | 0.4339 |
| Dibenzo(a,h)anthracene | 2.92E-06 | 2.57E-06 | 2.92E-06 | 2.57E-06 |
| Diesel Particulate Matter | 0.2276 | 0.2237 | 0.2276 | 0.2237 |
| Indeno(1,2,3-cd)pyrene | 3.41E-06 | 2.99E-06 | 3.41E-06 | 2.99E-06 |
| Manganese Compounds | 0.0638 | 0.0450 | 0.0702 | 0.0488 |
| Nickel Compounds | 0.0245 | 0.0152 | 0.0266 | 0.0166 |
| Oxides of Nitrogen ($NO_x$ as $NO_2$) | 12.5173 | 9.2554 | 12.5173 | 9.2554 |
| Dioxins/Furans (as 2,3,7,8-TCDD TEQ) | 4.12E-10 | 3.73E-10 | 4.12E-10 | 3.73E-10 |

**Table 5-4 Maximum modeled air concentrations evaluated in the Supplemental AERA conducted for the proposed Mine Site**

| | PolyMet Mine Site Ownership Boundary Maximum Modeled Air Concentrations ($\mu g/m^3$) | | | | Mineral Mining/Industrial District Boundary Maximum Modeled Air Conc. ($\mu g/m^3$) | |
|---|---|---|---|---|---|---|
| Chemical Name | 1-Hour Year 8 | 1-Hour Year 13 | Annual Year 8 | Annual Year 13 | Annual Year 8 | Annual Year 13 |
| Acetaldehyde | 0.00116 | 0.00116 | 4.36E-07 | 4.57E-07 | 8.82E-08 | 9.44E-08 |
| Arsenic compounds | 0.00616 | 0.00660 | 1.42E-04 | 1.14E-04 | 2.75E-05 | 2.82E-05 |
| Cobalt | NA | NA | 3.76E-04 | 3.48E-04 | 3.15E-05 | 3.59E-05 |
| Crystalline Silica | NA | NA | 0.0609 | 0.0572 | 0.005502 | 0.00654 |
| Dibenzo(a,h)anthracene | NA | NA | 3.09E-06 | 2.17E-06 | 7.26E-07 | 7.19E-07 |

| | PolyMet Mine Site Ownership Boundary Maximum Modeled Air Concentrations ($\mu g/m^3$) | | | | Mineral Mining/Industrial District Boundary Maximum Modeled Air Conc. ($\mu g/m^3$) | |
|---|---|---|---|---|---|---|
| **Chemical Name** | **1-Hour Year 8** | **1-Hour Year 13** | **Annual Year 8** | **Annual Year 13** | **Annual Year 8** | **Annual Year 13** |
| Diesel Particulate Matter | NA | NA | 0.264 | 0.187 | 0.0562 | 0.0523 |
| Dioxins/Furans (as 2,3,7,8-TCDD TEQ) | NA | NA | 4.56E-10 | 3.21E-10 | 9.58E-11 | 8.83E-11 |
| Indeno(1,2,3-cd)pyrene | NA | NA | 3.61E-06 | 2.54E-06 | 8.51E-07 | 8.45E-07 |
| Manganese compounds | NA | NA | 0.0126 | 0.0103 | 0.00217 | 0.00227 |
| Nickel compounds | 0.0836 | 0.0631 | 0.00150 | 0.00210 | 2.11E-04 | 2.71E-04 |
| Oxides of Nitrogen (NOx)(1) | 393.91 | 471.15 | NA | NA | NA | NA |

(1) The USEPA factor of 80% for the conversion of $NO_X$ to $NO_2$ was applied to the maximum modeled one-hour $NO_X$ air concentration. Value shown in table is $NO_x$ not $NO_2$ estimate.

## 5.4 Receptor Locations and Risk Concept Applications

Reasonably expected future land use is a critical consideration for a risk assessment with regard to receptor locations and application of risk concepts. Resident and/or farmer receptors are assessed where residential and/or farming land use has the potential to occur in the future. When other future land use prohibits residential and/or farming land uses in specific areas, risks are typically not estimated for the farmer or resident receptor at those locations.

With regard to the Mine Site, PolyMet's property ownership boundary (i.e. the Mine Site ambient air boundary, separating land to which the public has/does not have legal access) and the entire mine location are within the City of Babbitt Mineral Mining District and the St Louis County Industrial District (Large Figure 2). The St Louis County Industrial District abuts the east side of the projected PolyMet Mine Site property ownership boundary (Large Figure 2). Both of these zoned districts prohibit residential and farming operations. Due to the "Mineral Mining/Industrial District" zoning, residential and farming development are not a reasonably foreseeable land use in areas immediately adjacent to the projected PolyMet Mine Site property ownership boundary nor are there any residents in this area. Only areas outside the Mineral Mining/Industrial District zoning areas are considered to have the potential to have residential or farming development as a reasonable future land use. Therefore, potential multipathway impacts are evaluated for a potential farmer and resident receptor at the more distant boundaries of these zoning areas (see receptor placement in Large Figure 3 and Large Figure 2). The boundary of this area where residential and farming development is precluded is referred to as the "Mineral

Mining/Industrial District Boundary" in this report or "just outside" of the Mineral Mining/Industrial district boundary.

### 5.4.1 Maximum Exposed Off-property Receptor

Under the MEI exposure concept, it was assumed that a hypothetical person or "receptor" lives at a specific location regardless of whether or not anyone lives, or has the ability to live at this specific location, or in the general area. The receptor location to assess adult maximum exposed individual inhalation risks (acute, chronic noncancer, and chronic cancer) was at the maximum modeled air concentration at the Mine Site property ownership boundary. For multipathway exposure (includes inhalation), both the farmer/resident receptors were located just outside of the Mineral Mining/Industrial zoning boundaries (see Large Figure 2). There are currently no actual residents or farmers in the areas adjacent to the Mine Site property ownership boundary or the Mineral Mining/Industrial District Boundary and no individuals are expected to be residing in these areas in the foreseeable future during active mining operations. In addition, soil, current forest vegetation, and climate indicate that any future farming development in this area is highly unlikely. Therefore, the assumption that a resident or farmer is present at the Mine Site property ownership boundary or the Mineral Mining/Industrial zoning boundary likely overestimates the potential risk to any "real" receptor.

### 5.4.2 Indoor Air versus Outdoor Air

For both receptors (maximum off-site receptor, farmer and resident) it was further assumed that the hypothetical individual is continuously exposed to outdoor air for a lifetime (24 hours per day, 365 days per year, over a 70-year period for inhalation, a 30-year period for resident ingestion and a 40-year period for farmer ingestion). In reality people spend a considerable amount of time indoors, where concentrations of project related emissions are most likely lower. It has been estimated that U.S. residents spend only 6% of a day outdoors and 87% of a day indoors (Reference (32)).

Concentrations of particulate metal in air, associated with potential emissions from the proposed Mine Site operations, are different for indoor versus outdoor environments. When people are indoors, they reduce their exposure to outdoor air contaminants. A recent study measured the contribution of outdoor air concentrations of $PM_{2.5}$ to indoor air, and to personal exposure (as measured by subjects wearing a personal environmental monitor) in Los Angeles, CA, Houston TX, and Elizabeth NJ. The mean percent contribution of outdoor $PM_{2.5}$ to indoor air was 60% (Reference (32)). The mean concentration of outdoor $PM_{2.5}$ to personal exposure was even lower, 26%. Most sources of indoor air pollutants are released from within buildings (Reference (33)). However, for the MEI exposure concept, it was conservatively assumed that that a person would be outdoors continuously. In addition, it was assumed that all metals in ambient air would be in the respirable size range, bioaccessible, and bioavailable (less than or equal to 10 microns in diameter).

## 5.5 Changes to AERA Methodology Compared to the January 2008 AERA

For the most part, the methodology used in this Supplemental AERA is the same or similar to that used in the January 2008 Mine Site AERA. Changes that are not specified in detail in the work plan for the Supplemental AERA are described here.

- The most recent versions of the RASS and AERMOD were used for the Supplemental AERA. As a result, cobalt was added as a CFE in addition to pollutants described in the work plan.

- The air dispersion modeling included plume depletion half-life terms to model deposition of particulate sources in the Supplemental AERA (see Section 5.3.2 for more details).

- The emission factor for dioxins and furans from diesel combustion was changed to the factor the USEPA used in the 1987, 1995, and 2000 national dioxin emission inventory (Reference (29)). The USEPA approved emission factor of 172 pg TEQ/km is based on a 1996 tunnel study (Reference (30)). The emission factor used in calculating potential dioxin/furan emissions from mobile source diesel fuel combustion for the January 2008 AERA (288 pg TEQ/km) is a Barr-derived emission factor based on data from studies conducted in the U.S. in the 1996-1998 time period (Reference (10)).

## 6.0 Toxicity Assessment

The objective of the toxicity assessment is to identify potentially toxic effects caused by chemicals of interest and to examine the dose-response relationship. For this Supplemental AERA, all of the CFE have toxicity values available in the MPCA's RASS (version 20120302). These toxicity values were used in this AERA without modification. No alternative toxicity values were used in this evaluation.

Additional discussions of the toxicity values found in the MPCA's RASS (version 20120302) for the CFE evaluated in this Supplemental AERA may be found in Attachment B.

## 7.0 Quantitative Risk Estimates

### 7.1 General Methodology

Risk characterization is the process whereby exposure point concentrations and toxicity information are combined to generate estimates of potential health risks. These estimates are compared to acceptable incremental guideline risk values. The USEPA (Reference (34)) defines risk characterization as the process that "... *integrates information from the preceding components of the risk assessment and synthesizes an overall conclusion about risk that is complete, informative, and useful for decision makers....*" However, because of the limitations inherent in the risk assessment process it is very important to recognize that the risk characterization in this AERA or any health risk assessment cannot predict actual health outcomes, such as cancer. In other words, this or any health risk assessment does not provide an estimate of actual risk to a real person.

In the AERA process, "quantitative analysis" specifically refers to the estimation of additional lifetime potential cancer risks and potential noncancer health effects using the MPCA's RASS. The most recent electronic version of the RASS (version 20120302) was obtained from the MPCA. An individual RASS file for each year of emissions (Year 8, Year 13) was then set up to estimate potential risks at the:

- Mine Site property ownership boundary (i.e. Mine Site ambient air boundary) for inhalation only risks for maximum exposed individual (acute 1-hour and chronic)
- Mineral Mining/Industrial Zoning Boundary (multipathway risks for a famer and resident)

Because the highest estimated noncancer acute inhalation risks occur at the Mine Site property ownership boundary and are applied to a potential off-site receptor, potential acute inhalation risks at the more distant Mineral Mining/Industrial Zoning Boundary are not calculated. Although an acute inhalation hazard index is not specifically calculated at the Mineral Mining/Industrial Zoning Boundary, the hazard index calculated at the Mine Site property ownership boundary may be considered a conservative estimate for farmers or residents.

Further details on the methodology and assumptions used to calculate potential risk estimates may be found in Attachment C. Risk estimates from the MPCA RASS can be found in Attachment D.

### 7.2 Risk Results

Risk results obtained from the individual RASS runs for each emission scenario are summarized in Table 7-1 and Table 7-2.

### 7.2.1 Incremental Inhalation Risks at the PolyMet Ownership Boundary

Noncancer inhalation risks at the Mine Site Ownership Boundary are well below the general risk guideline value of 1.0 (see Table 7-1 and Table 7-2).

Noncancer Acute (1-hour worst case risk, Mine Year 13 emissions and mine layout)

- estimated potential inhalation acute health risks for individual chemicals (HQs) did not exceed the Hazard Index guideline value of 1.0
- estimated potential summed inhalation acute health risk regardless of toxic endpoint, expressed as a Hazard Index (HI), is 0.8 and is below the guideline value of 1.0
- the only risk-driver chemical is $NO_2$ (HQ = 0.8), primarily from diesel engines
- The acute RRE for sulfuric acid is HQ=0.0023 (included in total acute risk calculation)
- estimated risks calculated for the 2012 Supplemental AERA are in the same range as the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

Noncancer, chronic (worst case risk, Mine Year 8 emissions and mine layout)

- estimated potential noncancer chronic inhalation risks for the individual chemicals evaluated were below the Hazard Index guideline value of 1.0
- the summed potential noncancer chronic inhalation risk, for all chemicals combined, regardless of toxic endpoint, is 0.2 and is below the Hazard Index guideline value of 1.0
- there were no chemicals above the MPCA's risk driver level for the chronic noncancer endpoint (all HQs < 0.1)
- estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

Cancer, chronic (worst case risk, Mine Year 13 emissions and mine layout)

- estimated potential inhalation cancer risks for both years for the individual chemicals evaluated were below the MDH guideline value of 1E-05
- the summed potential cancer chronic inhalation risk for all carcinogens combined, regardless of the mode of action, is 5E-06, which is below the MDH cancer risk guideline of 1E-05

- there are two risk drivers associated with Year 13 risk: cobalt (3E-06) and nickel compounds (1E-06), both associated with particulate matter
- estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

### 7.2.2 MEI Incremental Multipathway Risks at the Mineral Mining/Industrial District Boundary

Noncancer, multipathway chronic (worst case risk, Mine Year 13 emissions and mine layout)

- estimated potential multipathway noncancer chronic risks for individual chemicals (HQs) did not exceed the guideline value of 1.0
- estimated potential summed noncancer chronic risk for both a farmer and resident receptor, regardless of toxic endpoint, equals 0.04 and is less than the guideline value of 1.0
- there are no chemicals above the MPCAs risk-driver level for multipathway chronic noncancer risk (all HQs < 0.1)
- estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

Cancer, multipathway chronic (worst case risk, Mine Year 13 emissions and mine layout)

- farmer receptor
  - estimated summed potential cancer risks for all carcinogens combined regardless of mode of action is 1E-05 (Years 8 and 13), which does not exceed the MDH guideline value of 1E-05
  - risk-driver chemicals from multipathway exposure (food consumption and inhalation) are dibenzo(a,h)anthracene and dioxins/furans
    - dibenzo(a,h)anthracene = 5E-06.
    - dioxins/furans = 8E-06.
    - the indirect exposure pathway (consumption of home grown produce, dairy and meat) contributes about 92% of the estimated potential incremental risk
- resident receptor

- estimated summed potential risks for all carcinogens combined, regardless of mode of action, is 8E-07 (Year 13) and does not exceed the MDH guideline value of 1E-05
- there are no risk-driver chemicals for resident multipathway chronic cancer risk (all individual chemical risks < 1E-06)

- for both the Farmer and Resident receptors, estimated cancer risks calculated for the 2012 Supplemental AERA are in the same range as those calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

**Table 7-1 Comparison Summary of the Estimated Incremental Human Health Risks for the Mine Year 8 Stockpile Waste Rock Storage Emissions Scenario for the Supplemental Air Emissions Risk Analysis (AERA) and the 2008 AERA Conducted for the Mine Site**

| Exposure Route | Exposure Scenario | Receptor[1] | Potential noncancer effects (Hazard Index)[2] | | Potential cancer effects (Risk Estimate)[3] | |
|---|---|---|---|---|---|---|
| | | | 2008 | 2012 | 2008 | 2012 |
| Inhalation Only Exposure | Acute (1 hour)[4] | Mine-Site property ownership boundary | 0.2 | 0.7 | N/A | N/A |
| | Chronic (greater than 1 year) | Mine-Site property ownership boundary | 0.2 | 0.2 | 3E-06 | 5E-06 |
| | | Resident/Farmer Mineral Mining/ Industrial District boundary [5] | 0.04 | 0.04 | 6E-07 | 5E-07 |
| Multipathway Exposure Receptors are just outside of the Mineral Mining/ Industrial District boundary[5] | Chronic-indirect multipathway only (food and incidental soil ingestion) | Farmer | 0.00007 | 0.005 | 3E-05 | 1E-05 |
| | | Resident | N/A | 0.002 | 8E-08 | 2E-07 |
| | Chronic-total multipathway = inhalation + food and incidental soil ingestion | Farmer | 0.04 | 0.04 | 3E-05 | 1E-05 |
| | | Resident | 0.04 | 0.04 | 7E-07 | 8E-07 |

(1) The off-site worker and the resident and farmer receptors are evaluated for potential human health risks using a maximum modeled air concentration. Use of a maximum modeled air concentration is considered by USEPA (Reference (1)) to represent a maximum exposed individual (MEI). All receptors are assumed to be outside 24 hours per day, 365 days per year.

(2) Incremental noncancer (chronic and acute) guideline value is 1.0.

(3) Incremental cancer risk guideline value is 1E-05, MDH.

(4) The USEPA factor of 80% is applied to the maximum modeled one-hour $NO_x$ air concentration as a conservative estimate of the conversion of NO to $NO_2$. Acute inhalation risk was only calculated at the Mine Site property ownership boundary. This estimate may be considered a conservative estimate of acute risk at the Mineral Mining/Industrial Zoning Boundary. The acute RRE for sulfuric acid is 0.0023. The RRE has been added to the HI estimated from modeled concentrations, HI+RRE = 0.7

(5) PolyMet' s land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Therefore, resident and farmer multipathway risks were not calculated at PolyMet's ownership boundary. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer from the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated potential to emit emissions and for both stockpile storage and in-pit storage mine layout.

**Table 7-2 Comparison Summary of the Estimated Incremental Human Health Risks for the Mine Year 13 In-Pit Waste Rock Disposal Scenario for the Supplemental Air Emissions Risk Analysis (AERA) and the 2008 AERA Conducted for the Mine Site**

| Exposure Route | Exposure Scenario | Receptor[1] | Potential noncancer effects (Hazard Index)[2] | | Potential cancer effects (Risk Estimate)[3] | |
|---|---|---|---|---|---|---|
| | | | 2008 | 2012 | 2008 | 2012 |
| Inhalation Only Exposure | Acute (1 hour)[4] | Mine-Site property ownership boundary | 0.1 | 0.8 | N/A | N/A |
| | Chronic (greater than 1 year) | Mine-Site property ownership boundary | 0.3 | 0.2 | 4E-06 | 5E-06 |
| | | Just outside of the Mineral Mining/ Industrial District boundary[5] | 0.04 | 0.04 | 6E-07 | 6E-07 |
| Multipathway Exposure Receptors are just outside of the Mineral Mining/ Industrial District boundary[5] | Chronic-indirect multipathway only (food and incidental soil ingestion) | Farmer | 0.00007 | 0.005 | 2E-05 | 1E-05 |
| | | Resident | N/A | 0.002 | 7E-08 | 2E-07 |
| | Chronic-total multipathway = inhalation + food and incidental soil ingestion | Farmer | 0.04 | 0.04 | 2E-05 | 1E-05 |
| | | Resident | 0.04 | 0.04 | 6E-07 | 8E-07 |

RASS = Risk Assessment Screening Spreadsheet
HQ = hazard quotient

(1) The off-site worker and the resident and farmer receptors are evaluated for potential human health risks using a maximum modeled air concentration. Use of a maximum modeled air concentration is considered by USEPA (Reference (1)) to represent a maximum exposed individual (MEI). All receptors are assumed to be outside 24 hours per day, 365 days per year.

(2) Incremental noncancer (chronic and acute) guideline value is 1.0.

(3) Incremental cancer risk guideline value is 1E-05, MDH.

(4) The USEPA factor of 80% is applied to the maximum modeled one-hour $NO_X$ air concentration as a conservative estimate of the conversion of $NO_X$ to $NO_2$. Acute inhalation risk was only calculated at the Mine Site property ownership boundary. This estimate may be considered a conservative estimate of acute risk at the Mineral Mining/Industrial Zoning Boundary. The acute RRE for sulfuric acid is 0.0023. The RRE has been added to the HI estimated from modeled concentrations, HI+RRE = 0.8

(5) PolyMet' s land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Therefore, resident and farmer multipathway risks were not calculated at PolyMet's ownership boundary. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer from the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated potential to emit emissions and for both stockpile storage and in-pit storage mine layout.

## 7.3 Assessment of Early Life Sensitivity and Exposure to Carcinogens

Animal studies have shown that young animals (e.g. birth to weaning) can be more sensitive to exposure to some carcinogens than adult animals. The chemical cancer potency can be greater when animals are exposed early in life, depending on how the chemical causes cancer (mode of action). Both USEPA and MDH recommend adjusting cancer risk estimates to account for early life exposure (Reference (22)). This is especially true for chemicals which are carcinogens by the mutagenic mode of action. Additionally, MDH recommends applying age adjustments to all linear carcinogens regardless of mode of action. Potential cancer risks can be adjusted for early life exposure using Age Dependent Adjustment Factors (ADAFs) (Reference (22)).

Age adjustments for early life exposure are sometimes incorporated into toxicity values (i.e. slope factor or inhalation unit risk) themselves. When this occurs, cancer risk estimates using these values are considered already adjusted for early life exposure. Seven of the CFE were assessed for potential cancer effects; acetaldehyde, arsenic compounds, cobalt compounds, dibenzo(a,h)anthracene (PAH), indeno(1,2,3-cd)pyrene (PAH), nickel compounds, and dioxins/furans (as 2,3,7,8-TCDD equivalents). Diesel engine exhaust has recently been classified as a carcinogen by the International Agency for Research on Cancer. Currently, a toxicity value to assess potential cancer effects is not available for diesel engine exhaust (or diesel particulate matter). However, carcinogenic constituents of diesel particulate matter (i.e. arsenic, dioxins/furans, PAHs) were evaluated for potential cancer risks in this AERA. A summary relating to their carcinogenicity is in Table 7-3.

**Table 7-3 Assessment of Chemicals for Evaluation Considered Carcinogens in Terms of Adjustments for Early Life Exposure at the Mine Site**

| Chemical For Evaluation Evaluated as a Carcinogen | MPCA Status In terms of Early Life Adjustment (Reference (35)) | Action Taken in the AERA |
|---|---|---|
| Acetaldehyde | Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment. | None<br>(Not a risk driver) |
| Arsenic Compounds | On MPCA list of Pollutant of Interest in terms of age adjustment | None<br>(Not a risk driver) |
| Cobalt Compounds | Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment. | None<br>(Not a risk Driver at LTVSMC boundary)<br>PPRTV documentation recommends against age adjustment for cobalt because the mutagenic mode of action has not been clearly established for cobalt (Reference (36)) |

| Chemical For Evaluation Evaluated as a Carcinogen | MPCA Status In terms of Early Life Adjustment (Reference (35)) | Action Taken in the AERA |
|---|---|---|
| Dibenzo(a,h) anthracene (PAH) | On MPCA list of Pollutant of Interest in terms of age adjustment | Adjusted Risk Estimate for Inhalation |
| Diesel Particulate Matter | Currently not evaluated as a carcinogen in the RASS. | None<br>(Constituents of diesel particulate matter that are risk drivers such as arsenic, cobalt compounds, nickel and dioxins/furans were assessed separately) |
| Indeno(1,2,3-cd)pyrene (PAH) | On MPCA list of Pollutant of Interest in terms of age adjustment | None<br>(Not a risk driver) |
| Nickel Compounds | Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment. | None<br>(Not a risk driver) |
| Dioxin/Furans (2,3,7,8-TCDD equivalents) | On MPCA list of Pollutant of Interest in terms of age adjustment | None<br>MDH advises against age adjustment for dioxins/furans (Reference (35)). |

Cobalt and nickel compounds were the only CFE that were risk drivers for carcinogenicity at the Mine Site boundary. Cobalt was a risk driver for Mine Year 8 and both cobalt and nickel compounds were risk drivers for Mine Year 13 modeling. Early life exposures are not expected to occur at the Mine Site boundary, given the current and reasonably foreseeable future land use and industrial/mining zoning. Therefore, adjustments to inhalation cancer risk estimates at the Mine Site boundary were not made.

The risk drivers for farmer cancer risk by multipathway exposure at the Mineral Mining/Industrial Zoning Boundary were dibenzo(a,h)anthracene and dioxins/furans for both Years 8 and 13. The MDH recommends against making age adjustments for dioxins/furans, although the MPCA has noted that the toxicity value for dioxins/furans in the current version of the RASS has been age adjusted. The toxicity value in the RASS for dibenzo(a,h)anthracene was not age adjusted. USEPA considers dibenzo(a,h)anthracene a chemical which can cause cancer by the mutagenic mode of action (Reference (37)). Currently the USEPA does not list Indeno(1,2,3-c)pyrene as a PAH which can cause cancer by the mutagenic mode of action.

MPCA recommends multiplying the cancer risk estimate by 1.6 to account for early life exposure. MPCA Guidance (Reference (35)) lists dibenzo(a,h)anthracene as a potential pollutant of interest with respect to ADAFs by inhalation. If the dibenzo(a,h)anthracene cancer risk estimate by inhalation is multiplied by 1.6, and added to the total cancer risk estimate, the age

adjusted risk for Mine Years 8 and 13 do not exceed the MDH guideline of 1 E-05. No additional adjustments were made to the cancer risk estimates to incorporate early-life sensitivity.

The potential cancer risks after adjusting the inhalation cancer risk estimate for dibenzo(a,h)anthracene are shown in Table 7-4.

**Table 7-4 Multipathway Farmer Age Adjusted Cancer Risk Estimate for Years 8 and 13 based on Early Life Exposure Age Adjustment for dibenzo(a,h)anthracene**

| | Multipathway Farmer Cancer Risk for Mine Year 8 | Multipathway Farmer Cancer Risk for Mine Year 13 |
|---|---|---|
| Total Cancer Risk (unadjusted) | 1 E-05 | 1E-05 |
| Unadjusted risk estimate for inhalation dibenzo(a,h)anthracene | 9E-10 | 9E-10 |
| Age adjusted risk estimate for inhalation for dibenzo(a,h)anthracene(1) | 1E-09 | 1E-09 |
| Age Adjusted Total Cancer Risk Estimate(2) | 1E-05 | 1E-05 |

(1) Age Adjusted Dibenzo(a,h)anthracene risk = Unadjusted Dibenzo(a,h)anthracene Risk X 1.6
(2) Age Adjusted Total Cancer Risk = Unadjusted Total Cancer Risk – Unadjusted dibenzo[a,h]anthracene Risk + Age Adjusted Dibenzo(a,h)anthracene Risk

Additional discussions of the toxicity values found in the MPCA's RASS (version 20120302) for the CFE evaluated in this Supplemental AERA may be found in Attachment B

## 7.4 Percent of Emissions Assessed; Potential Additional Risk from Chemicals Not Evaluated Quantitatively for Risks

In the 2008 Mine Site AERA, a total of 52 CFPE were identified, with 32 identified as CFE in that analysis. Of the 32 CFE, six were identified as "risk driver chemicals" (cancer risk of 1E-06 or greater; noncancer risk of 0.1 or greater). The other 26 CFE were identified as being insignificant for risk. The six risk driver chemicals from the 2008 Mine Site AERA were quantitatively assessed in this Supplemental AERA. Because the other 26 CFE from the 2008 Mine Site AERA had very small estimates of potential risk, excluding them from this Supplemental AERA does not have a significant effect on the estimated risks for this analysis.

There were 20 chemicals from the 2008 Mine Site AERA that were not evaluated quantitatively. As described in the 2008 AERA, emissions for these 20 CFPE without toxicity values were approximately 20 tons/year in the Mine Year 8 and Mine Year 16 inventories and represented approximately 3.1% of the emission inventory at that time. Emissions of the 20 CFPE without toxicity values were a small part of total emissions in the 2008 emission inventory and they continue to be a small part of total emissions in the current emission inventory. When the Supplemental AERA and the 2008 AERA are considered together, about 99% of the emission

inventory has been quantitatively evaluated for risks. Based on current knowledge, the exclusion of the non-evaluated chemicals from the quantitative risk estimates is unlikely to have a significant effect on the quantitative risk estimates.

## 7.5 Conservatism in the Risk Estimates

### 7.5.1 General Conservatism

As part of the risk assessment process, risks are estimated as a function of exposure and toxicity. Conservative assumptions are those that tend to maximize estimates of exposure (Reference (16) and Reference (5)). Toxicity values are also derived to be protective of public health. The combination of several conservative assumptions can lead to unrealistically conservative bounding estimates (Reference (16) and Reference (5)), with the result that the potential estimated risks are likely to be greatly overestimated. Combining maximum exposure point concentrations with maximum values for exposure frequency and duration in combination with upperbound toxicity values, results in a potential cancer risk estimate that may be thousands of times greater than those for the average exposed individual. The combination of maximum or high-end emissions, exposure and toxicity parameters make it extremely unlikely that quantitative risks are underestimates rather than overestimates. The use of the MEI concept, assumptions about metal speciation and bioavailability, and the way toxicity factors and emission factors are used all contribute to an assessment that overestimates potential exposure and risks.

In this Supplemental AERA the following represent sources of conservatism that result in overestimation of potential human health risks:

- use of maximum modeled air concentrations as the potential dose (or exposure concentration) for each receptor
- the assumption that receptors will be exposed to the maximum modeled ambient air concentration for the entire acute or chronic time period
- use of toxicity values (or inhalation benchmarks: reference concentrations, HRVs, inhalation unit risk values) which were derived with the intention of being conservative and protective of sensitive populations
- use of chronic inhalation health benchmarks derived to account for "daily exposures throughout a lifetime" (Reference (14)). ("Daily exposures throughout a lifetime" is generally assumed to mean continuous exposure, or exposure 24 hours/day, 365 days/year for 70 years.)
- the risk estimates (i.e. hazard quotients) for non-carcinogens are summed across all toxicity endpoints, regardless of potential toxic effects

- the risk estimates for carcinogens are summed for all types of cancer endpoints, regardless of the type of cancer the chemical is associated with causing

- assumption that metals inherent to the mineral structure of a rock particle are 100% bioavailable and in the respirable size fraction ($PM_{10}$ or smaller)

### 7.5.2 Conservatism Specific to Farmer Cancer Risk

The highest risks estimated in this Supplemental AERA are for a potential farmer receptor located approximately one kilometer southeast of the Mine Site. Estimated multipathway farmer cancer risks were 1E-05. It is likely that this risk is overestimated because:

- The current mining operations in the area and the general climate, terrain, predominance of forest vegetation and low fertility soils suggest that it is highly unlikely for farming to occur in this general area. Assuming a farmer is present near the active mining zone is considered a conservative assumption.

- Dioxins/furans were a risk driver chemical. The USEPA emission factor used to estimate potential dioxin emissions from diesel fuel combustion is based on a 1996 tunnel study. Both diesel fuel standards and engine technologies have improved since 1996. The World Health Organization (WHO) through the United Nations Environment Programme (UNEP) has calculated a dioxin emission factor more than 10 times lower than the USEPA factor used in this evaluation that is based on newer data (Reference (38)).

## 7.6 Range of Risk Estimates

The AERA methodology relies on a deterministic estimate of risk (i.e., a point estimate) for the decision-making process which differs from USEPA guidance. USEPA's exposure assessment policies include "*....consideration of a range of possible exposure levels ...*" (Reference (39)). In addition, USEPA recommends calculating Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) to inform risk managers of the range of more representative potential risks (References (40), (41), (42), (43)).

Based on previous risk assessment experience, when a range of cancer risk estimates are considered (i.e. an MEI exposure and a Central Tendency Estimate), potential health risks for Central Tendency haven been substantially lower (e.g. an order of magnitude) than an MEI exposure. In simple terms, the MEI potential exposure is for 613,200 hours (24 hours/day x 365 days/year x 70 years) while a Central Tendency Exposure (CTE) is estimated at 4,068 hours (1.5 hours/day x 226 days/year x 12 years). In this case, the CTE exposure factor is 150.7 less than the MEI exposure which means CTE risks would be proportionally lower as well. When risk estimates are lower than the guidelines it is interpreted to mean that adverse effects to human health are unlikely.

## 7.7 Conclusions - Potential Incremental Human Health Risks

The potential health risks were calculated based on the maximum modeled air concentrations at specific receptors assuming mine operations 24 hours/day, 365 days/year except for the Portable Crushing Plant and Overburden Screening operations.

The potential incremental inhalation cancer and noncancer (acute and chronic) risks for a potential individual at the PolyMet Mine Site ownership boundary were below the guideline values of 1E-05 and of 1.0, respectively. Potential total multipathway cancer and noncancer chronic risks (inhalation + indirect pathways) estimated for a future resident and farmer receptor at the Mineral Mining/Industrial District Boundary did not exceed the MDH guideline value of 1E-05.

In summary, taking into account the conservatism in the emission estimates, toxicity values, maximum modeled air concentrations (exposure concentrations), multipathway screening factors, and the assumption that each particulate metal is in the respirable size range and is 100% bioavailable, ~~no~~ adverse human health impacts are not expected to be associated with the potential air emissions from the proposed Mine Site operations evaluated in this AERA.

# 8.0 Uncertainty Analysis

## 8.1 Conservatism in the Quantitative Health Risk Assessment - Uncertainty and Variability

The risk assessment process is subject to uncertainty and variability from a variety of sources. These are inherent in the risk assessment process and are not unique to this AERA. Uncertainties represent incomplete knowledge about certain parameters, and the values of the parameters generally depend upon limited data and model estimations. Variability, on the other hand, represents true heterogeneity and inherent differences within a population, across geographic regions, and throughout a given time period (Reference (44)). Variability is inherent in any group of people.

The main difference between uncertainty and variability is that variability can only be better characterized, but not necessarily reduced.

### 8.1.1 A Summary of Sources and Direction of Uncertainty in Risk Analysis Parameters

The major sources of uncertainty for this AERA are found in Table 8-1 and are discussed in further detail in Attachment E.

**Table 8-1 Summary of Sources and Direction of Uncertainty and Variability in the Parameters used for the Supplemental AERA for the Mine Site**

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| ***Exposure Assessment*** | | | |
| Basis of Chemical Selection | Knowledge of copper-nickel-ore mining processes | May under- or overestimate potential risk | Low |
| | AP-42: Compilation of Air Pollution Factors. Emission factors used to calculate fugitive dust emissions are "A" and "B" rated. The dust emissions along with extensive site-specific composition data were used to calculate metals emissions from fugitive dust. Emission factors for propane combustion and for PAH and metals emissions from diesel fuel combustion are rated lower. However, PAHs were not risk drivers and $NO_2$ from propane combustion and metals from diesel combustion contribute small amounts to the total emissions of these pollutants. | May under- or overestimate potential risk | Low |
| | All chemicals of potential significant impact which have toxicity values for comparison | May under- or overestimate potential risk | Low |
| | Professional judgment and acceptance by reviewing agency | May under- or overestimate potential risk | Low |
| Emissions | Controlled potential emissions used in all standard calculations including AERMOD inputs from emission inventory. | Overestimates potential risk | Moderate |
| | Assumption that all operations occur 24 hours/day for 365 days/year except for the Portable Crushing Plant and Overburden screening activities which were assumed to occur 24 hours/day from April through October. | Overestimates potential risk | Moderate |

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| Emissions | Use of highest projected annual fuel usage for any year for on-site vehicles | Overestimates potential risk | Moderate |
| | Emissions from locomotives were based on total fuel usage and attributed to only the loading (rail transfer hopper) and unloading (at Plant Site) points | Overestimates potential risk | Moderate |
| | Vehicle miles traveled assumed to be on longest haul routes and have annual maximum material handling | Overestimates potential risk | Moderate |
| | Assumption that use of emission factors collected in the 1996-1998 time period for diesel burning engines to estimate potential PAH and dioxin/furan reflect current conditions. Diesel formulations and fuel technology have changed since these data were collected. | Overestimates potential risk | Moderate |
| | Instant Conversion of 80% $NO_X$ emissions to $NO_2$. $NO_2$ is the sole risk-driver chemical for the assessing the acute inhalation risk. | Overestimates potential risk | Moderate |
| | Particulate metals were calculated assuming the worst case composition of all rock types that would be processed at each emission source. | Overestimates potential risk | Moderate |
| | Did not estimate emissions from insignificant activities that occur intermittently for a short period of time like use of diesel powered back-up generator and mobile diesel generator, and diesel fuel tanks | Underestimates potential risk | Low |
| | All sources of emissions were modeled except those that did not emit the pollutants included in the supplemental AERA or sources that were excluded per MPCA Guidance | Likely no effect on estimated risks | Likely no effect on estimated risks |

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| Air Dispersion Modeling | Meteorological data from a single station input to AERMOD. | May under- or overestimate potential risk | Moderate |
| | Comparison to air monitoring data that shows model results are generally within a factor of 2. 40 CFR Part 51 Appendix W states "1) Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and 2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area" (Reference (45)) | Over estimates potential risk | Moderate |
| Exposure point concentrations | Used maximum modeled air concentrations. | Overestimates potential risk | Moderate |
| | Assumed that the worst case meteorological conditions over a five year period are representative of conditions over the exposure duration. | Likely under- or overestimates potential risk | Moderate |
| Exposure parameters | For Inhalation risk, receptors assumed to be outdoors 24 hours per day, 365 days per year for 35 to 70 years in the area of highest modeled air concentration regardless of whether people actually live in that area. | Overestimates potential risk | High |
| Multipathway screening factors | The development of the MPS Factors was not site-specific, and as a result their level of accuracy is unknown. | May under- or overestimate potential risk | Moderate |
| ***Toxicity Assessment*** | | | |
| Acute toxicity values | Extrapolation of data from longer term studies to a one hour equivalent. | May overestimate potential risk | Low |
| | Incorporation of uncertainty factors, modifying factors, safety factors, and exposure frequency and duration into the toxicity values. | May overestimate potential risk | Moderate |

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| Chronic noncancer toxicity values<br>Chronic noncancer toxicity values | Primarily derived from animal studies which often use of the most sensitive species/strain/sex | May overestimate potential risk | Moderate |
| | Use data solely from positive studies | May overestimate potential risk | Moderate |
| | Incorporation of uncertainty factors, modifying factors, and safety factors | May overestimate potential risk | Moderate |
| | Toxicity values are primarily derived from high doses while most exposures are at low doses | May overestimate potential risk | Moderate |
| | Toxicity value for a single chemical may not incorporate all possible endpoints | May underestimate potential risk | Moderate |
| | Assumption that absorption of the chemical evaluated is the same as the absorption of the chemical used in toxicity testing | May under- or over- estimate potential risk | Moderate |
| | Use of surrogate toxicity values to represent chemical mixtures | May under- or over-estimate potential risk | Moderate |

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| Cancer toxicity values | Toxicity values were derived for individual PAHs by extrapolation and are highly uncertain. | Overestimates potential risk | High |
| | Use of nickel unit risk value (from IRIS) which is derived from studies using nickel subsulfide in refinery dust. Nickel cancer potency is very dependent on the solubility and speciation of each nickel compound. The bioaccessibility and bioavailability of the nickel compounds from mine site operations is not known. | Overestimates potential risk | Moderate |
| | Use of provisional toxicity value (PPRTVs) in the RASS for cobalt (a worker exposure value) to assess potential risks. | Overestimates potential risk | Moderate |
| | Use of cancer unit risk/slope factors which are generally upper 95$^{th}$ % confidence limits derived from the linearized model. General assumption of linear non-threshold dose/response | Overestimates potential risk | Moderate |
| | Cancer unit risk/slope factors are primarily derived from animal studies. Use of data from most sensitive species/strain/sex. Use of data solely from positive studies. | May overestimate potential risk | Moderate |
| Multipathway screening assessment | The RASS only evaluates chemicals with inhalation benchmarks for potential ingestion risk (multipathway exposure). Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks and are not evaluated for multipathway exposure (ingestion plus inhalation). | May underestimate potential risk | Low |

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| ***Risk Characterization*** | | | |
| Inhalation Risks | Assumption that all metals exist in a physical form that makes them 100% bioavailable and in a respirable size range. About 97% of the metal emissions for the Mine Site are associated with rock handling operations. This means the metals are much more likely to be inherent to the mineral structure of the rocks and present as compounds- they are not likely present in ionic forms. Therefore, it is very unlikely that 100% of the metals will be in a respirable size range and be bioavailable by inhalation. In terms of multipathway exposure, it is unlikely that 100% of the metals will be bioavailable by ingestion. | Overestimates potential risk | High |
| | Assumed that the chemicals are in the same form as the chemicals upon which the toxicity values are based. | Overestimates potential risk | Moderate |
| | Assumed that all chemicals have an additive effect. | Overestimates potential risk | Moderate |
| | Upper bound values for exposure parameters were used. | Overestimates potential risk | High |
| | Assumed that all noncarcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects. | Likely overestimates potential risk | Moderate |
| | Assumed that all carcinogenic unit risks have the same weight of evidence for human carcinogenicity. | Overestimates potential risk | High |
| | Chemicals without toxicity values could not be directly evaluated. | Underestimates potential risk | Low |
| | Acute risk for sulfuric acid was determined using an RRE based on 2008 modeled concentration and not remodeled. | May under- or overestimate potential risk | Low |

| Risk Analysis Component | Comment | Effect on Risk Estimate[1] | Overall Impact |
|---|---|---|---|
| Inhalation Risks | Risks to especially sensitive receptors (e.g. unborn child, very young children, those whose health is compromised with preexisting conditions) were not specifically evaluated. However, this evaluation relies upon the toxicity value development process that accounts for these sensitive populations. | May underestimate potential risk | Moderate |
| | Synergism/antagonism was not considered | May under- or overestimate potential risk | Unknown |

(1) Key for Effects Determination:

- Overestimates potential risk: A value or assumption intentionally chosen to provide high risk estimates
- Likely overestimates potential risk: A value or assumption intentionally chosen that is expected to provide high risk estimates
- May overestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a high risk estimate
- Underestimates potential risk: A gap in information or an available value that is known to provide a low risk estimate
- Likely underestimates potential risk: A gap in information or an available value that may provide a low risk estimate
- May underestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a low risk estimate.
- Likely no effect on estimated risk: Value or assumption that is known or suspected to have very little, if any, effect on potential risk

**Table 8-2 Summary of Sources of Variability in the Parameters used for the Supplemental Air Emissions Risk Analysis (AERA) for the Proposed NorthMet Mine Site near Babbitt, Minnesota**

| Source of Variability | Comments | Impact of Risk Analysis |
|---|---|---|
| Daily, seasonal, and yearly meteorological conditions | An agency-approved meteorological dataset for a 5-year time period is used in the air dispersion modeling. Controlled Potential emission rates and worst case meteorological conditions are used to determine the maximum modeled air concentration. The maximum modeled air concentration for the respective 1-hour and annual averaging time period is used to assess the respective potential risks. | Likely none |
| Actual Mine Site activities on a day-to-day basis that may alter emissions. | Potential emission calculations tend to overestimate emissions, especially over longer time periods, because the mine does not operate at maximum capacity 100% of the time; Potential maximum hourly and maximum annual emissions modeled for the AERA and a receptor is assumed to be exposed to the modeled air concentration for the entire exposure time period. | Likely none or small |
| Differences in receptor susceptibility to actual chemical exposure and actual exposure durations. | Toxicity values are developed to be conservative and protective of sensitive populations. Actual exposures are typically lower than the potential exposures evaluated in a risk analysis and that is why risk results from this AERA, or any risk assessment, cannot be used as an indicator of actual risk to any receptor. | Likely none or small |

## 9.0 Qualitative Screening Analysis for Specific AERA Topics

### 9.1 Land Use and Receptors Information

Land use within 10 kilometers (approximately six miles) of the Mine Site is rural and predominantly mine lands or natural forest/wetlands. The nearest resident is located about five or six miles from the Mine Site.

See Section 3.0 for the general facility and site descriptions.

### 9.2 Sensitive Receptors

The proposed Mine Site is to be located within the Mineral Mining District of Babbitt (Large Figure 2). Potentially sensitive receptors within three kilometers of the proposed facility include off-site forestry workers, offsite workers at the Peter Mitchell Mine to the north and on the railroad to the south. Workers at the Peter Mitchell Mine or forest industry workers on adjacent lands could be present for the length of their shift during the work week, over the course of a year. Potential cancer and noncancer (acute and chronic) inhalation risks may be applicable to these off-site workers. Based on the cancer and noncancer inhalation risks calculated at the PolyMet Mine Site property ownership boundary (Table 7-1 and Table 7-2), adverse inhalation impacts to these off-site workers are not expected to occur. Due to the mineral mining/industrial zoning, potential workers cannot live at the Mine Site property ownership boundary (i.e. Mine Site ambient air boundary) and therefore they are not expected to be exposed to Mine Site air emissions by indirect pathways (i.e., home-grown food consumption). Therefore, indirect pathway risks (cancer and noncancer) would not apply to these potential off-site workers.

There is also the potential for individuals to engage in recreational activities (snowmobiling, hunting, etc.) within 10 kilometers (approximately six miles) of the proposed facility. Potential individuals engaging in recreational activities would not be expected to be present within the 10 km zone for any length of time (less than one day and likely for no more than a few hours). Therefore, chronic risks likely would not apply. Based on the acute inhalation risks calculated at the PolyMet Mine Site property ownership boundary (HI ~ 0.7 for year 8 and ~ 0.8 for year 13) (Table 7-1 and Table 7-2), no potential adverse impacts to these potential individuals are expected.

Other potentially sensitive receptors, such as day cares/preschools, schools, civic and government centers, hospitals, retirement homes/communities, etc., are not present within three kilometers of the proposed Mine Site.

### 9.3 Multipathway Receptors

Another type of "sensitive receptor" is the population surrounding a facility that could be exposed to the PBT pollutants emitted to air from a facility via the food pathway. The Mine Site operations are estimated to release only very small amounts of PBT chemicals; however MPCA AERA guidance indicates that PBTs may need some consideration beyond the indirect risks

calculated in the RASS. Site information indicates that some agricultural lands are present within 10 kilometers of the facility, although agriculture is not a predominant land use. Water bodies (lakes, rivers) are also present within 10 kilometers of the Mine Site (Embarrass River, Partridge River, Mud Lake, Iron Lake, Argo Lake, Butterfly Lake). Therefore, multipathway receptors were evaluated for potential risks.

The RASS evaluated two generic receptors: (1) a farmer who only consumes homegrown vegetables, meat (beef, pork, and poultry) and dairy products, and (2) a nearby resident who consumes vegetables grown in his/her garden. Further discussion on potential risks to a generic farmer and a generic resident is provided in the next section. The multipathway exposure assessment also includes incidental ingestion of soil as a potential source of exposure.

### 9.3.1 Farmers and Residents

A review of zoning and land use within 10 kilometers (approximately six miles) of the proposed Mine Site identified small areas of agricultural lands (Large Figure 6): small farms approximately 6.5 kilometers to the northwest of the proposed facility. This is also the closest area to the Mine Site with land identified as "agricultural."

The nearest current residents to the proposed mine location are as follows:

- approximately six miles north of the proposed mine location in the city of Babbitt
- approximately five miles south of the proposed mine location toward the unincorporated village of Skibo
- Chemicals assessed for multipathway risks include selected particulate metals, PAHs, and dioxins/furans. The estimated total multipathway risks (Table 7-1 and Table 7-2), assuming the farmer receptor and resident receptor are immediately adjacent to the Mineral Mining/Industrial District Boundary, are as follows: cancer = 1E-05 for the farmer receptor, 8E-07 for the resident; Noncancer chronic risks are 0.04 for both the farmer and resident. These risk estimates are all within incremental risk guideline values of 1E-05 for cancer and 1.0 for noncancer. These risk results indicate that no adverse health effects to potential farmer or resident receptors would be expected to be associated with potential air emissions from Mine Site operations.

### 9.3.2 Fishers

Water bodies are located within 10 kilometers of the proposed facility (Embarrass River, Partridge River, Mud Lake, Iron Lake, Argo Lake, Butterfly Lake). The MPCA's RASS does not assess chemical deposition to water bodies or accumulation in fish or humans consuming the fish because of the very large variability in the surrounding water bodies. The variations in watershed size, water body turnover rate, flow rate, etc. make it difficult to describe an appropriate assessment at this time (Reference (14)).

Overall, emission estimates for PBTs (e.g., arsenic, PAHs, dioxin/furans and mercury) from the Mine Site are low. For example, potential mercury emissions from Mine Site operations are estimated to be 0.7 pounds per year, while potential dioxin/furan emissions are estimated to be approximately 0.00003 pounds per year (~ 0.01 grams per year). Small emissions, combined with the expectation that only a very small percentage of the emissions would deposit locally near the facility, indicates that the potential deposition to surface waters (lakes and rivers) of PBTs resulting from mine site operations is likely not significant.

For mercury, a screening-level analysis of potential mercury deposition to nearby lakes from estimated air emissions from the NorthMet Plant Site (~ 5 pounds/year) and the nearby Mesabi Nugget Large Scale Demonstration Plant (~ 75 pounds/year) has been conducted (Reference (46)) and the potential incremental change in fish mercury concentration is estimated to be small and not likely measurable. Potential emissions of mercury from the Mine Site of about 0.7 pounds per year would have a smaller effect than that estimated for Plant Site emissions.

## 9.4 Chemicals and Emissions

The discussions under this section of the AERA are to provide the reader with additional qualitative information and perspective on chemicals and emissions associated with the Mine Site.

### 9.4.1 Mixtures and Surrogate Toxicity Values

In terms of risk driver chemicals, the following chemical was used as a surrogate for CFEs in the Supplemental 2012 Mine Site AERA:

- Nickel subsulfide was used as a surrogate for all nickel compounds

Calculating risks using surrogate toxicity values to represent chemical mixtures introduces a high level of uncertainty to the risk estimates. At best, surrogate toxicity values they can be used as a screening tool in risk evaluation. The MPCA guidance (Reference (14)) states that:

> With a goal of not under-predicting risk, all available toxicity values for chemicals in a given mixture are considered, and a chemical is selected because its toxicity relative to the other chemicals in the mixture is greater. There may, however, be instances in which the mixture contains chemicals with higher toxicity than the surrogate, in which case the potential exists for risks from the mixture to be under-predicted.

In this AERA, the use of surrogate toxicity values is assumed to provide a conservative estimate of potential inhalation risks because arsenic, manganese, and nickel at this site likely exist in a different form that that on which the toxicity value is based.

### 9.4.2 Sensitizers

Respiratory sensitizers are of particular concern and can cause severe adverse reactions sometimes at very small concentrations for persons who have been previously sensitized to the

chemical. Chemicals potentially emitted from the Mine Site that are identified as sensitizer chemicals include: beryllium, cobalt, nickel compounds. Of these, only cobalt and nickel have been identified as potential risk-drivers and are included in this AERA analysis. Beryllium emissions decreased more than 60% compared to those evaluated in the January 2008.

A reference toxicity concentration (RfCs, HRVs, RELs, or PPRTVs) is generally considered by the USEPA to be protective against asthma and other potential effects for non-sensitized individuals (Reference (47)). Often, the supporting toxicity data used for derivation of a reference toxicity concentration will state if the value was derived to be protective for respiratory sensitization. The annual chronic noncancer toxicity values for the chemical sensitizers in the RASS are from the following sources:

- beryllium: RfC from USEPA Integrated Risk Information System (IRIS)
- cobalt: PPRTV from USEPA Superfund Health Risk Technical Support Center
- nickel compounds: REL from California EPA Office of Environmental Health Hazard Assessment for the Hot Spots program

Additionally, MDH assesses chemical toxicity in order to develop HRVs which become part of Minnesota Rules. HRVs are derived to be protective of the "...most sensitive portion of the population" (Reference (48)). MDH goes on to acknowledge the following:

> However, HRVs may not be protective of every individual. Certain people are hypersensitized by exposures to high concentrations of particular chemicals during occupational chemical use or in other situations. Because ranges of exposures that result in such hypersensitivities are highly variable and poorly studied, MDH is unable to derive HRVs that would be protective of all sensitized individuals. Chemicals that are known to cause sensitization are noted in the chemical lists found in rule parts 4717.8100 - 4717.8250 (Reference (48)).

None of the chemicals noted as respiratory sensitizers in this Mine Site AERA are those for which MDH has noted in Minnesota Rules, parts 4717.8100-4717-8250 as being able to cause respiratory sensitization from environmental exposures (Reference (49)). According to the USEPA IRIS database, the RfC for beryllium was established to protect for potential respiratory sensitization. Although the documentation for derivation of the cobalt PPRTV states that the PPRTV may not be protective of those with a hypersensitivity to cobalt (Reference (36), MDH does not consider it a chemical known to cause sensitization. The chronic REL for nickel was established to be protective of the respiratory system and the blood forming system. Again, nickel is not considered a chemical considered by MDH as known to cause respiratory sensitization. Based on this information, the potential for emissions from the Mine Site to cause respiratory sensitization to the general public is considered unlikely.

### 9.4.3 Developmental Toxicants/Chemicals with Ceiling Values

Exposure to developmental/reproductive toxicants can have long lasting effects. Pregnant women are a sensitive subgroup who must be given special consideration in a risk analysis. Chemicals that are developmental toxicants may directly harm an unborn child. Those chemicals for which sufficient scientific evidence was available to develop an IHB for developmental effects have been noted in the RiskCalcs worksheet of the MPCA's RASS.

Of special importance are chemicals with HRVs and California RELs that are known to be developmental toxicants. Acute HRVs with developmental endpoints have been identified in the RASS as chemicals with "ceiling values" that should not be exceeded. The potential acute exposure, that is the resulting maximum estimated hourly concentration from a facility, is compared to the ceiling value to determine whether the ceiling value has been exceeded. Like chronic chemicals and other exposure scenarios, ceiling value chemicals with ratios of less than 0.1 of the acute threshold can be excluded from further analysis. Ceiling values do not apply to surrogate values.

Developmental toxicants potentially emitted from the Mine Site include: arsenic, benzene, and mercury. Benzene was not risk driver chemical in the 2008 AERA and arsenic is not a risk driver in this Supplemental AERA. Mercury health impacts are discussed in the cumulative mercury analysis report submitted January 2012. Benzene emissions decreased by almost 80% compared to those evaluated in the January 2008 AERA. Risk results from the MPCA's RASS indicate that no ceiling values were exceeded for the Year 8 emission scenario or the Year 13 emission scenario (see Section 5.3.1 for Years 8 and 13 rationale). Therefore, potential impacts to the general public from exposure to developmental toxicants associated with Mine Site air emissions are not expected.

### 9.4.4 Criteria Pollutants

Modeling at the Mine Site for particulate matter less than 10 microns in size ($PM_{10}$) and less than 2.5 microns in size ($PM_{2.5}$), sulfur dioxide ($SO_2$), and nitrogen oxides ($NO_x$) has been completed. Carbon monoxide (CO) was not modeled because it estimated emissions are relatively small and exceedances of the ambient air quality standards are not expected.

Criteria pollutant modeling results are shown in Large Table 5 and all modeling results indicate compliance with ambient air quality standards. The $PM_{10}$ and $PM_{2.5}$, the modeling results include PolyMet Mine Site sources plus background concentrations. Modeled $SO_2$ and $NO_x$ concentrations from only PolyMet Mine Site sources (shown in Large Table 5) were well below the Class II area significant impact levels (SILs) for all time periods (1-hour, 3-hour, 24-hour, annual). Based on the modeled air concentrations from the Project being below the respective SILs, the Project is expected to comply with ambient air quality standards. The ratios of the modeled air concentrations to ambient air quality standards for the criteria pollutants are not comparable to the estimated human health risks, as the HQs discussed in Section 7.0 are based on a dose-response relationship. Therefore the ratios in Large Table 5 cannot be added to the summed risks presented in Section 7.0.

### 9.4.5 Fine Particulate ($PM_{2.5}$)

Fine particulate emissions were estimated for the NorthMet Mine Site and modeled for compliance with the $PM_{2.5}$ ambient air quality standards (Large Table 5).

Modeled air concentrations were below the respective most restrictive standard of 35 $\mu g/m^3$ for the 24-hour averaging period and 12 $\mu g/m^3$ for the annual averaging period.

A specific risk estimate for $PM_{2.5}$ direct emissions has not been calculated. Modeled compliance with the ambient air quality standards indicates that adverse health impacts are not expected to be associated with the Mine Site $PM_{2.5}$ emissions. However, the modeled air concentrations compared to the respective NAAQS (Large Table 5) are not an indicator of potential additive effects because the NAAQS are developed differently from the RfCs used in the quantitative risk estimate. The particulate emissions have been speciated to the individual metals but it is unknown whether the potential additional impacts, if any, from inhalation of $PM_{2.5}$ would be additive to, or possibly double counting of, potential health effects.

Secondary formation of $PM_{2.5}$ potentially associated with the facility's $SO_2$ and $NO_X$ emissions that may be transformed into sulfate and nitrate aerosol (typically as ammonium sulfate or ammonium nitrate) by atmospheric processes was addressed in this evaluation with the use of offset ratios. Secondary fine particle pollution is recognized as being a long-range transport issue (Reference (50)). For $SO_2$ conversion to sulfate aerosol, the conversion typically occurs over several days and during that time the emissions from a facility may have moved several hundred miles. Research is ongoing with regard to the conversion of $NO/NO_2$ to nitrate aerosol. Due to this long range transport of fine particles associated with $SO_2$ and $NO_x$ emissions, the extent the secondary formation of sulfate and nitrate aerosol affect air concentrations near an emission source is uncertain. The NorthMet Mine Site is dominated by fugitive sources with very few sources of combustion emissions that would generate the $NO_x$ and $SO_2$ associated with secondary particulate formation.

## 9.5 Regulatory Requirements

### 9.5.1 State and Federal Control Requirements

PolyMet is proposing to obtain a Title V air permit for the Plant Site and Mine Site. The proposed facility will be a major Title V source, but not a major source under Prevention of Significant Deterioration (PSD) air permitting. The permit application will propose emission limitations based on air dispersion modeling inputs and the objective of being a minor source for PSD purposes. The permit application will also provide details on the applicability of state and federal requirements including New Source Performance Standards, Part 61 and Part 63 National Emission Standards for Hazardous Air Pollutants (NESHAPS), and Minnesota Standards for Performance for Stationary Sources.

### 9.5.2 Air Permitting

Limitations will be proposed in the air emissions permit application to keep emissions below the PSD major source level. Therefore the Project is not subject to PSD review. However, the following analyses have been, or will be, conducted to support preparation of the SDEIS:

- control technology review (completed and approved)
- a Class II area air quality analysis, including modeled compliance with the applicable NAAQS for $SO_2$, $NO_x$, $PM_{10}$ and $PM_{2.5}$ (Mine Site: completed and approved; Plant Site version 1 completed and reviewed, version 2 underway)
- an air quality analysis of Class I area impacts as agreed upon with the Federal Land Managers (FLMs) has been completed. Details of the analysis are available in a separate report. (completed and approved)

### 9.5.3 Emergency Generators

The MPCA requests that a project proposer inventory and characterize emergency generators and fire pumps at the facility separately from the inventory of emission sources included in the risk estimate.

NorthMet will have one emergency diesel generator for the Mine Site operations. This generator is expected to be operated sparingly and only in emergency situations and will not be used for peak shaving or used in other way that would be inconsistent with the classification as an emergency generator. Testing of the generator will occur periodically to make sure it is in good operating condition. Due to the infrequent operations and the relatively short operating times when in use, potential emissions from the generator is expected to be small and they were not included in the risk analysis. Potential emissions from this emergency generator are not expected to significantly affect the quantitative risk estimates.

NorthMet will not have any emergency diesel fire pumps for the Mine Site operations.

### 9.5.4 Accidental Releases

Minnesota's Notification of Deviations, Shutdowns and Breakdowns rule (Minnesota Rules, part 7019.1000) requires the owner or operator of an emission facility to notify the MPCA of shutdowns or breakdowns that cause any increase in emissions. The MPCA maintains a log of these notifications. In addition, the permit to be issued for the Project may require the facility to maintain records of start-up, shutdown, breakdown or malfunctions of operating units and/or control equipment. The MPCA will generate a report from the Incident Management System that logs shutdown and breakdown reports for the previous five years.

## 10.0 Cumulative Inhalation Risk Assessment

A cumulative human health inhalation risk assessment for the Project will be presented as part of the Supplemental AERA for the Plant Site. The cumulative human health risk assessment will include the sum of risk estimates from the Mine Site + Plant Site + Laskin Energy Station + Mesabi Nugget + background risks as identified in the November 2011 Work Plan (Reference (3)).

## 11.0 Summary

Following the MPCA-accepted Work Plan for the Supplemental AERA, potential inhalation risks for an off-site worker at the Mine Site property ownership boundary (i.e., Mine Site ambient air boundary) and multipathway risk (inhalation + ingestion) for a farmer and a resident receptor at the associated Mineral Mining/Industrial Zoning Boundary were estimated for two emission scenarios. The highest estimated risks for either scenario are summarized below.

- inhalation risks – potential off-site worker at the Mine Site property ownership boundary
    - The estimated potential maximum acute (1-hour) inhalation risk, summed for all chemicals regardless of toxic endpoint is 0.8 and does not exceed the guideline value of 1.0. The risk driver pollutant is $NO_x$ (evaluated as $NO_2$) for which the USEPA factor of 80% is applied for the conversion of NO to $NO_2$ and provides a conservative overestimate for potential $NO_2$ air concentrations.
    - the estimated maximum chronic inhalation risks (cancer = 5E-06 and noncancer = 0.2), summed for all chemicals regardless of toxic endpoint, do not exceed the respective guideline values of 1E-05 and 1.0
- multipathway risks – Mineral Mining/Industrial District Boundary.
    - for a potential resident, estimated potential cancer (8E-07) and noncancer chronic risks (0.04) are below the incremental risk guideline values of 1E-05 for cancer and 1.0 for noncancer chronic
    - for a potential farmer, estimated potential cancer risks (1E-05) and noncancer chronic risks (0.04) do not exceed the incremental guideline values of 1E-05 and 1.0, respectively.
- Additionally, the estimated potential inhalation and multipathway risks for this Supplemental AERA are similar to those estimated in the 2008 Mine Site AERA.

Conclusion: The MPCA AERA methodology ensures that a conservative approach is used to assess potential health risks and protect public health (including sensitive populations) with a suitable margin of safety. When potential health risks are assessed to be at or below acceptable guidelines using this methodology, adverse health effects, even in sensitive populations, are not expected. When the estimated risks are compared to guideline values, and accounting for conservatism in the risk analysis methodology, adverse impacts to human health are not expected to be associated with the potential air emissions from the proposed Mine Site operations.

## 12.0 Certification

PolyMet hereby provides the following certification for the Mine Site Air Emissions Risk Analysis:

"I hereby certify under penalty of law that the enclosed documents and all attachments were prepared under my direction in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or the person directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true and accurate and complete."

_____

{responsible official}
Poly Met Mining, Inc.

## Glossary of Terms Used in Air Emissions Risk Analysis

| Term | Definition |
|---|---|
| Acute exposure | Single or multiple exposure occurring within a short time (24 hours or less). For purpose of the AERA, acute exposure is a single event with a duration of one-hour |
| Acute toxicity | Adverse health effects that occur or develop rapidly after a single administration of a chemical |
| Additivity | Refers to a situation where the combined effect of exposure to two or more chemicals is equal to the sum of the effect of each of those chemicals given alone (e.g.10 + 10 = 20). |
| Algorithm | Systematic method for solving a problem. Usually refers to multiple step methods for performing complex mathematical calculations. |
| Antagonistic | Description of two or more chemicals which when given together interfere with each other's actions. |
| Bioaccessible | A value representing the availability of a metal for absorption when dissolved in in vitro surrogates of body fluids or juices. |
| Bioavailable | The fraction of a dose that becomes available for distribution to internal target tissues and organs. |
| Bioconcentration Factor (BCF) | The ratio of a contaminant concentration in biota to its concentration in the surrounding medium (e.g., water). |
| Biokinetic | Refers to the modeling and mathematical description of a chemicals distribution over time in a whole organism. |
| Carcinogen | A chemical that may be capable of causing cancer in mammals. For purposes of this risk assessment a carcinogen is a chemical that is defined by the USEPA as a carcinogen. |
| Central Tendency Exposure | A measure of the middle or the center of an exposure distribution. The mean is the most commonly used measure of central tendency (EPA Exposure Factors Handbook, Glossary) |
| Chemicals for Evaluation (CFE) | Chemicals which may be emitted to air as a result of this facility's operations and that have toxicity values in the MPCA RASS and have data available to estimate potential emissions |
| Chemicals for Potential Evaluation (CFPE) | Chemicals that may be emitted to air as a result of a facility's operations |
| Chronic exposure | Prolonged or repeated exposure typically occurring over a period of several years. The assumed exposure periods used in this AERA vary between exposure scenarios. |
| Chronic toxicity | Adverse health effects that occur after a lapse of time between the initial exposure, or effects that persist over a long period of time whether or not they occurred immediately or are delayed. |
| Class I area | Federally mandatory Class I areas are wilderness areas and national parks. |

| Term | Definition |
|---|---|
| Class II area | In Minnesota, Class II areas are all areas that are not designated as Class I areas. |
| Dose-response curve | Graphical representation of the relationship between chemical dose and response of the population to that dose (incidence of adverse effect). |
| Dosimetric | Corrections for differences in body weight, surface area and metabolic rate applied to dosage. |
| Epidemiological | Refers to the study of disease and its spread in people. |
| Genotoxic | Substance that can cause damage to cellular DNA. |
| Hazard Index (HI) | The sum of HQs for non-carcinogenic chemicals with similar modes of action and toxic endpoints. A HI of one or more indicates that there is a potential for adverse health effects. |
| Hazard Quotient (HQ) | The calculated or measured exposure to a given chemical divided by the RfC for that chemical. An HQ of one or greater indicates that there is a potential for adverse health effects. |
| Health Risk Value (HRV) or Inhalation Risk Value | A Health Risk Value is the concentration of a chemical (or defined mixture of chemicals) defined by the Minnesota Department of Health (MDH) that is likely to pose little or no risk to human health. For carcinogens, MDH defines significant risk as a risk of 1 in 100,000. For noncarcinogens, MDH defines significant risk as a Hazard Index greater than 1 (for an individual chemical) or a Hazard Quotient greater than 1 (for a mixture of chemicals. |
| MAAQS | Minnesota Ambient Air Quality Standards. |
| Maximum Exposed Individual (MEI) | An exposure concept is based upon the following assumptions: continuous lifetime exposure (365 days per year for 70 years), individual is outside 24-hours per day, individual is at the point of maximum estimated air concentration. The MEI represents the maximum or near maximum for potential risk from exposure to plant airborne emissions. |
| Modified Central Tendency Exposure (MCTE) | An exposure concept in which mean, or median exposure frequency and duration data are used in the calculation of risk. In this risk assessment upper value airborne concentrations were used in the MCTE concept. The resultant risk estimate would correspond to a $50^{th}$ – 85th percentile range for chronic and sub-chronic exposure. |
| Multimedia factors | A term used in previous versions of MPCA AERA Guidance. See Multipathway Screening Factors for a current definition. |
| Multipathway Screening Factors (MPSFs) | As defined by the Minnesota Pollution Control Agency (MPCA), based on individual chemical information in the Industrial Risk Assessment Program (IRAP), it is the ratio of a chemical's total multipathway risk/a chemical's inhalation risk. |
| Non-carcinogen | For the purposes of this risk assessment, a non-carcinogen is a chemical, which is not included on the USEPA list of carcinogens. |

| Term | Definition |
|---|---|
| Particulate Matter | Small discrete masses of solid or liquid materials. Particles are often defined as having aerodynamic diameters (incorporates considerations of shape and density of the particle) from 0.001 to 100 microns (one micron equals one-millionth of a meter). |
| Persistent, bioaccumulative, toxic (PBT) chemicals | In terms of PBT chemicals are defined by the MPCA AERA-RASS. The MPCA AERA-RASS uses the "EPA PBT Profiler" to determine if a chemical is persistent and bioaccumulative. If the half-life in water, soil, and sediment is 60 days or more a substance is considered persistent, and if the half-life is more than 180 days, it is considered very persistent. If the BCF is 1000 or more, a substance is considered bioaccumulative, and if the BCF is 5000 or more, it is considered very bioaccumulative. The MPCA considers a chemical persistent and bioaccumulative and carried the chemical through for further analyses if the percent partitioning to water was greater than 10%, the half- life in water was greater than 60 days, and the bioconcentration factor was greater than or equal to 1000. or the percent partitioning to soil was greater than 10%, the half-life in soil was greater than 60 days, and the BCF was greater than or equal to 1000; or the percent partitioning to sediment was greater than 10%, the half-life in sediment was greater than 60 days, and the BCF was greater than or equal to 1000. EPA has classified some metals as PBTs under the Community Right to Know Act.11 A more comprehensive list of metals with potential PBT characteristics was adopted by the European Union. Seven metals from the initial list of 315 substances were also included in the EU list were carried forward in subsequent analyses in the RASS. |
| PM2.5 | Particulate matter with an aerodynamic diameter of 2.5 micrometers or less. |
| PM10 | Particulate matter with an aerodynamic diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of human hair). |
| Reasonable Maximum Exposure (RME) | The exposure concept representing the highest exposure that is reasonably expected at the site. RME refers to people who are at the high end of the exposure distribution (approximately the 90$^{th}$ percentile). The RME scenario is intended to assess exposures that are higher than average, but are still within a realistic range of exposure (http://www.epa.gov/risk/exposure.htm). |
| Receptor | For purposes of this risk assessment, a receptor is an individual living or working (outside of the facilities property boundary) who may be exposed to emissions from the facility. |
| Reference concentration (RfC) | An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse noncancer effects during a lifetime. |
| Reference Dose (RfD) | An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous ingestion exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse noncancer effects during a lifetime. |

| Term | Definition |
|---|---|
| Reference Exposure Level (REL) | RELs are derived for the California Hot Spots program (by the Office of Environmental Health Hazard Assessment-OEHHA) in a manner similar to U.S. EPA values and have undergone internal and external review. An REL represents an airborne concentration of a chemical at or below which no adverse effects are anticipated in individuals exposed to that level. RELs can apply to exposures for 1 hour, 8 hours, or up to a lifetime. http://oehha.ca.gov/air/allrels.html |
| Respirable | Particles that can be inhaled and deposited into the lungs and alveoli. Respirable particles are typically defined as having aerodynamic diameters of 10 microns or less. |
| Risk Driver | For non-carcinogens, this means a chemical with a Hazard Quotient greater than 0.1. For carcinogens, this means a chemical with an estimated risk greater than 1 in 1,000,000 (> 1E-06). |
| Semi-volatile organic compound (SVOC) | Organic compounds which may be present in both vapor and particulate phase within the atmosphere. These compounds tend to evaporate very slowly at normal temperatures and can be very persistent in the environment. SVOCs have vapor pressures ranging from $10^{-1}$ to $10^{-7}$ mmHg and boiling points that range from 120 to 300°C. |
| Sensitive receptor | In general, a sensitive receptor refers to a person or group of people that may be more sensitive to chemical exposure. Examples include pregnant women, children, the elderly, or those who are immuno-compromised. |
| Settling velocity | The velocity at which a particle in still air at normal temperature and pressure will fall through the atmosphere. Settling velocity depends upon the particles size, shape and density. Heavy (dense) particles have higher settling velocities than light particles. |
| Significant impact levels (SILs) | Screening levels for incremental ambient air concentrations. Projects with incremental ambient air concentrations below the SIL for a given pollutant are not necessarily required to complete NAAQS modeling for that pollutant. |
| Slope factor | Used to define the potency of a carcinogen at low dose levels. The slope of the dose-response curve in the low-dose region. When low-dose linearity cannot be assumed, the slope factor is the slope of the straight line from 0 dose to the dose at 1% excess risk. (double check this) |
| Synergistic | The combined effect of two or more chemicals given together is greater than the sum of the effects of those chemicals. |
| Toxicity | Measure or degree of adverse effect of a given chemical on a living organism. In the case of this risk assessment – humans. |
| Toxicity Equivalent (TEQ) | Toxicity Equivalents (TEQ) for dioxin and furan congeners is the toxicity weighted masses of mixtures of dioxins/furans. In practical terms, it is the summed concentration of dioxin/furan congeners expressed in terms of the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin. |
| Toxicity factor | Can refer to a toxicity value used to calculate a risk estimate (e.g.,. slope factor, unit risk, RfC, RfD, etc.) |

| Term | Definition |
|---|---|
| Unit risk (UR) | The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 μg/L in water, or 1 $\mu g/m^3$ in air. |
| Volatile organic compound (VOC) | Organic compounds that evaporates easily and are usually found as a vapor in the air. VOCs have vapor pressures greater than $10^{-1}$ and boiling points less than 120°C. |
| Weight-of-evidence | Procedure for evaluating the toxicity, and in particular the carcinogenicity of a chemical using evidence from human (epidemiological) studies, and animal studies. Studies are weighted based upon their relevance to human exposure, and assessed quality of the study. Well-designed studies are given greater weight in the consideration of toxicity than poorly designed studies. Similarly human studies are given greater weight than animal studies. |

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**Revision History**

| Date | Version | Description |
| --- | --- | --- |
| 10/25/2012 | 1 | Initial release |
| 01/23/2013 | 2 | Report revised to address comments received on Version 1. |
| 02/21/2013 | 3 | Report revised to address comments received on Version 2. |

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**Large Table 1 Exposure Parameters for the PolyMet Mine Site for Noncancer Effects**

| Exposure Information | | | Exposure Concentration Adjustments (note: if exposure is not adjusted the underlying assumptions in deriving the toxicity values and/or multipathway screening factors (MPSFs) continue to apply) | | | | MPCA- RASS Toxicity value or Multipathway screening factor (MPSF) assumptions | Classification of assessed risk |
|---|---|---|---|---|---|---|---|---|
| **Exposure Route** | **Exposure Conc. µg/m3** | **Receptor Location** | **Exp. Time (hours/day)** | **Exp. Freq. (days/year)** | **Exp. Duration (years)** | **Averaging time (years= exposure duration for non-carcinogens)** | **Assumptions and/or adjustments** | **Maximum Exposed Individual (MEI) or Reasonable Maximum Exposure (RME)** |
| Inhalation only - 1 hour | Maximum modeled 1- hour concentration | Individual at the Mine-Site Property Boundary | NA | NA | NA | NA | Toxicity values assume one hour of exposure | Maximum exposed individual (MEI) |
| Chronic inhalation | Maximum modeled annual concentration | Individual at the Mine-Site Property Boundary | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years) | Maximum exposed individual (MEI) |
| Inhalation-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside the Mineral-Mining/Industrial district boundary | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years)<br>MPSFs do not apply to inhalation risk | Maximum exposed individual (MEI) |
| Ingestion-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside the Mineral-Mining/Industrial district boundary | None-see MPSF value assumptions | None-see MPSF value assumptions | None-see MPSF value assumptions | None-see MPSF value assumptions | MPSFs assume exposure duration equals averaging time (i.e. they cancel out in the calculations) | Maximum exposed individual (MEI) |

NA=not applicable- maximum modeled air concentrations are not adjusted for acute exposures.

**Large Table 2 Exposure Parameters for the PolyMet Mine Site for Cancer Effects**

| Exposure Information | | | Exposure Concentration Adjustments (note: if exposure is not adjusted the underlying assumptions in deriving the toxicity values and/or multipathway screening factors (MPSFs) continue to apply) | | | | MPCA- RASS Toxicity value or Multipathway screening factor assumptions | Classification of assessed risk |
|---|---|---|---|---|---|---|---|---|
| **Exposure Route** | **Exposure Conc. µg/m3** | **Receptor** | **Exposure Time (hours/day)** | **Exposure Frequency (days/year)** | **Exposure Duration (years)** | **Averaging time (always 70 years for carcinogens)** | **Other adjustments** | **Maximum Exposed Individual (MEI) or Reasonable Maximum Exposure (RME)** |
| Chronic inhalation | Maximum modeled annual concentration | Individual at the Mine-Site Property Boundary | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumptions | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years) | Maximum exposed individual (MEI) |
| Inhalation-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside of Mineral-Mining/Industrial boundary | None-see toxicity value assumptions | None-see toxicity value assumptions | None-see toxicity value assumption | None-see toxicity value assumptions | Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years)<br>MPSFs do not apply to inhalation risk | Maximum exposed individual (MEI) |
| Ingestion-for multipathway calculation | Maximum modeled annual concentration | Resident and farmer just outside of Mineral-Mining/Industrial boundary | None-see MPSF assumptions | None-see MPSF assumptions | None-see MPSF assumptions | None-see MPSF assumptions | The MPCA adjusts MPSFs in the RASS for exposure duration and averaging time<br>-Exposure duration is 30 years for a resident and 40 years for a farmer<br>-averaging time is 70 years | Reasonable maximum exposure (RME) |

**Large Table 3 Comparison of 2008 and 2012 Estimated Hourly Emissions of Chemicals for Potential Evaluation (CFPE) in the Supplemental Air Emissions Risk Analysis Conducted for the Proposed Mine Site**

| CFPE | 2008 Emissions year 8, lb/hr | 2012 Emissions year 8, lb/hr | % change year 8 | 2008 Emissions year 16, lb/hr | 2012 Emissions year 13, lb/hr | % change year 13/16 |
|---|---|---|---|---|---|---|
| Acenaphthene | 0.0003 | 0.0003 | 19.4% | 0.0003 | 0.0003 | 19.4% |
| Acenaphthylene | 0.0008 | 0.0006 | -21.4% | 0.0008 | 0.0006 | -21.4% |
| Acetaldehyde | 0.0156 | 0.0003 | -97.9% | 0.0156 | 0.0003 | -97.9% |
| Acrolein | 0.0023 | 0.0001 | -95.7% | 0.0023 | 0.0001 | -95.7% |
| Anthracene | 0.0002 | 0.0001 | -42.9% | 0.0002 | 0.0001 | -42.9% |
| Antimony | 0.0040 | 0.0024 | -40.2% | 0.0040 | 0.0026 | -33.7% |
| Arsenic | 0.0060 | 0.0102 | 70.3% | 0.0060 | 0.0114 | 90.0% |
| Barium | 0.0726 | 0.2109 | 190.7% | 0.0726 | 0.2389 | 229.3% |
| Benzene | 0.0479 | 0.0100 | -79.1% | 0.0479 | 0.0100 | -79.1% |
| Benzo(a)anthracene | 0.0001 | 0.0000 | -27.6% | 0.0001 | 0.0000 | -27.6% |
| Benzo(a)pyrene | 1.6E-05 | 0.0000 | 10.5% | 1.6E-05 | 0.0000 | 10.5% |
| Benzo(e)pyrene | 3.3E-06 | 0.0000 | -100.0% | 3.3E-06 | 0.0000 | -100.0% |
| Benzo(b)fluoranthene | 0.0001 | 0.0001 | 30.6% | 0.0001 | 0.0001 | 30.6% |
| Benzo(g,h,i)perylene | 3.5E-05 | 0.0000 | 13.4% | 3.5E-05 | 0.0000 | 13.4% |
| Benzo(k)fluoranthene | 1.5E-05 | 0.0000 | 0.4% | 1.5E-05 | 0.0000 | 0.4% |
| Beryllium | 0.0009 | 0.0003 | -65.2% | 0.0009 | 0.0003 | -61.5% |
| Boron | 0.0857 | 0.0051 | -94.1% | 0.0857 | 0.0057 | -93.4% |
| 1,3-Butadiene | 0.0026 | 0.0000 | -100.0% | 0.0026 | 0.0000 | -100.0% |
| Cadmium | 0.0030 | 0.0006 | -81.1% | 0.0030 | 0.0006 | -80.0% |
| CH4 (methane) | 0.0181 | 0.5327 | 2836.0% | 0.0181 | 0.5327 | 2836.0% |
| Chromium | 0.1146 | 0.0847 | -26.1% | 0.1146 | 0.0943 | -17.8% |

| CFPE | 2008 Emissions year 8, lb/hr | 2012 Emissions year 8, lb/hr | % change year 8 | 2008 Emissions year 16, lb/hr | 2012 Emissions year 13, lb/hr | % change year 13/16 |
|---|---|---|---|---|---|---|
| Chrysene | 0.0001 | 0.0001 | 25.2% | 0.0001 | 0.0001 | 25.2% |
| Cobalt | 0.0496 | 0.0286 | -42.3% | 0.0496 | 0.0318 | -35.9% |
| Copper | 0.3680 | 0.3441 | -6.5% | 0.3680 | 0.3722 | 1.2% |
| Crystalline Silica ($SiO_2$) | | 4.6190 | New | | 5.1323 | New |
| Dibenzo(a,h)anthracene | 2.2E-05 | 0.0000 | 14.6% | 2.2E-05 | 0.0000 | 14.6% |
| Diesel Particulate | | 2.4943 | New | | 2.4943 | New |
| Fluoranthene | 0.0003 | 0.0003 | -7.7% | 0.0003 | 0.0003 | -7.7% |
| Fluorene | 0.0010 | 0.0009 | -6.1% | 0.0010 | 0.0009 | -6.1% |
| Fluorides (as F) | 0.0588 | 0.0330 | -43.8% | 0.0588 | 0.0364 | -38.0% |
| Formaldehyde | 0.0349 | 0.0010 | -97.1% | 0.0349 | 0.0010 | -97.1% |
| H2SO4/SO3[(1)] | 0.0075 | 0.1001 | 1232.2% | 0.0075 | 0.1001 | 1232.2% |
| Hafnium | 4.3E-05 | 0.0000 | 4.4% | 4.3E-05 | 0.0000 | 4.4% |
| Indeno(1,2,3-cd)pyrene | 2.6E-05 | 0.0000 | 14.2% | 2.6E-05 | 0.0000 | 14.2% |
| Manganese | 1.2153 | 0.5067 | -58.3% | 1.2153 | 0.5574 | -54.1% |
| Mercury | 0.0001 | 0.0001 | 16.0% | 0.0001 | 0.0001 | 18.8% |
| 2-Methylnaphthalene | 0.0006 | 0.0000 | -100.0% | 0.0006 | 0.0000 | -100.0% |
| Molybdenum | 0.0021 | 0.0016 | -23.5% | 0.0021 | 0.0018 | -13.5% |
| $N_2O$ | 4.0681 | 0.2546 | -93.7% | 4.0681 | 0.2546 | -93.7% |
| Naphthalene | 0.0092 | 0.0091 | -0.5% | 0.0092 | 0.0091 | -0.5% |
| Nickel | 0.2522 | 0.1946 | -22.8% | 0.2522 | 0.2112 | -16.3% |
| NOx | 30.3425 | 116.1 | 282.6% | 30.3425 | 116.1 | 282.6% |
| Pb (Lead) | 0.0776 | 0.0032 | -95.9% | 0.0776 | 0.0036 | -95.4% |
| Phenanthrene | 0.0028 | 0.0029 | 4.1% | 0.0028 | 0.0029 | 4.1% |

| CFPE | 2008 Emissions year 8, lb/hr | 2012 Emissions year 8, lb/hr | % change year 8 | 2008 Emissions year 16, lb/hr | 2012 Emissions year 13, lb/hr | % change year 13/16 |
|---|---|---|---|---|---|---|
| Phosphorus | 0.0532 | 0.0335 | -37.0% | 0.0532 | 0.0318 | -40.3% |
| Propylene | 0.1584 | 0.0000 | -100.0% | 0.1584 | 0.0000 | -100.0% |
| Pyrene | 0.0003 | 0.0003 | -18.4% | 0.0003 | 0.0003 | -18.4% |
| Selenium | 0.0096 | 0.0052 | -45.6% | 0.0096 | 0.0057 | -41.0% |
| Dioxins/Furans (2,3,7,8-TCDD TEQ basis) | 5.5E-09 | 0.0000 | -40.1% | 5.5E-09 | 0.0000 | -40.1% |
| Tellurium | 0.0212 | 0.0116 | -45.3% | 0.0212 | 0.0129 | -39.3% |
| Toluene | 0.0172 | 0.0036 | -78.9% | 0.0172 | 0.0036 | -78.9% |
| Vanadium | 0.0459 | 0.0601 | 30.8% | 0.0459 | 0.0672 | 46.4% |
| Xylene | 0.0118 | 0.0025 | -78.9% | 0.0118 | 0.0025 | -78.9% |
| Zinc | 0.6094 | 0.0498 | -91.8% | 0.6094 | 0.0556 | -90.9% |

(1) 2012 sulfuric acid emissions do not include emissions from the emergency generator. All other 2012 emissions are total Mine Site emissions, which include emergency generator emissions.

**Large Table 4 Revised Risk Estimates (RRE) for CFPE and Resulting CFE for the Supplemental Air Emissions Risk Analysis Conducted for the Proposed Mine Site**

| CFPE (CFE are shaded) | Acute inhalation RRE | Noncancer inhalation RRE | Cancer inhalation RRE | Noncancer farmer RRE | Cancer farmer RRE | Noncancer resident RRE | Cancer resident RRE |
|---|---|---|---|---|---|---|---|
| Acetaldehyde [1][3][7] | | 2.0E-06 | 3.9E-11 | 7.0E-07 | 1.4E-11 | 7.0E-07 | 1.4E-11 |
| Acrolein | 0.0001 | 0.0003 | | 0.0001 | | 0.0001 | |
| Antimony | | 0.0003 | | 3.9E-05 | | 3.9E-05 | |
| Arsenic[1][2][4] | 0.0402 | 0.0180 | 1.2E-06 | 0.0106 | 1.1E-06 | 0.0071 | 4.6E-07 |
| Barium[6] | | | | 0.0014 | | 0.0014 | |
| Benzene | 2.6E-05 | 1.6E-05 | 3.3E-09 | 6.3E-06 | 1.5E-09 | 6.3E-06 | 1.5E-09 |
| Benzo(a)anthracene[2] | | | 2.3E-10 | | 4.0E-08 | | 5.8E-10 |
| Benzo(a)pyrene[2] | | | 8.9E-10 | | 2.6E-07 | | 2.6E-09 |
| Benzo(b)fluoranthene[2] | | | 3.9E-10 | | 5.5E-09 | | 3.2E-10 |
| Benzo(k)fluoranthene[2] | | | 7.5E-11 | | 2.7E-08 | | 3.2E-10 |
| Beryllium | | 0.0004 | 1.7E-08 | 0.0001 | 1.0E-08 | 0.0001 | 2.6E-09 |
| Boron[6] | | | | 8.6E-07 | | 8.6E-07 | |
| 1,3-Butadiene[1] | | | | | | | |
| Cadmium[2] | | 0.0007 | 2.5E-08 | 0.0001 | 5.3E-08 | 0.0001 | 4.8E-09 |
| Chrysene[2] | | | 5.3E-11 | | 4.1E-09 | | 8.9E-11 |
| Cobalt[3][7] | | | | | | | |
| Copper | 0.0021 | | | | | | |
| Crystalline silica ($SiO_2$)[3] | | | | | | | |
| Dibenzo(a,h)anthracene[2][5] | | | 1.3E-09 | | 3.3E-06 | | 1.2E-08 |
| Diesel Particulate[3][7] | | | | | | | |
| Formaldehyde | 1.8E-05 | 6.8E-06 | 3.1E-10 | 6.8E-06 | 1.0E-10 | 6.8E-06 | 1.0E-10 |

| CFPE<br>(CFE are shaded) | Acute inhalation RRE | Noncancer inhalation RRE | Cancer inhalation RRE | Noncancer farmer RRE | Cancer farmer RRE | Noncancer resident RRE | Cancer resident RRE |
|---|---|---|---|---|---|---|---|
| H2SO4/SO3[8] | 0.0024 | 0.0080 | | 0.0032 | | 0.0032 | |
| Indeno(1,2,3-cd)pyrene[2] [5] | | | 1.5E-10 | | 1.1E-07 | | 1.7E-09 |
| Manganese[5] | | 0.0617 | | 0.0097 | | 0.0097 | |
| Mercury | 0.0004 | 1.3E-05 | | 5.5E-06 | | 5.5E-06 | |
| Naphthalene | 0.0001 | 4.6E-05 | 1.4E-08 | 1.9E-05 | 5.9E-09 | 1.9E-05 | 5.9E-09 |
| Nickel[5] | 0.0099 | 0.0901 | 2.2E-06 | 0.0131 | 3.2E-07 | 0.0131 | 3.2E-07 |
| NOx[5] | 0.5153 | | | | | | |
| Pb (lead) [2] | | | 9.2E-10 | | 5.4E-10 | | 4.1E-10 |
| Propylene | | 0.0E+00 | | 0.0E+00 | | 0.0E+00 | |
| Selenium[2] | | 7.0E-06 | | 4.7E-05 | | 1.5E-06 | |
| Dioxins/Furans<br>(TEQ basis ) [2] [5] | | 3.9E-06 | 6.2E-08 | 0.0006 | 5.0E-06 | 1.5E-05 | 7.4E-08 |
| Toluene | 2.7E-07 | 4.3E-07 | | 1.7E-07 | | 1.7E-07 | |
| Vanadium | 0.0012 | | | | | | |
| Xylene | 1.6E-07 | 1.2E-06 | | 4.7E-07 | | 4.7E-07 | |
| **Risk Driver Threshold** | **0.1** | **0.1** | **1 E-06** | **0.1** | **1 E-06** | **0.1** | **1 E-06** |

(1) Change in toxicity factor since 2008
(2) Change in multipathway screening factor (MPSF) since 2008 (called multimedia factors in 2008)
(3) CFE due to new toxicity factor that was not available in 2008
(4) CFE because is a potential risk driver based on changes since 2008
(5) CFE because was a risk driver in the Jan 2008 AERA
(6) Toxicity factor removed from RASS since 2008
(7) No RRE is calculated because Jan 2008 estimated risk was zero or not available
(8) 2008 modeled concentrations and 2012 toxicity factor used with percent change in emissions to determine acute RRE (See Section 4.3 for more information.)

**Large Table 5 Estimated Maximum Criteria Pollutant Air Concentrations at the Mine Site Property Ownership Boundary Compared to Ambient Air Quality Standards**

| Pollutant[1] | Time Period | Estimated Ambient Air Concentrations ($\mu g/m^3$)[2] [3] | Minnesota Ambient Air Quality Standard ($\mu g/m^3$) | National Ambient Air Quality Standard ($\mu g/m^3$) | Ratio of Modeled Air Concentration to the Minnesota Ambient Air Standard | Ratio of Modeled Air Concentration to the Federal Ambient Air Standard | Pollutant Toxic Endpoint |
|---|---|---|---|---|---|---|---|
| Particulate matter ($PM_{10}$) [2] | 24 hour | 88.4 | 150 | 150 | 0.59 | 0.59 | Respiratory system |
| | Annual | 28.5 | 50 | | 0.57 | 0.57 | |
| Particulate matter ($PM_{2.5}$) [2] | 24 hour | 32.5 | 65 | 35 | 0.50 | 0.93 | Respiratory system, Cardiovascular effects |
| | Annual | 10.4 | 15 | 12 | 0.69 | 0.87 | |
| Sulfur dioxide ($SO_2$) [3] | 1 hour | 0.74 | 1300 | 196 | NC | NC | Respiratory system |
| | 3 hour | 0.54 | 915 | | | | |
| | 24 hour | 0.13 | 365 | 365 | | | |
| | annual | 0.01 | 60 | 80 | | | |
| Nitrogen oxides ($NO_x$) [3] | 1 hour | 5.34 | 188 | 188 | NC | NC | Respiratory system |
| | Annual | 0.10 | 100 | 100 | | | |
| Carbon monoxide (CO) | 1 hour | NM | 35,000 | 40,000 | NM | NM | Cardiovascular system |
| | 8 hour | NM | 10,000 | 10,000 | | | |

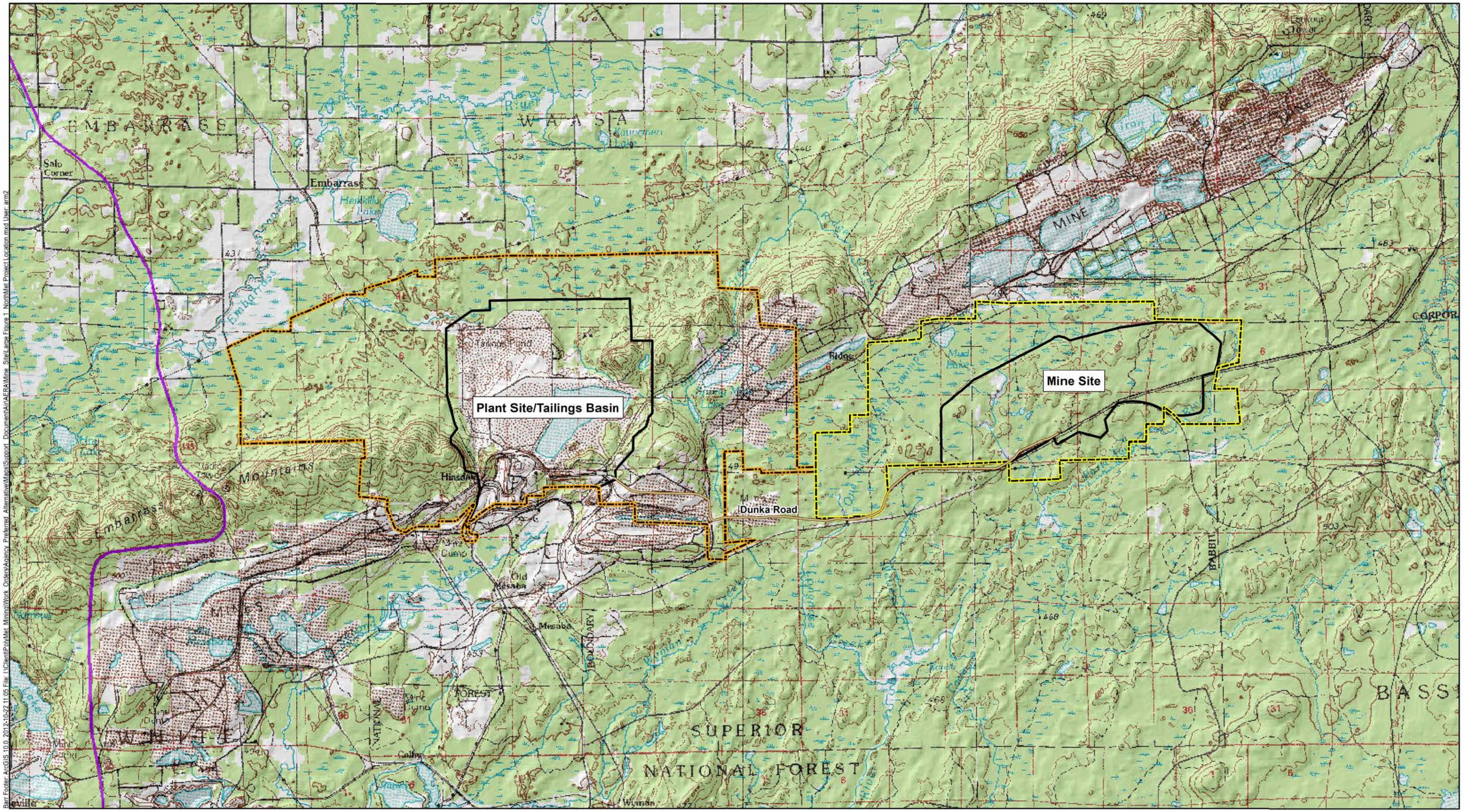
NC = Ratio not calculated because project-only modeling results were below the respective Significant Impact Level.
NM = Not modeled for environmental review purposes. See [1].

(1) CO was not identified as a pollutant of concern during the EIS scoping process. Exceedances of the ambient air quality standards are not expected.

(2) Final modeling results for $PM_{10}$ and $PM_{2.5}$ at the Mine Site property ownership boundary include PolyMet Mine Site emissions (fugitive emissions + stack emissions) and background concentration. Final modeling results for $NO_x$ and $SO_2$ at the Mine Site property ownership boundary include only PolyMet Mine Site emissions ( stack emissions).

(3) $NO_x$ and $SO_2$ concentrations are the incremental concentrations that result from PolyMet Mine Site sources only and do not include background concentrations. These values are far enough below the Significant Impact Levels (SILs) not to warrant further modeling analysis. Therefore comparison to NAAQS and MAAQS is not applicable for these concentrations.

## Large Figures

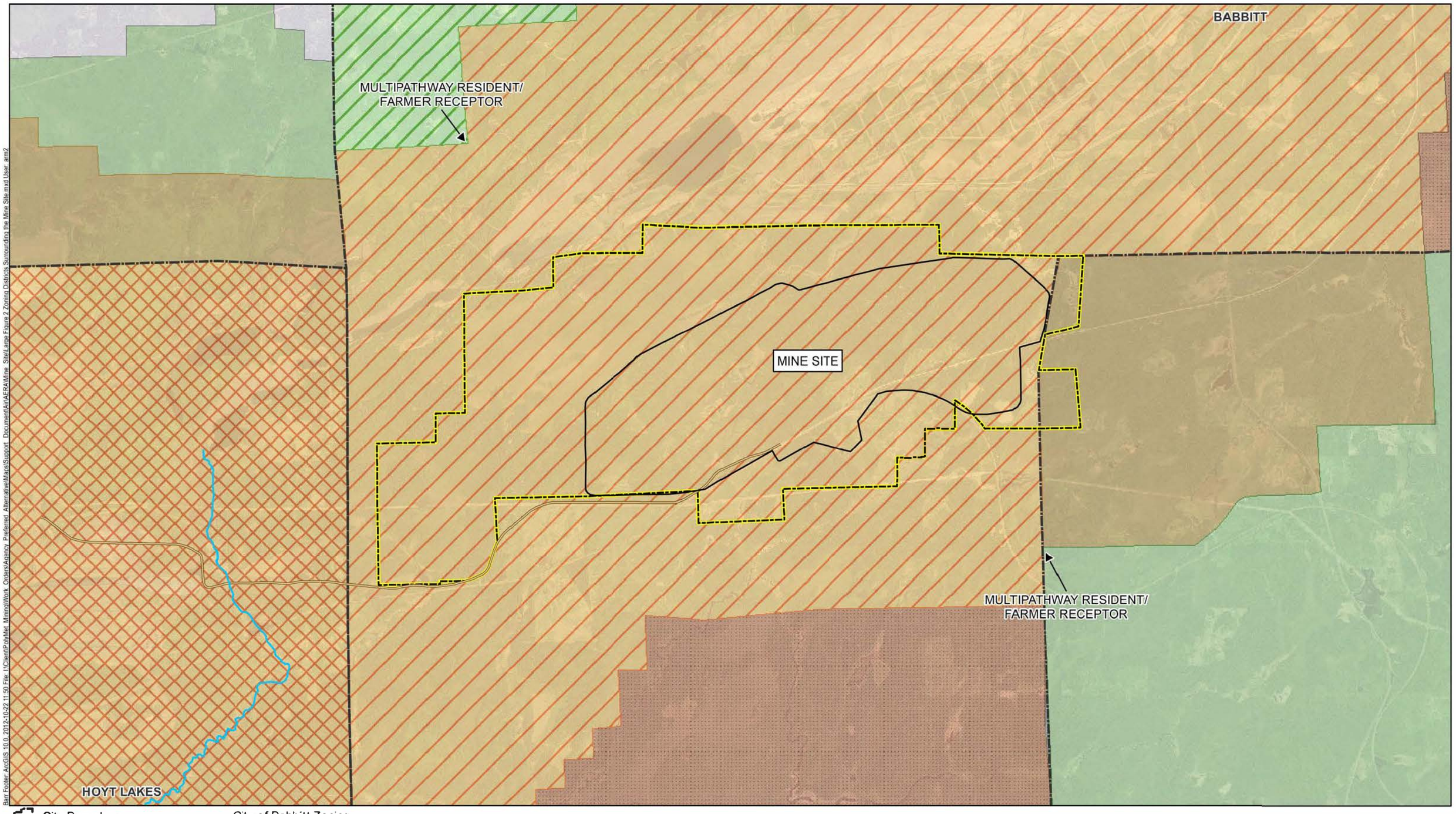



Barr Footer: ArcGIS 10.0, 2012-10-22 11:05 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative Maps\Support Documents\Air\AERA\Mine_SiteLarge Figure 1 NorthMet Project Location.mxd User: arm2

- Ambient Air Boundary - Mine Site
- Ambient Air Boundary - Plant Site
- Dunka Road
- Project Areas

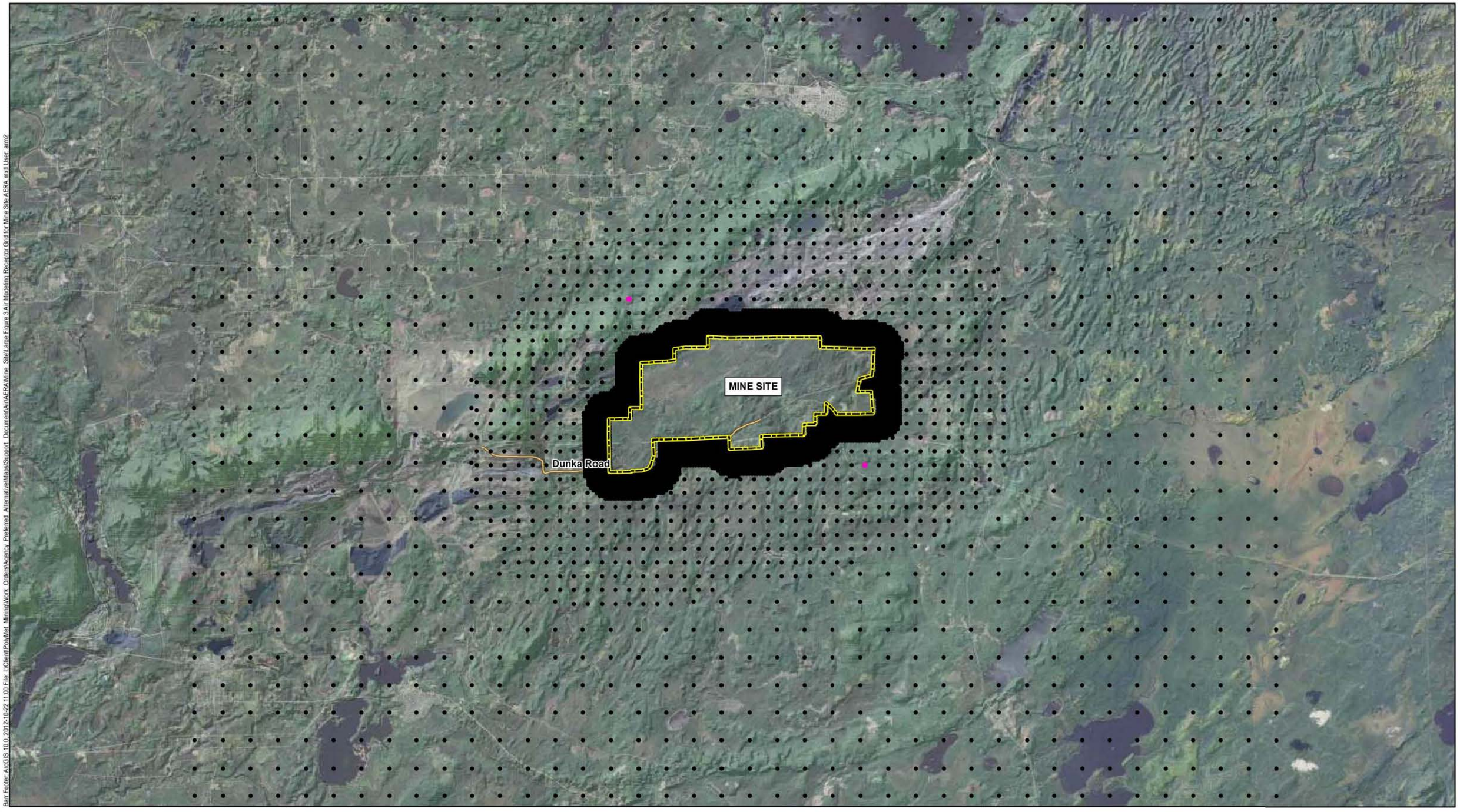
1.25 0.625 0 1.25
Miles

Lare Figure 1
NORTHMET PROJECT LOCATION IN
THE BABBITT AND HOYT LAKES AREA
IN NORTHEAST MINNESOTA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota




Large Figure 2
ZONING DISTRICTS SURROUNDING
THE NORTHMET MINE SITE
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

Barr Footer: ArcGIS 10.0, 2012-10-22 11:50, File: I:\Client\PolyMet_Mining\Work Orders\Agency Preferred Alternative\Maps\Support Documents\AirAERA\Mine Site\Large Figure 2 Zoning Districts Surrounding the Mine Site.mxd User: arm2




Barr Footer: ArcGIS 10.0, 2012-10-22 11:00 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\AERA\Mine_Site\Lane Figure 3 Air Modeling Receptor Grid for Mine Site AERA.mxd User: amn2

Ambient Air Boundary - Mine Site

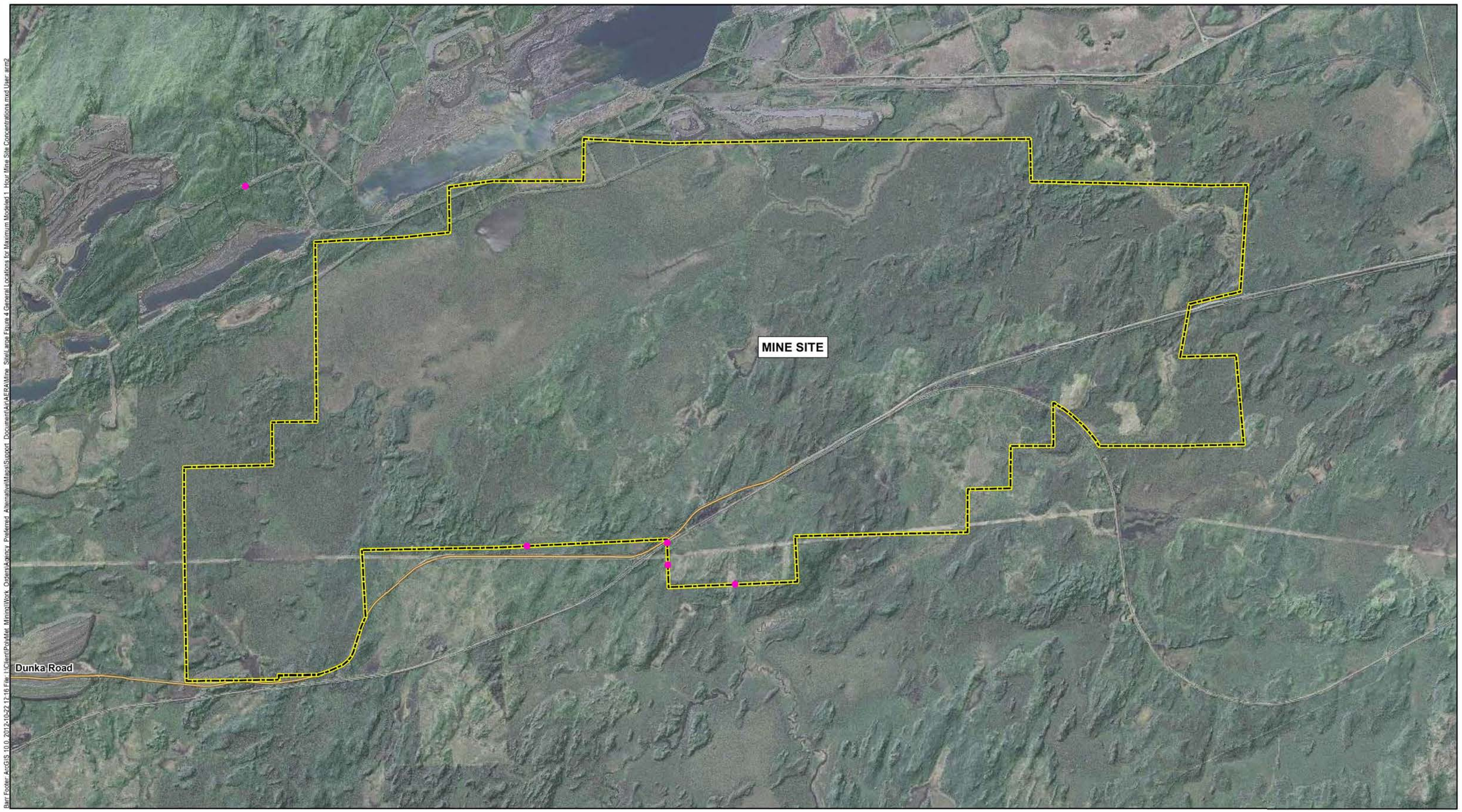
Mine Site AERA Inhalation Receptors

Mine Site AERA Multipathway Resident/Farmer Receptors

2 1 0 2

Miles

Large Figure 3
AIR MODELING RECEPTOR GRID FOR THE SUPPLEMENTAL MINE SITE AERA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



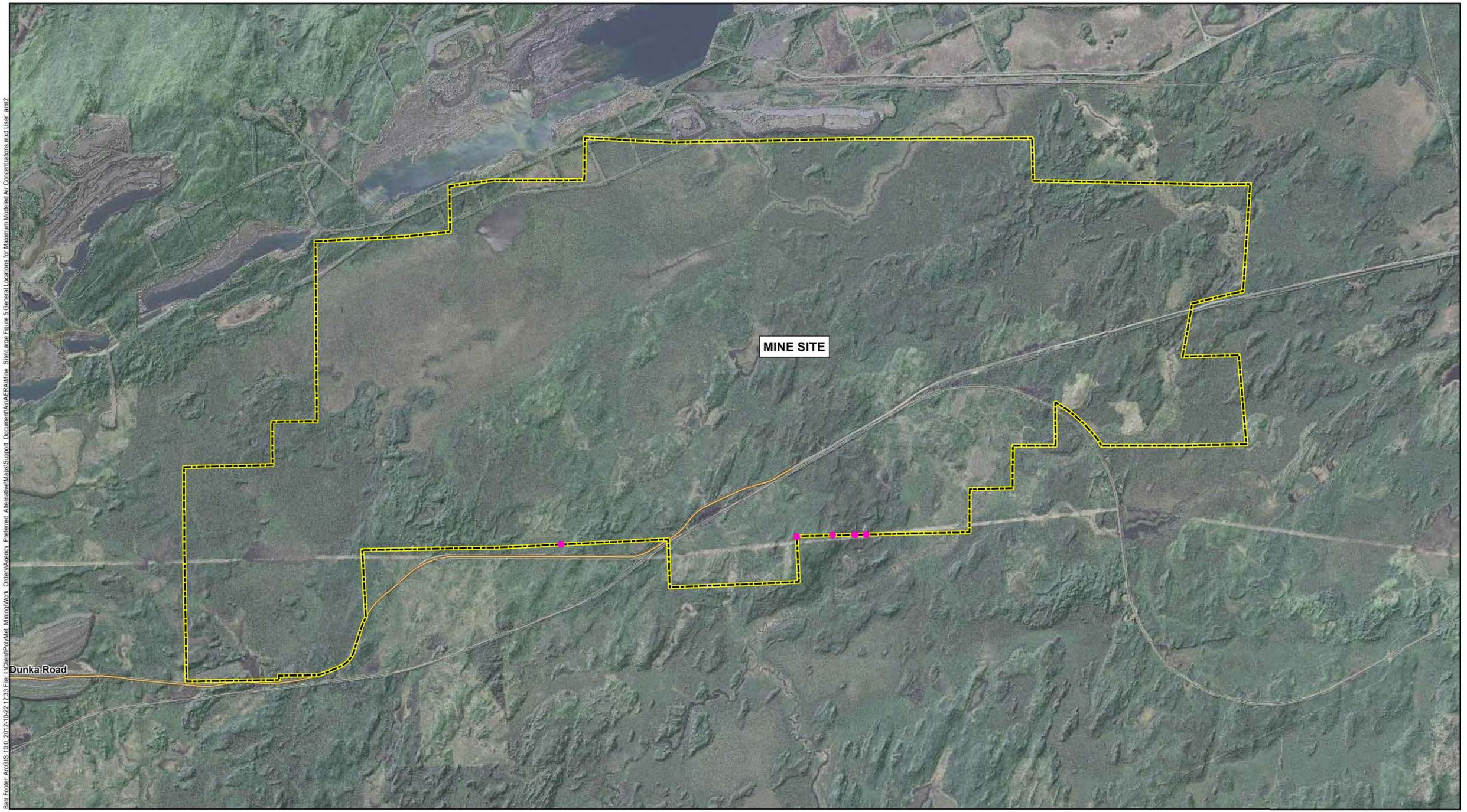

Basin Footer: ArcGIS 10.0, 2012-10-22 12:16 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Support Documents\AirQuality\AERAMine Site\Large Figure 4 General Locations for Maximum Modeled 1 Hour Mine Site Concentrations.mxd User: arm2

- Maximum Hourly Inhalation Concentration Receptors
- Ambient Air Boundary - Mine Site

0.5 0.25 0 0.5

Miles

Large Figure 4
GENERAL LOCATIONS FOR MAXIMUM MODELED 1-HOUR AIR CONCENTRATIONS AT THE MINE SITE FOR BOTH YEAR 8 AND YEAR 13 MINE LAYOUTS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota




Barr Footer: ArcGIS 10.0, 2012-10-22 12:33 File: I:\Client\PolyMet Mining\Work Orders\Agency Preferred Alternative\Maps\Support Document\Air\AERA\Mine Site\Large Figure 5 General Locations for Maximum Modeled Air Concentrations.mxd User: amf2

- Maximum Annual Inhalation Concentration Receptors
- Ambient Air Boundary - Mine Site

N

0.5 0.25 0 0.5

Miles

Large Figure 5
GENERAL LOCATIONS FOR MAXIMUM MODELED AIR CONCENTRATIONS AT THE MINE SITE FOR BOTH YEAR 8 AND YEAR 13 MINE LAYOUTS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

10 km

3 km

Mine Site

Land Cover*

- Barren Land (Rock/Sand/Clay)
- Cultivated Crops
- Forest
- Developed
- Developed Open Space
- Wetlands
- Grassland/Herbaceous
- Open Water
- Pasture/Hay
- Shrub/Scrub

*National Land Cover Dataset, 2006.

1.75 0.875 0 1.75

Miles

Large Figure 6
LAND USE WITHIN 3 AND 10 KM OF THE
NORTHMET PROJECT MINE SITE NEAR BABBITT, MN
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

Barr Footer: ArcGIS 10.0, 2012-10-22 11:59 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Documents\Air\AERA\Mine_Site\Large Figure 6 Land Use within 3 and 10km.mxd User: amn2

## Attachments

**Attachment A**

**Multipathway Factors from the MPCA's Risk Assessment Screening Spreadsheet**

**Table A-1 Multipathway Factors from the MPCA's Risk Assessment Screening Spreadsheet**

| CAS number or MPCA number | Chemical Name | Farmer Noncancer | Farmer Cancer | Resident Noncancer | Resident Cancer |
|---|---|---|---|---|---|
| 75-07-0 | Acetaldehyde | 0 | 0 | 0 | 0 |
| 0-00-2 | Arsenic Compounds | 2 | 4 | 1 | 1 |
| 7440-48-4 | Cobalt | 0 | 0 | 0 | 0 |
| 53-70-3 | Dibenz[a,h]anthracene | 0 | 5937 | 0 | 21 |
| 0-02-4 | Diesel exhaust particulate | 0 | 0 | 0 | 0 |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 0 | 1765 | 0 | 27 |
| 0-01-4 | Manganese Compounds | 0 | 0 | 0 | 0 |
| 0-01-5 | Nickel Compounds | 0 | 0 | 0 | 0 |
| 10102-44-0 | Nitrogen oxide (NO2) | 0 | 0 | 0 | 0 |
| 1175.00 | Silica (crystalline, respirable) | 0 | 0 | 0 | 0 |
| 00-09-1 | TCDD Equivalents, 2,3,7,8- | 419 | 200 | 9 | 2 |

**Attachment B**

**Toxicity Assessment for Risk Driver Chemicals**

## B. Toxicity Assessment for Risk Driver Chemicals

### B.1 Sources of Toxicity Values Used in the MPCA-RASS

The sources for the toxicity values used in this Supplemental 2012 AERA and their preferred order of use are shown in Table B-1.

**Table B-1 Sources of Toxicity Values used in the MPCA 20120302 RASS**

| Source of Toxicity Value | Comments |
|---|---|
| Minnesota Department of Health (MDH) Health Based Values (HBVs) | MDH may issue HBVs that are guidance, that have not yet been promulgated in Minnesota Rules through rulemaking. These values may be incorporated in the AERA. MDH and MPCA agree to use guidance values before HRVs. |
| Minnesota Department of Health (MDH) - Health Risk Values (HRVs) and provisional and surrogate values | HRVs are values that MDH has promulgated through rulemaking and have been incorporated into Minnesota Rules. Values mainly based on USEPA RfCs with the possible addition of an uncertainty factor (s).<br>Provisional and surrogate values lack the same level of confidence as the HRVs adopted via rulemaking. |
| USEPA Integrated Risk Information System (IRIS) RfCs, RfDs, Unit Risk Estimates | IRIS values have undergone technical review by USEPA's internal workgroup and external peer review and public comment. |
| California EPA-Office of Environmental Health Assessment (OEHHA) - Reference Exposure Levels (RELs) | RELs are derived for the California Hot Spots program and are derived in a manner similar to USEPA and have undergone internal and external review. However, draft RELs do not have the same level of confidence as adopted RELs. |
| USEPA Superfund Health Risk Technical Support Center – Provisional Peer Reviewed Toxicity Values (PPRTVs)[1] | PPRTVs are derived using methods similar to the USEPA IRIS program and are internally reviewed by two USEPA experts and three external experts. They do not receive the same multi-program consensus as do the USEPA IRIS values. |

(1) In March 2012 the MPCA removed the USEPA's Health Effects Summary Tables (HEAST) database values and replaced them with the PPRTVs.

The methods used to derive the toxicity values (RELs, RfCs, RfDs, PPRTVs, and URs) use a dosimetric adjustment and generally assume exposure 24 hour/day, 365 days/year, for 70 years. This builds another level of conservatism into the health risk estimates.

### B.2 Toxicity Information for Selected CFE

Chemicals potentially emitted from the Mine Site are primarily associated with particulate matter from loading, unloading and storage of either waste rock or ore, and emissions from unpaved roads and mine vehicle emissions. With few exceptions, conservative assumptions were used in assessing chemicals potentially emitted from the Mine Site thereby overestimating potential inhalation and multipathway risks.

### B.2.1 Cobalt

Cobalt is a risk driver for cancer effects (chronic) via inhalation at the mine site property boundary for stockpile storage (Years 8 and 13). The calculated inhalation cancer risk is 3E-06 for both years. Cobalt is a new chemical for evaluation because a provisional value (PPRTV) was added to the RASS in March 2012. The toxicity values in the RASS are for cancer effects, and noncancer chronic effects

The PPRTV unit risk number for cancer is of particular interest with regards to the PolyMet Mine Site. The development of this factor is based on a principal study of inhalation effects on rats and mice (References (1) (2)(27)). Cobalt can exist in numerous forms (e.g. elemental cobalt, cobalt sulfate, cobalt ions, etc.). Cobalt metals and salts have been shown to be genotoxic in studies (Reference (3)). The study on which the PPRTV is based only investigated the soluble form of cobalt, cobalt sulfate heptahydrate. The solubility of cobalt sulfate heptahydrate (used in the critical study) ranged from 82.8-100% (i.e. very soluble).

Stopford *et al.* evaluated the bioaccessibility of different cobalt compounds in surrogate body fluids (e.g. interstitial fluid, lysosomal fluid, alveolar fluid, serum, synovial fluid, gastric juice, and intestinal juice) by determining it solubility (Reference (4)). Among the compounds evaluated by Stopford *et al.*, the cobalt compound tested that is most similar to that most likely associated with fugitive dust in the Mine Site rock was cobalt aluminum spinel. When cobalt aluminum spinel was dissolved in the surrogate body fluids, solubilities ranged from 0.006-0095% (i.e., not very soluble). This information indicates that the assumption of 100% bioavailability for cobalt is very conservative.

Although there is information on the carcinogenic mode of action, the derivation of the unit risk value for cobalt uses a linear extrapolation non-threshold approach to a zero exposure level (References (1) (2)). This is generally accepted methodology and is considered to provide a conservative estimate of the potential toxicity of the chemical (Reference (5)).

Further study of the carcinogenicity of cobalt and cobalt compounds indicates that a distinction between different compounds is required to account for the mechanism of toxicity (Reference (6). Although soluble cobalt has been linked to carcinogenic activity in animals, there is insufficient evidence of any carcinogenic activity for other cobalt compounds and insufficient evidence without confounding factors of any carcinogenic activity in humans (References (2) (6)).

The International Agency for Research on Cancer (IARC, 2005) evaluated the carcinogenic hazards of cobalt and cobalt compounds and concluded that:

- there is inadequate evidence in humans for the carcinogenicity of cobalt metal without tungsten carbide
- there is sufficient evidence in experimental animals for the carcinogenicity of cobalt sulfate

- there is sufficient evidence in experimental animals for the carcinogenicity of cobalt metal powder

Based on this data and data for other cobalt compounds, IARC concluded that "cobalt and cobalt compounds are possibly carcinogenic to humans (Group 2B)." The IARC 2B classification means there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. IARC goes on to state the following about chemicals in the 2B classification:

> It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances, an agent for which there is *inadequate evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data.

These findings suggest that the PPRTV used for carcinogenic cobalt toxicity as applied to the form of cobalt most likely present in fugitive dust at the Mine Site, is conservative and provides for an overestimation of potential risks.

### B.2.2 Diesel Engine Exhaust/Diesel Particulate

On June 12, 2012, IARC classified diesel engine exhaust as a Group 1 carcinogen based on sufficient evidence in humans that exposure is associated with an increased risk for lung cancer. It had previously been classified as "probably carcinogenic to humans" (IARC Group 2A). Diesel particulate currently is not evaluated for carcinogenicity in the RASS. However, the constituents of diesel engine exhaust/diesel particulate such as arsenic, nickel, cobalt, dioxins/furans and PAHs are evaluated for potential health risks.

### B.2.3 Dioxins/furans

The toxicity of dioxins/furans from the combustion of diesel fuel was evaluated on a Toxic Equivalency Quotient basis (TEQ) with 2,3,7,8 – TCDD as an index chemical. Emission factors were expressed on a grams Toxicity Equivalent Quotient (TEQ) per kilometer driven basis (g TEQ/km) (Reference (7)).This means that in terms of toxicological effects, the toxicity of all dioxins/furans are weighted as compared to the toxicity of 2,3,7,8-TCDD.

### B.2.4 Nickel compounds

Nickel compounds are a risk driver for cancer effects (chronic) via inhalation at the mine site property boundary for in-pit storage (Year 13). The calculated risk is 1E-06. In the RASS, nickel compounds were evaluated using a cancer URE developed by the EPA-IRIS for nickel subsulfide in refinery dust. The carcinogenic potency of different nickel compounds varies significantly based on the solubility properties and speciation (Reference (8)). The Office of Environmental Health Hazard Assessment (OEHHA) in California, under the Hot Spots program, has established Guideline Reference Exposure Levels (RELs) of 0.2 µg/m3 for acute exposure and 0.014 µg/m3 chronic exposure for nickel and compounds

(http://www.oehha.ca.gov/air/allrels.html). The estimated total maximum one-hour (acute) concentration of nickel in air at the PolyMet Mine Site property ownership boundary is 0.084 $\mu g/m^3$ (0.000084 $mg/m^3$). The estimated total maximum annual (chronic) concentration of nickel in air at the PolyMet Mine Site property ownership boundary is 0.0021 $\mu g/m^3$ (0.0000021 $mg/m^3$). Both the modeled maximum one-hour and annual concentrations are below their respective RELs.

### B.2.5 Nitrogen oxides ($NO_x$ and $NO_2$)

- $NO_x$ emissions at the Mine Site are primarily from diesel engines. The Cal EPA-OEHHA 1 hour REL used in the AERA for $NO_2$ is 470 µg/m3. For this AERA the USEPA screening value of 75% has been applied to the $NO_x$ maximum modeled one-hour air concentration and this adjusted air concentration. The USEPA screening value assumes that 75% of the NO emitted to air converts instantaneously to $NO_2$. This is a conservative estimate of potential risk because the USEPA (Reference (7)) identifies that almost all $NO_x$ emissions from diesel engines is as NO and typically the conversion of NO to $NO_2$ is on the order of several hours to days (Reference (9). As described by the USEPA (Reference (7)):

- "... Emissions from combustion engines produce oxide of nitrogen ($NO_x$) primarily (at least initially) as NO. High combustion temperatures cause reactions between oxygen and nitrogen to form NO and some $NO_2$. Most $NO_2$ formed during combustion is rapidly decomposed to NO. $NO_2$ can also decompose to $N_2$ and $O_2$, but the rate of decomposition is very slow (References (10) (11)). Thus, almost all of the $NO_x$ emitted from diesel combustion engines is NO...."

- As a comparison, the 1-hr National Ambient Air Quality Standard (NAAQ) is 188 µg/m3. AERMOD modeling for NAAQS 1-hour compliance indicates that conversion of NO to $NO_2$ is less than 10%. Facilities can model compliance with the NAAQS of 188 µg/m3, but have risks greater than acceptable guidelines when modeling the AERA with the higher toxicity value.

### B.2.6 Persistent, Bioaccumulative, and Toxic Chemicals (PBTs)

The MPCA AERA defines PBT chemicals as per the "EPA PBT Profiler" and those chemicals on Lists I and II of Directive 2006/11/EC. In terms of persistence, MPCA uses the following definitions (as per the EPA PBT Profiler):

- air: $t_{1/2} > 2$ days = persistent

- water, soil sediment: $t_{1/2} \geq 60$ days = persistent, $t_{1/2} \geq 180$ days = very persistent

In terms of bioaccumulation, the MPCA uses the following bioconcentration factor (BCF) criteria (as per the EPA PBT Profiler):

- BCF $\geq$ 1000 = bioaccumulative, BCF $\geq$ 5000 = very bioaccumulative

The MPCA considered a substance to be PBT and carried it forward in subsequent analyses if the (Reference (12)):

- percent partitioning to water was greater than 10%, the half-life in water was greater than 60 days, and the BCF was greater than or equal to 1000,
- percent partitioning to soil was greater than 10%, the half-life in soil was greater than 60 days, and the BCF was greater than or equal to 1000, or
- percent partitioning to sediment was greater than 10%, the halflife in sediment was greater than 60 days, and the BCF was greater than or equal to 1000.

Pratt and Dymond (Reference (12)) state the following in regards to PBT chemicals:

> The PBT profiler does not handle metals and inorganic substances (hereafter referred to as metals). EPA classified some metals as PBTs under the Community Right to Know Act. A more comprehensive list of metals with potential PBT characteristics was adopted by the European Union. Metals from the MPCA's initial list of 315 substances that were also included in the EU list were carried forward in subsequent analyses in this study.

Table B-2 summarizes the CFEs, their sources and the toxic effects they are assessed for in the MPCA-RASS.

**Table B-2 Summary Sources and Toxic Effects Evaluated of Compounds for Evaluation (CFEs) in the Supplemental AERA for the Mine Site.**

| Chemical | Potential Emission Source | Type of Chemical | Toxicity Effects to be Assessed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Inhalation | | | Multipathway | |
| | | | Acute | Non cancer chronic | Cancer | Non cancer chronic | Cancer |
| Acetaldehyde | Diesel Fuel burning engines (trucks, locomotive engines) | Volatile Organic Compound | X | X | X | | |
| Arsenic compounds | Diesel Fuel burning engines (trucks, locomotive engines); airborne rock particles | Metal | X | X | X | X | X |
| Cobalt | Diesel Fuel burning engines (trucks, locomotive engines), airborne rock particles | Metal | | X | X | | |
| Crystalline Silica | Crushing of rocks | Particulate | | X | | | |
| Dibenzo(a,h) anthracene | Diesel Fuel burning engines (trucks, locomotive engines) | PAH; (Semi-volatile compound) | | | X | | X |
| Diesel exhaust particulate | Diesel Fuel burning engines (trucks, locomotive engines) | Particulate | | X | | | |
| Dioxin/furans | Diesel Fuel burning engines (trucks, locomotive engines) | Dioxin/furans (Semi-volatile compound) | | X | X | X | X |
| Indeno(1,2,3-cd)pyrene | Diesel Fuel burning engines (trucks, locomotive engines) | PAH (Semi-volatile compound) | | | X | | X |

| Chemical | Potential Emission Source | Type of Chemical | Toxicity Effects to be Assessed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Inhalation | | | Multipathway | |
| | | | Acute | Non cancer chronic | Cancer | Non cancer chronic | Cancer |
| Manganese compounds | Diesel Fuel burning engines (trucks, locomotive engines), airborne rock particles | Metal | | X | | | |
| Nickel compounds | Diesel Fuel burning engines (trucks, locomotive engines), airborne rock particles | Metal | X | X | X | | |
| Nitrogen Oxides | Diesel Fuel burning engines (trucks, locomotive engines) | Gas | X | | | | |

**Attachment C**

**Methodology and Assumptions used in Calculating Risk Estimates (RASS 20120302)**

## C. Methodology and Assumptions used in Calculating Risk Estimates (RASS 20120302)

### C.1 Estimating Potential Incremental Inhalation Noncancer Risks

For each chemical to be evaluated, a noncancer risk is calculated in the MPCA-RASS by taking the ratio of the estimated dose (or the maximum modeled air concentration) to a toxicity reference value (TRV) for each chemical for evaluation. The resulting value is called the Hazard Quotient (HQ). The HQs for each chemical are then summed for all chemicals to calculate a Hazard Index (HI). The guideline value for comparison to estimated noncancer risks (HQ or HI) is one (1).

HQ = AIRc / TRV

Where: AIRc = modeled air concentration, typically a maximum value ($\mu g/m^3$)

TRV = Toxicity reference value (an HRV, REL, RfC or PPRTV) ($\mu g/m^3$)

$HI = HQ_{\text{chemical 1}} + HQ_{\text{chemical 2}} + HQ_{\text{chemical 3}}....$

A conservative feature built into the RASS is that hazard quotients for noncarcinogens are summed regardless of toxic endpoint, with the resulting Hazard Index (HI) being reported in the RASS summary risk table. If the HQ or HI is greater than 1, there may be a greater concern for potential noncancer health effects and more refined analyses are needed. This does not mean that adverse effects will occur. Some factors to consider in a more refined analyses include determining the toxic endpoints for each chemical, the confidence level in the toxicity values (HRVs, RELs, RfCs, or PPRTVs), and any uncertainties in the derivation of the toxicity values. Most often the individual chemicals likely impact several different organs or systems and should not be summed together into one HI. The RASS does include a refined analysis that allow for summing the chemical HQs by specific target endpoints; an HI for each organ or system may be evaluated if the total noncancer risk is above the general guideline value. Typically when the HI is calculated by target endpoint, the individual target endpoint HI are lower than the when all HQs are summed regardless of toxic endpoint. In the case of this AERA, total noncancer risks are not above the MDH guideline values so the refined analysis is not used.

### C.2 Estimating Potential Incremental Inhalation Cancer Risks

Maximum modeled annual ambient air concentrations were used to estimate the dose. The estimated dose was multiplied by the unit risk estimate to estimate potential cancer risks to an individual. Use of maximum modeled annual air concentrations results in an estimated cancer risk that represents the maximum possible risk for that specific chemical. The MDH guideline for acceptable cancer risks is a risk level of 1 in 100,000 (1E-5).

Estimated Cancer Risk = Unit Risk ($\mu g/m3$)-1 * AIRc

Where: AIRc = modeled air concentration, typically a maximum ($\mu g/m^3$)

To estimate chemical specific potential cancer risk under the MEI exposure concept, maximum values for exposure point concentrations and exposure conditions were used. Combining maximum exposure point concentrations with upper-bound toxicity values, results in a potential cancer risk estimate that may be thousands of times greater than those for the average exposed individual. While such maximum exposure conditions are individually possible when considered alone, a combination of these conditions is not likely to occur in an actual population. The estimated potential cancer risk for the MEI exposure conditions developed in the AERA represents a theoretical upper-bound risk that would not likely occur in the actual population.

## C.3 Estimating Potential Incremental Non-Inhalation (Multipathway) Risks

Chemicals emitted to the atmosphere may be deposited on soils and surface water and may subsequently enter the terrestrial and aquatic food chain that may lead to indirect human exposures from eating contaminated food. The purpose of the screening level multipathway analysis is to evaluate the potential for adverse human health effects associated with indirect exposure (ingestion) to chemicals potentially emitted from the proposed project.

Multipathway screening factors (MPSF) were developed by the MPCA for chemicals identified as being persistent or bioaccumulative in the environment, or toxic (PBT). Within the MPCA-RASS spreadsheet, for each type of receptor (e.g. resident, farmer), ingestion risks (i.e., indirect risk by the non-inhalation pathway) are estimated by multiplying a chemical's chronic screening inhalation HQ and/or screening inhalation cancer risk by the MPSF.

Ingestion (non-inhalation) risk, $Chemical_A$ = Noncancer Chronic Inhalation risk * MPSF

Ingestion (non-inhalation) risk, $Chemical_A$ = Cancer Inhalation risk * MPSF

For each chemical and receptor type, inhalation and ingestion (non-inhalation) risks are then summed for a chemical (HQs for noncancer chronic; cancer risks) to derive a "total" noncancer and/or cancer risk (see the RiskCalcs worksheet in the RASS). The individual chemical risks are then summed to derive a TOTAL cancer risk (all chemicals) and a TOTAL HI for each receptor type.

The multipathway screening factors were derived by the MPCA with the Industrial Risk Assessment Protocol (IRAP; multipathway risk model) using generic input parameters to calculate inhalation and indirect exposure risk for specific chemicals (Reference (13) (12)). The MPSF is the ratio of the maximum estimated risk from the ingestion exposure route to the maximum estimated risk from the inhalation exposure route (References (14) (15) (12)). The method used by the MPCA to derive the chemical-specific MPSF has not undergone widespread scientific review. The reliability and applicability of the method to site-specific analyses is uncertain. Therefore uncertainty is associated with the results of the multimedia analysis presented in this report. Based on the information available from the MPCA (Reference (13) (12)) regarding the multipathway screening factors, it is highly likely that potential risks are conservative and overestimate any potential risks.

## C.4 Additional Risk Calculation Information and Assumptions

**C.4.1 Calculation of the hazard index for 1- hour acute inhalation:**
The ratio of the hourly maximum modeled air concentration in any location to the toxicity value in the RASS (e.g., HBV, HRV, RfC) is used to calculate the hazard quotient. Summed hazard quotients are used to calculate the hazard index to assessed total potential risks. Toxicity endpoint: non-cancer effects only.

**C.4.2 Calculation of the hazard index for annual (chronic) inhalation non-cancer health effects:** The ratio of the annual maximum modeled air concentration to the toxicity values in the RASS (e.g., HBV, HRV, RfC) is used to calculate a hazard quotient (and summed for a hazard index). No adjustments to the maximum modeled air concentration are made in the AERA. An exposure concentration (EC) is not calculated using the maximum modeled air concentration. This means no adjustments to the maximum modeled air concentration are made to account for exposure frequency (EF), exposure time (ET), or exposure duration(ED), or averaging time (AT). It is assumed toxicity values in the RASS (e.g., HBV, HRV, RfC) are for chronic durations.

**C.4.3 Calculation of the cancer risk estimate for annual (chronic) inhalation:**
The product of the annual maximum modeled air concentration and the Inhalation Unit Risk (IUR) in the RASS is used to calculate the cancer risk estimate. Again, No adjustments to the maximum modeled air concentration are made in the AERA to calculate an exposure concentration (EC) to account for exposure frequency (EF), exposure time (ET), or exposure duration (ED), or averaging time (AT). EPA defines the Inhalation Unit Risk (IUR) as "the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent via inhalation per µg/m3 over a lifetime." Use of the IUR is the only place in the calculation, which accounts for exposure over a lifetime (assumes continuous exposure over 70 year lifetime).

**C.4.4 Calculation of the hazard index for annual (chronic) multipathway resident non-cancer-inhalation:**
Potential multipathway exposure risk is the sum of the chronic inhalation risk +chronic ingestion risk via food consumption. The chronic inhalation non-cancer risk is calculated as described in B.4.2 above and is based on the annual maximum modeled air concentration.

**C.4.5 Calculation of the cancer risk estimate for Annual (chronic) multipathway resident inhalation:**
Again, potential multipathway exposure risk is the sum of the chronic inhalation risk +chronic ingestion risk via food consumption. The chronic inhalation cancer risk is calculated as described in B.4.3 above and is based on the annual maximum modeled air concentration and is the inhalation component of the multipathway calculation. The cancer chronic inhalation risk is not adjusted because the assumption would be a 70-year exposure duration divided by a 70 year averaging time-which equals 1 (Reference (12)).

**C.4.6 Calculation of the hazard index for annual (chronic) multipathway resident non-cancer-ingestion:**
The chronic inhalation hazard quotient/index for non-cancer risk is calculated as described in B.4.2 above and is based on the annual maximum modeled air concentration. To account for potential ingestion risk, the hazard index is multiplied by a Multipathway Screening Factor (MPSF) derived for resident non-cancer risks. The MPSFs for non-cancer effects was derived by the MPCA as outlined in Reference (12).

**C.4.7 Calculation of the cancer risk estimate for annual (chronic) multipathway resident - ingestion:** The chronic inhalation cancer risk is calculated as described in B.4.3 above and is based on the annual maximum modeled air concentration. The multipathway ingestion risk was calculated by taking the calculated chronic inhalation cancer risk (in B.4.3 above) and multiplying it by the derived MPSF. The MPCA derived the MPSF for cancer endpoints by using IRAP-h to calculate potential ingestion and inhalation risks. The MPSF is the ratio of the ingestion risk to the inhalation risk. In the derivation of the MPSF, the MPCA adjusted the calculated inhalation risk to account for a 30-year exposure duration (ED) for a resident over a 70-year averaging time (AT). This is where the 30-year exposure duration over an averaging time of 70 years is incorporated into the ingestion portion of the multipathway risk.

**C.4.8 Calculation of the hazard index for annual (chronic) multipathway farmer non-cancer-ingestion:** The chronic inhalation hazard quotient/index non-cancer risk is calculated as described in B.4.2 above and is based on the annual maximum modeled air concentration. To account for potential ingestion risk, this hazard quotient is multiplied by a Multipathway Screening Factor (MPSF) derived for farmer non-cancer risks. The MPSFs for non- cancer effects were derived by the MPCA as outlined in Reference (12).

**C.4.9 Calculation of the cancer risk estimate for annual (chronic) multipathway farmer - ingestion:** The chronic inhalation cancer risk is calculated as described in B.4.3 above and is based on the annual maximum modeled air concentration. The multipathway ingestion risk was calculated by taking the calculated chronic inhalation cancer risk (in B.4.3 above) and multiplying it by the derived MPSF. The MPCA derived the MPSFs as described in B.4.7 above. In the derivation of the MPSF for the farmer, the MPCA adjusted the calculated inhalation risk to account for a 40-year exposure duration (ED) over a 70-year averaging time (AT). This is where the 40 exposure duration over an averaging time of 70 years is incorporated into the ingestion portion of the multipathway risk.

**Attachment D**

**Individual Pollutant Risk Estimates from the MPCA's Risk Assessment Screening Spreadsheet**

**Table D-1 Inhalation Risk at the Mine Site Ownership Boundary for Year 8 (Stockpile Storage Mine Phase)**

| cas # or MPCA # | Chemical Name | Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Acute | Subchronic Noncancer | Chronic Noncancer | Cancer |
| **Total** | | **7.1E-01** | | **2.4E-01** | **4.9E-06** |
| 75-07-0 | Acetaldehyde | 2.5E-06 | | 4.8E-08 | 9.6E-13 |
| 0-00-2 | Arsenic Compounds | 3.1E-02 | | 9.5E-03 | 6.1E-07 |
| 7440-48-4 | Cobalt | | | 6.3E-02 | 3.4E-06 |
| 53-70-3 | Dibenz[a,h]anthracene | | | | 3.7E-09 |
| 0-02-4 | Diesel exhaust particulate | | | 5.3E-02 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | | | | 4.0E-10 |
| 0-01-4 | Manganese Compounds | | | 6.3E-02 | |
| 0-01-5 | Nickel Compounds | 7.6E-03 | | 3.0E-02 | 7.2E-07 |
| 10102-44-0 | Nitrogen oxide (NO2) | 6.7E-01 | | | |
| 1175 | Silica (crystalline, respirable) | | | 2.0E-02 | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | | | 1.1E-05 | 1.8E-07 |

**Table D-2 Inhalation Risk at the Mine Site Ownership Boundary for Year 13 (In-Pit Storage Mine Phase)**

| cas # or MPCA # | Chemical Name | Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Acute | Subchronic Noncancer | Chronic Noncancer | Cancer |
| **Total** | | **8.4E-01** | | **2.2E-01** | **4.8E-06** |
| 75-07-0 | Acetaldehyde | 2.5E-06 | | 5.1E-08 | 1.0E-12 |
| 0-00-2 | Arsenic Compounds | 3.3E-02 | | 7.6E-03 | 4.9E-07 |
| 7440-48-4 | Cobalt | | | 5.8E-02 | 3.1E-06 |
| 53-70-3 | Dibenz[a,h]anthracene | | | | 2.6E-09 |
| 0-02-4 | Diesel exhaust particulate | | | 3.7E-02 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | | | | 2.8E-10 |
| 0-01-4 | Manganese Compounds | | | 5.1E-02 | |
| 0-01-5 | Nickel Compounds | 5.7E-03 | | 4.2E-02 | 1.0E-06 |
| 10102-44-0 | Nitrogen oxide (NO2) | 8.0E-01 | | | |
| 1175 | Silica (crystalline, respirable) | | | 1.9E-02 | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | | | 8.0E-06 | 1.3E-07 |

**Table D-3 Multipathway Farmer and Resident Risk at the Mineral Mining/Industrial District Boundary for Year 8 (Stockpile Storage Mine Phase)**

| cas # or MPCA # | Chemical Name | Chronic Screening Total Hazard Quotients and Cancer Risks (Inhalation + Non-inhalation) for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Farmer Noncancer | Farmer Cancer | Resident Noncancer | Resident Cancer |
| **Total** | | **4.0E-02** | **1.4E-05** | **3.7E-02** | **7.6E-07** |
| 75-07-0 | Acetaldehyde | 9.8E-09 | 1.9E-13 | 9.8E-09 | 1.9E-13 |
| 0-00-2 | Arsenic Compounds | 5.5E-03 | 5.9E-07 | 3.7E-03 | 2.4E-07 |
| 7440-48-4 | Cobalt | 5.3E-03 | 2.8E-07 | 5.3E-03 | 2.8E-07 |
| 53-70-3 | Dibenz[a,h]anthracene | | 5.2E-06 | | 1.9E-08 |
| 0-02-4 | Diesel exhaust particulate | 1.1E-02 | | 1.1E-02 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | | 1.7E-07 | | 2.6E-09 |
| 0-01-4 | Manganese Compounds | 1.1E-02 | | 1.1E-02 | |
| 0-01-5 | Nickel Compounds | 4.2E-03 | 1.0E-07 | 4.2E-03 | 1.0E-07 |
| 10102-44-0 | Nitrogen oxide (NO2) | | | | |
| 1175 | Silica (crystalline, respirable) | 1.8E-03 | | 1.8E-03 | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | 1.0E-03 | 7.7E-06 | 2.4E-05 | 1.1E-07 |

**Table D-4 Multipathway Farmer and Resident Risk at the Mineral Mining/Industrial District Boundary for Year 13 (In-Pit Storage Mine Phase)**

| cas # or MPCA # | Chemical Name | Chronic Screening Total Hazard Quotients and Cancer Risks (Inhalation + Non-inhalation) for Individual Substances | | | |
|---|---|---|---|---|---|
| | | Farmer Noncancer | Farmer Cancer | Resident Noncancer | Resident Cancer |
| **Total** | | **4.2E-02** | **1.3E-05** | **3.9E-02** | **8.2E-07** |
| 75-07-0 | Acetaldehyde | 1.0E-08 | 2.1E-13 | 1.0E-08 | 2.1E-13 |
| 0-00-2 | Arsenic Compounds | 5.6E-03 | 6.1E-07 | 3.8E-03 | 2.4E-07 |
| 7440-48-4 | Cobalt | 6.0E-03 | 3.2E-07 | 6.0E-03 | 3.2E-07 |
| 53-70-3 | Dibenz[a,h]anthracene | | 5.1E-06 | | 1.9E-08 |
| 0-02-4 | Diesel exhaust particulate | 1.0E-02 | | 1.0E-02 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | | 1.6E-07 | | 2.6E-09 |
| 0-01-4 | Manganese Compounds | 1.1E-02 | | 1.1E-02 | |
| 0-01-5 | Nickel Compounds | 5.4E-03 | 1.3E-07 | 5.4E-03 | 1.3E-07 |
| 10102-44-0 | Nitrogen oxide (NO2) | | | | |
| 1175 | Silica (crystalline, respirable) | 2.2E-03 | | 2.2E-03 | |
| 00-09-1 | TCDD Eqivalents, 2,3,7,8- | 9.3E-04 | 7.1E-06 | 2.2E-05 | 1.1E-07 |

# Attachment E

# Sources of Uncertainty Specific to the Supplemental Mine Site AERA

## E. Sources of Uncertainty Specific to the Supplemental Mine Site AERA

### E.1 Uncertainty Specific to this Supplemental AERA

#### E.1.1 Emission Calculations

Numerous factors contribute to uncertainty in estimating emissions from the Mine Site.

- Use of EPA emission factor for dioxins/furans from tunnel studies performed in 1996-1998 (References (16) (17)).

- Use of AP-42 emission factors for PAHs derived from data in 1990 report that studied a single uncontrolled diesel engine (Reference (18)). As of 2012, the diesel standard for all large refiners and importers is ultra-low sulfur diesel, or a maximum of 15ppm sulfur.

- Lack of emission factors specifically for estimating dioxin/furan emissions from locomotives. The dioxin emission factors used for heavy duty diesel vehicles discussed above (References (16) (17)) were applied to locomotives on a fuel-usage basis. Locomotives are also subject to the same diesel fuel requirements as heavy duty off road vehicles.

- Upper end values (e.g. 99$^{th}$ percentile and 95% UCL) for metals concentrations assumed for different rock types and worst case material assumed where multiple materials are possible.

- Metals emission from fugitive dust are based on total PM emissions, not an estimate of inhalable fraction.

#### E.1.2 Exposure Assessment

The following assumptions contribute to conservatism in the exposure assessment:

- Use of only the maximum modeled air concentrations as the dose (MEI exposure)

- The assumption that the metal emissions (cobalt, nickel, manganese) from fugitive sources are in the ionic form, are all respirable and 100% bioavailable.

- The assumption that 80% of the NO emitted to air converts instantaneously to $NO_2$.

#### E.1.3 Toxicity Assessment

The following assumptions contribute to uncertainty in the toxicity assessment:

- Calculating risks using surrogate toxicity values to represent chemical mixtures. See Section 9.4.1 for a more complete discussion.

- Differences in the chemical species emitted from the proposed Mine Site operations, and the chemical species used in specific toxicity studies.

- Extrapolation from high dose, exposures in the experimental study to estimate effects in humans following longer-term exposure encountered in the environment to derive toxicity values.

- Use of adverse effects data available for the most sensitive laboratory animal species to derive toxicity values.

- Extrapolation from animal studies to humans for toxicity values.

- The use of dose-response data from one route of exposure to estimate effects from exposure via different routes for toxicity values.

- The variability in the quality of the studies upon which the toxicity values are based.

The lack of available information addressing synergism and/or antagonism. Toxicological interactions between multiple chemical exposures can occur. These potential interactions were not specifically addressed in the AERA. These interactions may result in greater (synergistic) or lesser (antagonistic) effect than the effect of each individual chemical. A significant source of uncertainty is inherent in the derivation of USEPA, MDH, Cal EPA-OEHHA, and Superfund toxicity values for chemicals (Reference (19)). This uncertainty is typically addressed by use of uncertainty factors or modifying factors in deriving a toxicity value and its use in estimating potential risks. It can be challenging to find toxicological data that is based on human exposures that can be appropriately used in a health risk assessment. Most toxicological data based on human exposures comes from epidemiological studies based on occupational exposures. Even though data from occupational human exposures is generally considered more relevant than animal data, occupational exposures are usually higher than environmental exposures. Given this lack of human data, toxicologists rely on data from animal studies or other *in vitro* tests. In developing these dose-response values, USEPA currently uses conservative assumptions to assure that the toxicity value is conservative and that the resultant risk estimate is more likely to overestimate risk than underestimate risk. USEPA applies these conservative assumptions for the development of both URs and RfCs.

### E.1.3.1 Non-Carcinogenic Toxicity Values-Uncertainty

Because appropriate human exposure data are rarely available, alternative methods are used to estimate dose-response values that are not likely to cause adverse health effects. The methods currently employed by the USEPA, Cal EPA-OEHHA, and the MDH to develop dose-response values do not allow for an assessment of the likelihood that effects will occur, nor allow an assessment of the severity of the effects in an exposed individual or population. Sources of uncertainty in the development of noncarcinogenic inhalation toxicity values (HRVs, RfCs, RELs, PPRTVs) include:

- Extrapolation from high dose, short-term exposures in the experimental study to estimate effects following longer-term exposure encountered in the environment.

- Use of adverse effects data available for the most sensitive laboratory animal species.

- Extrapolation from animal studies to humans.

- The use of dose-response data from one route of exposure to estimate effects from exposure via different routes.

- The variability in the quality of the studies upon which the toxicity values are based.

- Lack of consideration of toxicological interactions (i.e. synergism, antagonism, potentiation, additivity) between multiple chemicals.

#### E.1.3.2 Carcinogenic Toxicity Factors-Uncertainty

The toxicological database used for developing inhalation unit risk estimates is also a source of uncertainty. The USEPA outlined some of the sources of uncertainties in its *Guidelines for Carcinogen Risk Assessment* (References (20) (21)) and they include:

- Extrapolation from high to low doses and from animals to humans and species, gender age, and strain differences in uptake, metabolism, organ distribution and target site susceptibility.

- Assumption that cancer induction is a "non-threshold" event because it is believed that any level of exposure, however small, poses a finite probability of generating a carcinogenic response (22).

Other sources of uncertainty include:

- Classification of chemicals as either EPA Group A or B carcinogens even if there is just one positive finding of tumors in one laboratory experiment. This one finding is given more weight than any number of negative findings in studies of equal quality.

- The assumption that substances that have been found to be carcinogenic in some animal species means they are likely carcinogenic in humans.

- Cal EPA-OEHHA's use of oral studies to derive inhalation UR values for some chemicals. For example, the UR for dibenzo(a,h)anthracene is based on data derived from oral studies. The derived oral slope factor (SF) was then converted to a UR by assuming a body weight of 70 kg and an inhalation rate of 20 $m^3$ per day.

- Cal EPA-OEIIIIA's assumption that URs for inhalation have the same relative activities as cancer potencies for oral intake (Reference (22)). The route of administration may have an impact on the absorption, distribution, metabolism, excretion, and mode of action of the chemical.

### E.1.4 Conservatism/Uncertainty in Risk Characterization

To develop a cancer risk estimate associated with exposure to multiple chemicals identified by USEPA as carcinogens, the chemical specific cancer risk estimates were summed in accordance with MPCA and USEPA guidance. USEPA recognizes that there are several limitations associated with this approach. For chemicals where the UR is based on the upper 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as risks from a number of carcinogens are summed (Reference (19)). In addition, the following procedures and assumptions result in an additional level of conservatism in the cancer risk estimates:

- In summing the cancer risk, equal weight was given to all chemicals regardless of their classification (class A = known human carcinogen, class B = probable human carcinogen, class C = possible human carcinogen).

- Cancer risk values derived from animal studies were given equal weight to values based on human data.

- Carcinogenic responses arising in the same tissue should, according to USEPA, be considered additive unless the mechanism of carcinogenicity is unrelated. The chemicals identified by USEPA as potential carcinogens varied in target tissue. In the AERA, cancer risks were summed regardless of the difference in their mode of action or target tissue. In general, the assumption of additivity is expected to be conservative (Reference (20)).

## Attachment F

## Attachment References

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**Attachment S**

**Work Plan for a Supplemental Air Emissions Risk Analysis (AERA) for the NorthMet Mine Site**

# PolyMet Mining Inc.

## Work Plan for a Supplemental Air Emissions Risk Analysis (AERA) for the NorthMet Mine Site

Draft: July 26, 2011

## INTRODUCTION

In January 2008 an AERA for the Mine Site [1] was submitted to the Minnesota Pollution Control Agency (MPCA) in support of the draft Environmental Impact Statement (DEIS). The Mine Site is located within an area zoned as a Mineral Mining/Industrial District that prohibits residential or farming activities. The potential incremental risks in the January 2008 AERA at the Mine Site property boundary were below guideline values. Applicable potential risks to a hypothetical resident at the boundary of the Mineral Mining/Industrial District were also below guideline values. Risk results were described in the DEIS.[2]

The project is now as described in the Draft Alternative Summary Memo (March 4, 2011) prepared by the Lead Agencies and the NorthMet Project Description Version 2 submitted by PolyMet on April 15, 2011. The changes relative to the project evaluated in the DEIS are not expected to introduce new chemicals to the process. An updated chemical list and emission inventory will be completed for the revised project and compared to the chemical list and emission estimates in the January 2008 AERA.

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after acceptance by the Lead Agencies. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

## BACKGROUND

The January 2008 Mine Site AERA included the following components:

- Estimates of air emissions from Mine Site sources, including fugitive dust (e.g., truck hauling of waste rock and ore, stockpiles, loading/unloading trucks and railcars, portable rock crushing and screening), combustion sources (e.g., truck tailpipe emissions, locomotives and space heaters) and fuel tanks
- Chemicals For Potential Evaluation (CFPE) = 52 (Table 1); Chemicals quantitatively evaluated = 32 (Table 2)

- Receptor Types Evaluated
    - Maximum Off-Site Receptor (assumed to be a worker); assumed exposure to maximum modeled air concentrations at the Mine Site Property Boundary: Potential acute (1-hr), subchronic and chronic inhalation risks were estimated at the PolyMet property boundary. For chronic risk, assumed outdoor exposure 24 hours a day, 365 days per year.
    - Potential Resident/Farmer Receptor; assumed exposure to maximum modeled air concentrations at the Mining District or Industrial Land Boundary: Continuous outdoor exposure in one location 24 hours a day, 365 days per year (MPCA's RASS incorporates exposure durations of 30 years for a resident and 40 years for a farmer).

      Note: A local mercury deposition analysis was not conduced for the Mine Site because potential mercury emissions from Mine Site sources were estimated to be less than one pound per year. Therefore, a Fisher receptor was not assessed in the January 2008 AERA for the Mine Site.

- Risk Estimation Methodology
    - Screening multi-pathway risks. AERMOD dispersion modeling; maximum modeled air concentrations input to the MPCA Risk Assessment Screening Spreadsheet (RASS).
- Incremental Risk Results (Table 3)
    - Maximum Off-Site Receptor, Mine Site Property Boundary. Estimates of potential inhalation risks (cancer, noncancer chronic, noncancer acute) were well below guideline values.
    - Resident/Farmer Receptor, at the Mining District or Industrial Land Boundary. Multipathway (inhalation + indirect) risks.
        - Cancer – Farmer Receptor. Estimated risk for a farmer receptor was 3E-05, above the incremental guideline value of 1E-05. The risk driver chemicals (individual risk 1E-06 or greater) were PAHs and dioxins/furans (2,3,7,8-TCDD equivalents).
        - Cancer – Resident Receptor. Estimated risk for a resident was 7E-07, below the guideline value of 1E-05.
        - Noncancer chronic. Estimated risks were well below the guideline value of 1.0. No chemicals were identified as risk drivers (all individual chemical risk < 0.1) (Appendix A, January 2008 AERA for the Mine Site).

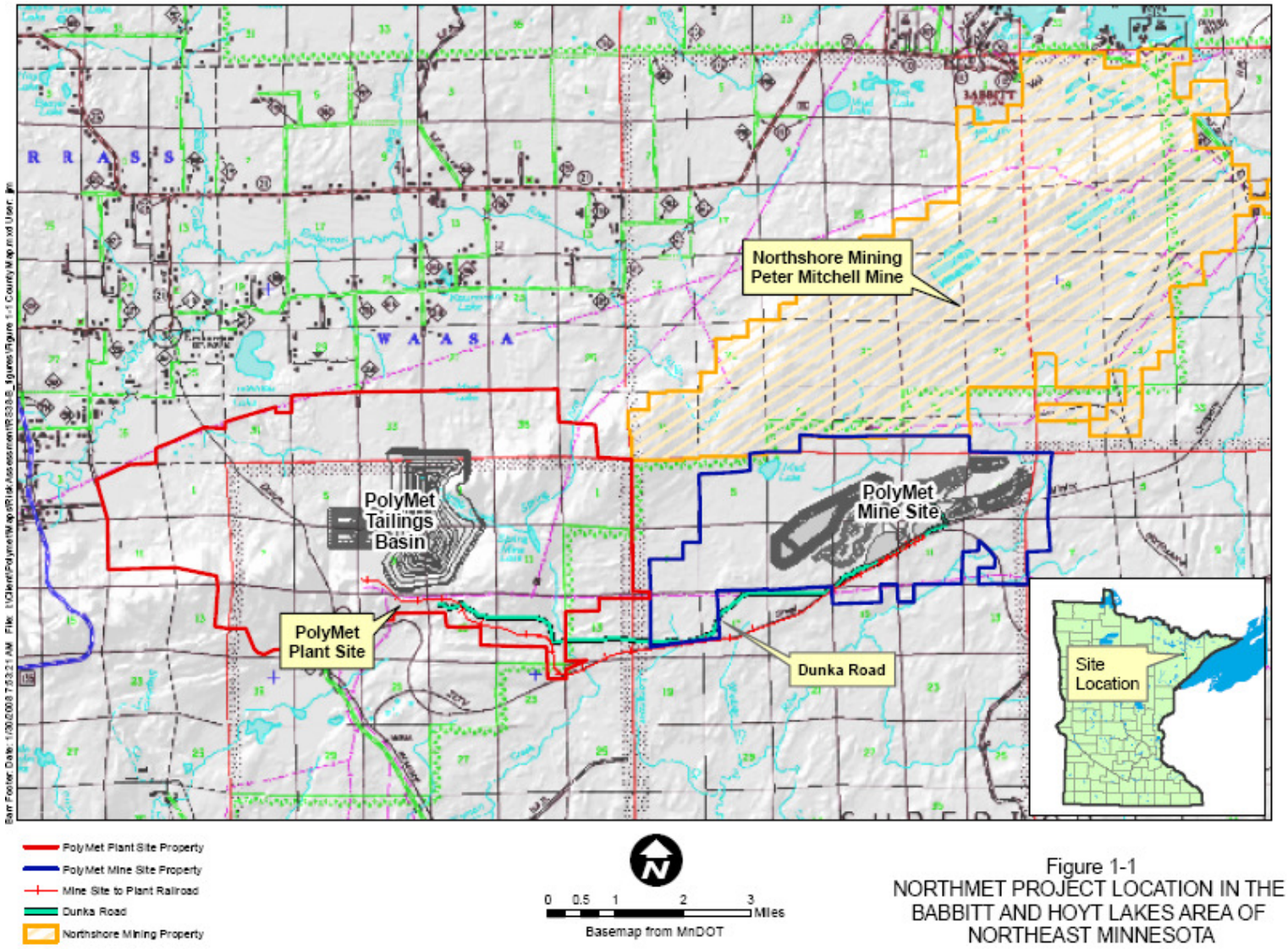



**Figure 1: Location of the NorthMet Mine Site in Relation to the Plant Site and Nearby Existing Mining Operations**
(from: January 2008 Mine Site AERA)

**Table 1**
**Chemicals Identified as Potentially Emitted from the Mine Site for the January 2008 AERA**
**(Chemicals for Potential Evaluation; CFPE)**
(from Table 2-1, January 2008 Mine Site AERA)

| Table 1<br>**Chemical Name** | **CAS No.** | **Mine Site Total Potential Emissions (Year 8) [1]** | | **Mine Site Total Potential Emissions (Year 16) [1]** | | **NOTES** |
|---|---|---|---|---|---|---|
| | | **(lb/hr)** | **(tons/yr)** | **(lb/hr)** | **(tons/yr)** | |
| 1,3 Butadiene | 106-99-0 | 0.0026 | 0.0113 | 0.0026 | 0.0113 | HAP |
| 2-Methylnaphthalene | 91-57-6 | 0.0006 | 0.0025 | 0.0006 | 0.0025 | |
| Acenaphthene | 83-32-9 | 2.72E-04 | 0.0012 | 2.72E-04 | 0.0012 | [2] |
| Acenaphtylene | 203-96-8 | 0.0008 | 0.0036 | 0.0008 | 0.0036 | [2] |
| Acetaldehyde | 75-07-0 | 0.0156 | 0.0681 | 0.0156 | 0.0681 | HAP |
| Acrolein | 107-02-8 | 0.0023 | 0.0102 | 0.0023 | 0.0102 | HAP |
| Anthracene | 120-12-7 | 1.55E-04 | 0.0007 | 1.55E-04 | 0.0007 | [2] |
| Antimony compounds | 7440-36-0 | 0.0040 | 0.0102 | 0.0040 | 0.0101 | HAP |
| Arsenic compounds | 7440-38-2 | 0.0060 | 0.0167 | 0.0060 | 0.0164 | HAP |
| Barium compounds | 7440-39-3 | 0.0726 | 0.1862 | 0.0719 | 0.1805 | |
| Benzene | 71-43-2 | 0.0479 | 0.2071 | 0.0479 | 0.2071 | HAP |
| Benzo(a)anthracene | 56-55-3 | 6.40E-05 | 2.78E-04 | 6.40E-05 | 2.78E-04 | [2] |
| Benzo(a)pyrene | 50-32-8 | 1.63E-05 | 7.07E-05 | 1.63E-05 | 7.07E-05 | [2] |
| Benzo(e)pyrene | 192-97-2 | 3.25E-06 | 1.43E-05 | 3.25E-06 | 1.43E-05 | [2] |
| Benzo(b)fluoranthene | 205-99-2 | 5.85E-05 | 2.53E-04 | 5.85E-05 | 2.53E-04 | [2] |
| Benzo(g,h,i)perylene | 191-24-2 | 3.46E-05 | 1.50E-04 | 3.46E-05 | 1.50E-04 | [2] |
| Benzo(k)fluoranthene | 205-82-3 | 1.52E-05 | 6.60E-05 | 1.52E-05 | 6.60E-05 | [2] |
| Beryllium compounds | 7440-41-7 | 0.0009 | 0.0023 | 0.0009 | 0.0023 | HAP |
| Boron compounds | 7440-42-8 | 0.0857 | 0.2041 | 0.0876 | 0.2092 | |
| Cadmium compounds | 7440-43-9 | 0.0030 | 0.0078 | 0.0030 | 0.0080 | HAP |
| Chromium compounds (as chromium III) | 7440-47-3 | 0.1146 | 0.2949 | 0.1152 | 0.2932 | HAP |
| Chrysene | 218-01-9 | 8.45E-05 | 0.0004 | 8.45E-05 | 0.0004 | [2] |
| Cobalt compounds | 7440-48-4 | 0.0496 | 0.1292 | 0.0497 | 0.1275 | HAP |
| Copper compounds | 7440-50-8 | 0.3680 | 1.0932 | 0.3840 | 1.1527 | |
| Dibenz(a,h)anthracene | 53-70-3 | 2.18E-05 | 9.43E-05 | 2.18E-05 | 9.43E-05 | [2] |
| Fluoranthene | 206-44-0 | 3.17E-04 | 0.0014 | 3.17E-04 | 0.0014 | [2] |
| Fluorene | 86-73-7 | 0.0010 | 0.0043 | 0.0010 | 0.0043 | [2] |
| Fluorides (as F) | N/A | 0.0588 | 0.1564 | 0.0588 | 0.1544 | |
| Formaldehyde | 50-00-0 | 0.0349 | 0.1522 | 0.0349 | 0.1522 | HAP |
| Hafnium | 7440-58-6 | 4.28E-05 | 1.87E-04 | 4.33E-05 | 1.90E-04 | |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 2.56E-05 | 1.11E-04 | 2.56E-05 | 1.11E-04 | [2] |
| Lead compounds | 7439-92-1 | 0.0776 | 0.1859 | 0.0794 | 0.1908 | HAP |
| Manganese compounds | 7439-96-5 | 1.2153 | 3.1822 | 1.2386 | 3.2406 | HAP |
| Mercury compounds | 7439-97-6 | 7.35E-05 | 3.18E-04 | 7.34E-05 | 3.18E-04 | HAP |
| Methane (CH4) | 74-82-8 | 0.0181 | 0.0795 | 0.0181 | 0.0795 | |
| Molybdenum compounds | 7439-98-7 | 0.0021 | 0.0054 | 0.0021 | 0.0053 | |
| Naphthalene | 91-20-3 | 0.0092 | 0.0397 | 0.0092 | 0.0397 | HAP |

| Table 1<br>**Chemical Name** | **CAS No.** | **Mine Site Total Potential Emissions (Year 8) [1]** | | **Mine Site Total Potential Emissions (Year 16) [1]** | | **NOTES** |
|---|---|---|---|---|---|---|
| | | **(lb/hr)** | **(tons/yr)** | **(lb/hr)** | **(tons/yr)** | |
| Nickel compounds | 7440-02-0 | 0.2522 | 0.6862 | 0.2522 | 0.6775 | HAP |
| Nitrous Oxide ($N_2O$) | 10102-44-0 | 4.0681 | 17.5989 | 4.0681 | 17.5989 | |
| Oxides of Nitrogen (NOx) (as $NO_2$) | N/A | 30.3425 | 611.2 | 30.3425 | 611.2 | |
| Phosphorus compounds | 7723-14-0 | 0.0532 | 0.2330 | 0.0413 | 0.1810 | HAP |
| Phenanthrene | 85-01-8 | 0.0028 | 0.0119 | 0.0028 | 0.0119 | [2] |
| Propylene | 115-07-1 | 0.1584 | 0.6841 | 0.1584 | 0.6841 | |
| Pyrene | 129-00-0 | 3.25E-04 | 0.0014 | 3.25E-04 | 0.0014 | [2] |
| Selenium compounds | 7782-49-2 | 0.0096 | 0.0273 | 0.0096 | 0.0270 | HAP |
| Sulfuric Acid Mist (as a mixture, with $SO_3$) | 7664-93-9 | 0.0075 | 0.0325 | 0.0075 | 0.0325 | |
| Tellurium | 13494-80-9 | 0.0212 | 0.0555 | 0.0212 | 0.0548 | |
| 2,3,7,8-TCDD equivalents | N/A | 5.46E-09 | 2.36E-08 | 5.46E-09 | 2.36E-08 | HAP [3] |
| Toluene | 108-88-3 | 0.0172 | 0.0743 | 0.0172 | 0.0743 | HAP |
| Vanadium compounds | 7440-62-2 | 0.0459 | 0.1194 | 0.0458 | 0.1170 | |
| Xylenes | 1330-20-7 | 0.0118 | 0.0512 | 0.0118 | 0.0512 | HAP |
| Zinc compounds | 7440-66-6 | 0.6094 | 1.4567 | 0.6236 | 1.4939 | |
| | | | | | | |
| ***# of CFPE*** | 52 | | | | | |
| ***Total CFPE Emissions*** | | 37.8 | 638.3 | 37.8 | 638.4 | |
| | | | | | | |

HAP = Hazardous air pollutant as defined by Section 112 of the 1990 Clean Air Act Amendments.

[1] Additional details on the emission estimates are provided in Stationary Point and Fugitive Source Emission Calculations for the NorthMet Project Mine Site (October 2007) and reformatted spreadsheet (December 2007). [3]

[2] Polycyclic organic matter (POM) is identified as a HAP by the 1990 Clean Air Act Amendments. Polycyclic aromatic hydrocarbons (PAHs) are a subset of POM. The individual PAH compounds are not identified as a HAP for this AERA.

[3] Emissions of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans were calculated as 2,3,7,8-TCDD equivalents based on published emission factors (factors calculated in Toxicity Equivalency Quotients, TEQs) and reflect the TEQ methodology used by the individual researchers at that time. No adjustment to the TEQ-based emission factor was made for this analysis.

**Table 2**
**Chemicals Quantitatively Evaluated for Potential Incremental Human Health Risks**
**in the January 2008 Mine Site AERA**
**(Chemicals for Evaluation, CFE)**
(From Table 2-2, January 2008 Mine Site AERA)

| Chemical [1] | CAS # | Total Mine Site Emissions (Year 8) (lb/hr) | Total Mine Site Emissions (Year 8) (tons/yr) | Total Mine Site Emissions (Year 16) (lb/hr) | Total Mine Site Emissions (Year 16) (tons/yr) |
|---|---|---|---|---|---|
| 1,3-Butadiene | 106-99-0 | 0.0026 | 0.0113 | 0.0026 | 0.0113 |
| Acetaldehyde | 75-07-0 | 0.0156 | 0.0681 | 0.0156 | 0.0681 |
| Acrolein | 107-02-8 | 0.0023 | 0.0102 | 0.0023 | 0.0102 |
| Antimony compounds | 7440-36-0 | 0.0040 | 0.0102 | 0.0040 | 0.0101 |
| Arsenic compounds | 7440-38-2 | 0.0060 | 0.0167 | 0.0060 | 0.0164 |
| Barium compounds | 7440-39-3 | 0.0726 | 0.1862 | 0.0719 | 0.1805 |
| Benzene | 71-43-2 | 0.0479 | 0.2071 | 0.0479 | 0.2071 |
| Benz(a)anthracene | 56-55-3 | 6.40E-05 | 2.78E-04 | 6.40E-05 | 2.78E-04 |
| Benzo(a)pyrene | 50-32-8 | 1.63E-05 | 7.07E-05 | 1.63E-05 | 7.07E-05 |
| Benzo(b)fluoranthene | 205-99-2 | 5.85E-05 | 2.53E-04 | 5.85E-05 | 2.53E-04 |
| Benzo(k)fluoranthene | 205-82-3 | 1.52E-05 | 6.60E-05 | 1.52E-05 | 6.60E-05 |
| Beryllium compounds | 7440-41-7 | 0.0009 | 0.0023 | 0.0009 | 0.0023 |
| Boron compounds | 7440-42-8 | 0.0857 | 0.2041 | 0.0876 | 0.2092 |
| Cadmium compounds | 7440-43-9 | 0.0030 | 0.0078 | 0.0030 | 0.0080 |
| Chrysene | 218-01-9 | 8.45E-05 | 0.0004 | 8.45E-05 | 0.0004 |
| Copper compounds | 7440-50-8 | 0.3680 | 1.0932 | 0.3840 | 1.1527 |
| Dibenzo(a,h)anthracene | 53-70-3 | 2.18E-05 | 9.43E-05 | 2.18E-05 | 9.43E-05 |
| Formaldehyde | 50-00-0 | 0.0349 | 0.1522 | 0.0349 | 0.1522 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 2.56E-05 | 0.0001 | 2.56E-05 | 1.11E-04 |
| Lead compounds | 7439-92-1 | 0.0776 | 0.1859 | 0.0794 | 0.1908 |
| Manganese compounds | 7439-96-5 | 1.2153 | 3.1822 | 1.2386 | 3.2406 |
| Mercury compounds | 7439-97-6 | 7.35E-05 | 3.18E-04 | 7.34E-05 | 3.18E-04 |
| Naphthalene | 91-20-3 | 0.0092 | 0.0397 | 0.0092 | 0.0397 |
| Nickel compounds | 7440-02-0 | 0.2522 | 0.6862 | 0.2522 | 0.6775 |
| Oxides of Nitrogen (NOx) as $NO_2$ | NA | 30.3425 | 611.2 | 30.3425 | 611.2 |
| Propylene | 115-07-1 | 0.1584 | 0.6841 | 0.1584 | 0.6841 |
| Selenium compounds | 7782-49-2 | 0.0096 | 0.0273 | 0.0096 | 0.0270 |
| Sulfuric Acid Mist (mixture with $SO_3$) | 7664-93-9 | 0.0075 | 0.0325 | 0.0075 | 0.0325 |
| PCDD/PCDF (TEQ basis) [2] | NA | 5.46E-09 | 2.36E-08 | 5.46E-09 | 2.36E-08 |
| Toluene | 108-88-3 | 0.0172 | 0.0743 | 0.0172 | 0.0743 |
| Vanadium (as vanadium oxide) | 7440-62-2 | 0.0459 | 0.1194 | 0.0458 | 0.1170 |
| Xylene (mixed isomers) | 1330-20-7 | 0.0118 | 0.0512 | 0.0118 | 0.0512 |
| | | | | | |
| Number of CFE | 32 | | | | |
| CFE Emissions | | 32.8 | 618.2 | 32.8 | 618.3 |

[1] Worst case Mine Site emissions were identified to occur in Year 8 and in Year 16. Quantitative risks were estimated for both the Year 8 and the Year 16 emission scenario. Additional details on the emission estimates provided in Reference [3]: Stationary Point and Fugitive Source Emission Calculations for the NorthMet Project Mine Site (October 2007) and reformatted spreadsheet (December 2007).

[2] PCDD/PCDF (TEQ, I-TEQ basis) is the same as 2,3,7,8-TCDD equivalents presented in Table 2-1.

## Table 3
## Estimated Potential Incremental Human Health Risks from the January 2008 Mine Site AERA
(Adapted from Table 3-3, January 2008 Mine Site AERA)

| Risk Category | PolyMet Mine Site Ownership Boundary (Year 8) | Mineral Mining/ Industrial District Boundary (Year 8) | PolyMet Mine Site Ownership Boundary (Year 16) | Mineral Mining/ Industrial District Boundary (Year 16) |
|---|---|---|---|---|
| | Potential Off-Site Receptor (MEI) [1] | Potential Resident/Farmer (MEI) [1] | Potential Off-Site Receptor {MEI) [1] | Potential Resident/Farmer (MEI) [1] |
| Cancer **[2]** | | | | |
| Inhalation | 3E-06 | 6E-07 | 4E-06 | 6E-07 |
| Indirect Pathway – Farmer | N/A | 3E-05 | N/A | 2E-05 |
| Indirect Pathway – Resident | N/A | 8E-08 | N/A | 7E-08 |
| | | | | |
| Total Multipathway – Farmer | N/A | 3E-05 | N/A | 2E-05 |
| Total Multipathway – Resident | N/A | 7E-07 | N/A | 6E-07 |
| Non-cancer Chronic **[3]** | | | | |
| Inhalation | 0.2 | 0.04 | 0.3 | 0.04 |
| Indirect Pathway – Farmer | N/A | 0.00007 | N/A | 0.00007 |
| Indirect Pathway – Resident | N/A | N/A [\5] | N/A | N/A [5] |
| | | | | |
| Total Multipathway – Farmer | N/A | 0.04 | N/A | 0.04 |
| Total Multipathway – Resident | N/A | 0.04 | N/A | 0.04 |
| Non-cancer subchronic **[3]** | 0.003 | N/A | 0.003 | N/A |
| Non-cancer Acute **[3], [4]** | 0.2 | N/A | 0.1 | N/A |

MEI = Maximum Exposed Individual (potential exposure to the maximum modeled air concentration at a receptor location)
RASS = Risk Assessment Screening Spreadsheet
N/A = not applicable and not assessed
HQ = hazard quotient

[1] PolyMet's land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Therefore, only potential inhalation risks to a potential off-site receptor (Maximum Exposed Individual) were estimated at PolyMet's ownership boundary and resident and farmer multipathway risks were not calculated. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer to the southeast of the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated potential to emit emissions and mine layout for Year 8 of Mine Site operations, and for Year 16, respectively.

[2] Incremental cancer risk guideline value is 1E-05, Minnesota Department of Health (MDH)

[3] Incremental non-cancer (chronic, subchronic and acute) guideline value is 1.0, MDH.

[4] The USEPA factor of 75% is applied to the maximum modeled one-hour $NO_x$ air concentration as a conservative estimate of the conversion of NO to $NO_2$.

[5] Multi-media factors not available for the Chemicals of Potential Interest; risks not estimated for a Resident receptor in MPCA's Risk Assessment Spreadsheet (RASS), version 20090704 used to estimate potential risks for the January 2008 Mine Site AERA.

## SCOPE OF WORK (proposed) – Supplemental Air Emissions Risk Analysis, Mine Site

## I PROJECT ONLY ASSESSMENT

### Objective

Conduct a supplemental risk evaluation to the January 2008 AERA that incorporates the changes to the Mine Site operations and provides revised risk estimates for use in the Supplemental DEIS.

### Chemicals to be Included in the Quantitative Analysis

Evaluate risks associated with the following chemicals:

- Risk driver chemicals from the January 2008 Mine Site AERA (Appendix A) (Table 4)
    - A "risk driver chemical" is a chemical with an individual cancer risk of 1E-06 or greater or an individual noncancer risk (hazard quotient) of 0.1 or greater.
        - Incremental cancer risk of 1E-06 or greater: nickel, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, dioxins/furans as 2,3,7,8-TCDD equivalents.
        - Incremental noncancer risk of 0.1 or greater: manganese, nickel, $NO_2$
- Chemicals not evaluated in the January 2008 Mine Site AERA because no toxicity values were available, but now have toxicity values available (Table 4) and may be associated with diesel fuel combustion or waste rock or ore handling: diesel particulate, crystalline silica

**Table 4**
**Chemicals to be Evaluated in the Supplemental AERA for the Mine Site**

| Chemical | Reason Included | Update Assessment for: | | |
|---|---|---|---|---|
| | | Cancer | Noncancer Chronic | Noncancer Acute |
| Diesel Particulate | Toxicity Value Now Available | N/a | X | N/a |
| Dioxins/furans (diesel fuel combustion) | Risk Driver January 2008 AERA | X | N/a | N/a |
| Manganese | Risk Driver January 2008 AERA | N/a | X | N/a |
| Nickel compounds | Risk Driver January 2008 AERA | X | X | X |
| Nitrogen oxides (NOx) (as $NO_2$) | Risk Driver January 2008 AERA | N/a | N/a | X |
| PAHs (diesel fuel combustion) | | | | |
| Dibenzo(a,h)anthracene | Risk Driver January 2008 AERA | X | N/a | N/a |
| Indeno(1,2,3-cd)pyrene | Risk Driver January 2008 AERA | X | N/a | N/a |
| Silica, crystalline (silicon dioxide) | Toxicity Value Now Available | N/a | X | N/a |

N/a = risk category not applicable; toxicity value not available.

## Receptor Types and Assumed Exposure

Two receptor types will be evaluated (same as in the January 2008 AERA).

- Maximum Off-Site Receptor. Assumed exposure to the maximum modeled air concentration for the one hour and annual averaging time periods at the Mine Site property boundary.
    - Acute (one-hour) inhalation risks
    - Chronic inhalation risks (outdoors for 24 hours/day, 365 days per year) (MPCA AERA guidance indicates the highest exposure duration in the RASS is for 40 years).
- Potential Resident/Farmer Exposure. Assumed exposure to the maximum modeled air concentration for the one hour and annual averaging time periods at the Mineral Mining/ Industrial District boundary.
    - Acute (one-hour) inhalation risks
    - Chronic multi-pathway risks (outdoors in one location for 24 hours per day, 365 days per year; AERA guidance assumes 35 years for a resident, 40 years for a farmer)

## Estimated Emissions and Sources

Emission estimates for Mine Site sources, including fugitive dust (from haul roads, loading/unloading of waste rock and ore, crushing and screening of construction rock) and diesel combustion emissions (from haul trucks and locomotives), will be updated to reflect any changes in operations. Estimates of potential emissions for toxic air pollutants will be based on the approach used to estimate criteria pollutant air emissions for use in Class II modeling.

Revised emissions of toxic air pollutants will be compared to emission estimates evaluated in the January 2008 AERA. The percent change in emissions will be used to assess whether other chemicals evaluated in the January 2008 AERA should be evaluated as potential risk driver chemicals in the Supplemental AERA. Changes in emissions will be assessed for significance by a screening calculation.

Revised Incremental Risk = January 2008 risk x % change in emissions

If the revised potential incremental cancer risk for a chemical is 1E-06 or greater, or the revised noncancer risk is 0.1 or greater, then that chemical will be added to the list of chemicals to be evaluated in the Supplemental risk analysis.

Emission sources that have the potential to emit the risk driver chemicals will be modeled. The Supplemental AERA will assess potential emissions from the Mine Site under typical operating scenarios. For example, upset conditions or breakdown/malfunction emission scenarios will not be evaluated.

Some minor sources of emissions that are expected to be operated infrequently are proposed to be excluded from modeling.

- *Emergency diesel generator* – An emergency diesel generator will be located in the wastewater treatment facility (WWTF; EU 332) and will be used at the Mine Site to provide backup in case of a power failure. The major pollutant to be emitted from this generator is $NO_X$. Some particulate metals may also be emitted. Due to the infrequent use and relatively short operating time potential emissions from these diesel generators are expected to be small and they will not be modeled in the AERA.
- *Mobile diesel generator* (EU 344) – A mobile diesel generator will provide temporary power to large excavators and drill rigs used in the mine pits. These large excavators and drill rigs will be electric powered for their primary operation, but will need a temporary power supply in order to move from one location to another. This generator is only sized to provide power for locomotion to the equipment, not to operate it for its primary function (drilling or loading haul trucks). It will be operated infrequently, and when it is operated, one of the large pieces of electrical mining equipment will be out of service, effectively limiting emissions from normal mining activities. Given the low utilization of the generator and the circumstances under which it is operated, emissions from this source will not be modeled for the AERA.
- *Diesel fuel tanks* – Diesel fuel tanks can potentially emit VOCs. Due to the very small potential VOC emissions likely associated with these tanks they will not be modeled in the AERA.

Potential emissions from these minor sources will be included in the emission inventory. MPCA's AERA guidance allows emissions to be eliminated from quantitative analysis if they are less than 1% of total emissions on a pollutant by pollutant basis. Therefore, estimated emissions for the risk driver chemicals for the individual sources will be compared to the MPCA's 1% threshold. If emissions for a risk driver chemical for a specific source exceed the 1% threshold, that source and the risk driver emissions will be included in the quantitative risk analysis.

Non-risk driver chemicals will be discussed qualitatively as needed in the AERA. The chemicals that are currently expected to be discussed qualitatively include iron. Other chemicals may be added to the list as

additional comments are received from reviewers of the Work Plan. Additional chemicals that require qualitative evaluation will be included in the updated AERA report for the Mine Site.

### Toxicity Values

The toxicity values in the MPCA's current version of the RASS, as of April 2011 (expected to be the same version of the RASS to be used for the Supplemental AERA for the Plant Site) will be used to estimate potential human health risks for the Supplemental AERA for the Mine Site.

For chemicals evaluated quantitatively in the January 2008 AERA, but are not listed in Table 4 of this Work Plan, chemical toxicity values used in the January 2008 AERA will be compared to current values. Changes in chemical toxicity values will be assessed for significance by a screening calculation.

Revised Risk = January 2008 risk x % change in toxicity value

If the revised potential incremental cancer risk for a chemical is 1E-06 or greater, or the revised noncancer risk is 0.1 or greater, then that chemical will be added to the list of chemicals to be evaluated in the Supplemental risk analysis.

In the case that a chemical has a change in emission rate and a change in toxicity value, the following screening calculation will be used to determine if the combined changes are significant enough to warrant further evaluation in this Supplemental AERA.

Revised Risk = January 2008 risk x % change in emissions x % change in toxicity value

If the revised potential incremental cancer risk for a chemical is 1E-06 or greater, or the revised noncancer risk is 0.1 or greater, then that chemical will be added to the list of chemicals to be evaluated in the Supplemental AERA.

### Air Dispersion Modeling and Estimating Potential Incremental Human Health Risks

Any updates to building dimensions, stack dimensions, road locations, etc. for the project will be used in the modeling. The modeling for the AERA will follow closely with the Class II modeling and will use the Class II receptor grid. The most recent version of the AERMOD model will be used to estimate one-hour and annual air concentrations. Surface meteorological data from Hibbing, MN (2006-2010) and

concurrent mixing height data from International Falls will be used. The same procedures for modeling fugitive sources will be used for the AERA as for the Mine Site criteria pollutant modeling.

Maximum modeled air concentrations will be identified for each receptor and exposure time/duration. The modeled air concentrations will be input to the most recent version of the MPCA's Risk Assessment Screening Spreadsheet ("Concs" tab) and potential incremental risks estimated.

### Local Mercury Deposition Analysis (not applicable)

A local mercury deposition analysis is excluded from the Mine Site AERA. Potential mercury emissions from the Mine Site are less than one pound per year, based on previously approved emission estimates (Table 2) and current draft emission calculations. Revisions to emission calculations are being discussed with MPCA staff. If revised estimates of potential mercury emissions are greater than one pound per year at the Mine Site as a result in the final updated emission inventory, mercury modeling will be reconsidered.

# II CUMULATIVE INHALATION RISK EVALUATION

The MPCA has requested a cumulative inhalation risk assessment be performed as part of the Supplemental AERA. MPCA guidance [4] indicates that the cumulative analysis should focus on the location of the most impacted residential location from the proposed project. When reasonably foreseeable land use is considered, the nearest potential locations for a resident receptor are approximately 0.6 miles (1.0 kilometers) to the southeast of the Mine Site property boundary and 1.25 miles (2 kilometers) northwest of the Mine Site property boundary, respectively, at the Mineral Mining/Industrial District boundary (Figure 2).

Two cities are located near the proposed Mine Site: Babbitt, approximately 6 miles (10 kilometers) north, and Hoyt Lakes, approximately 9 miles (16 kilometers) southwest. Estimates of potential cumulative risks for a receptor in either city will be lower than that estimated for the potential resident locations relatively close to the Mine Site property boundary. Therefore, cumulative risks estimated for the two potential resident receptor locations near the Mine Site will serve as surrogate estimates of potential risk to a resident of either Babbitt or Hoyt Lakes.

Other proposed or recently completed projects in the vicinity of the Mine Site include the following: NorthMet Plant Site, Mesabi Mining (formerly Mesabi Nugget Phase II), Mesabi Nugget Large Scale Demonstration Plant (environmental review and permitting completed), and the Cliffs Erie Pellet Yard (environmental review and permitting completed). Table 5 indicates that in most cases, these other projects are typically more than 10 km from the potential resident locations of interest near the Mine Site. At the larger distances, potential contributions of air emissions to the resident locations of interest are not likely to be significant. Additional discussion is provided for each project.

- NorthMet Plant Site. The Plant Site is located approximately 8 miles to the west of the Mine Site. The ambient air boundaries for the Mine Site and the Plant Site are adjacent, but the emission generating activities and the maximum modeled air concentrations are relatively far apart. The Supplemental AERA for the Plant Site [5] will provide updated modeled air concentrations on the Class II receptor grid. That receptor grid will overlap with the dispersion modeling receptor grid to be used for the Mine Site AERA. The modeled air concentrations and estimates of potential risk from the Supplemental AERA for the Plant Site will be used in assessing potential cumulative inhalation risks for the potential resident receptor locations near the Mine Site.

- The August 2009 AERA for the Mesabi Mining Project [6] included the proposed mining and crushing/concentrating of taconite ore and the recently built Mesabi Nugget Large Scale Demonstration Plan (LSDP). Modeling results from the Mesabi Mining Project were submitted to the MPCA and are considered to be publicly available. The modeling results (air concentrations; estimated inhalation risks) for receptor nodes nearest to the potential resident locations identified at the Mine Site (Figure 2) will be used in this cumulative evaluation.
- Cliffs Erie Pellet Yard. The Cliffs Erie Pellet Yard is not expected to be a significant source of emissions based on cumulative modeling. [7] Therefore, it is excluded from the cumulative inhalation risk evaluation at this time. Furthermore, since the previous Mines Site AERA was conducted, a construction permit for expanded operations at the pellet yard has expired and current permitted activities are minimal.

Projects more than 25 kilometers from the Mine Site, such as the Keetac Expansion Project, the Essar Steel Project and the Mesaba Energy Project (West Range site) near Keewatin and Nashwauk on the west end of the Iron Range, are not expected to be significant contributors to air concentrations in the Babbitt or Hoyt Lakes area. The risk report will reiterate this information.

Another emission source from the Hoyt Lakes area to be included in the cumulative analysis is Minnesota Power's Syl Laskin power plant. Facility emissions of selected air toxic pollutants (e.g., HCl, HF, PAHs, dioxins/furans) and $NO_X$ (assessed as $NO_2$) were modeled for the cumulative inhalation risk analysis conducted for the Mesabi Mining Project.[6] Those modeling results were submitted to the MPCA and can be obtained from that agency. Of the air pollutants assessed for the Syl Laskin facility, only the estimated $NO_X$ emissions (assessed as $NO_2$) were found to have estimated risks greater than the MPCA's significant threshold of 0.1 for noncancer risks; a maximum estimated noncancer acute inhalation risk of 0.12 for a hypothetical resident receptor at the former LTV Steel Mining Company ambient air boundary near mine area 2WX. [6] Therefore, only potential $NO_2$ air concentrations and inhalation risks from the Syl Laskin facility are proposed to be included in the cumulative analysis for the Supplemental AERA for the Mine Site.

Chemicals of interest for the cumulative inhalation evaluation are presented in Table 6 and primarily represent the risk driver chemicals from the NorthMet Project (Mine Site and Plant Site) and the Mesabi Mining Project. Table 6 provides a summary of the chemicals for each project or existing facility to be included in the cumulative inhalation risk evaluation.

**Table 5**
**Estimated Distances of Potential Residential Receptors near the Proposed Mine Site to Projects and Operating Facilities in the Babbitt and Hoyt Lakes Areas**

| Potential Residential Receptor Location | Distance To: | Distance (approximate; (miles) | Distance (approximate; kilometers) |
|---|---|---|---|
| North/Northwest of the Mine Site [1] | Mine Site, nearest operations or pit | 3 | 5 |
| | Plant Site Operations | 6 | 10 |
| | Mesabi Nugget LSDP | 8 | 13 |
| | Mesabi Mining (crushing area) | 7 | 13 |
| | Mesabi Mining (mine area 2WX) [2] | 9 | 16 |
| | Laskin Energy Center | 10 | 17 |
| | | | |
| Babbitt (north of the Mine Site) | Mine Site, nearest operations or pit | 5 | 9 |
| | Plant Site | 12 | 19 |
| | Mesabi Nugget LSDP | 14 | 23 |
| | Mesabi Mining (crushing area) | 13 | 22 |
| | Mesabi Mining (mine area 2WX) [2] | 15 | 26 |
| | Laskin Energy Center | 16 | 26 |
| | | | |
| Southeast of the Mine Site [1] | Mine Site, nearest operations or pit | 2 | 4 |
| | Plant Site | 10 | 17 |
| | Mesabi Nugget LSDP | 13 | 22 |
| | Mesabi Mining (crushing area) | 11 | 18 |
| | Mesabi Mining (area 2WX) | 12 | 20 |
| | Laskin Energy Center | 12 | 21 |
| | | | |

[1] The potential resident location to the north/northwest of the Mine Site and to the southeast of the Mine Site, respectively, are at the Mineral Mining/Industrial Land Boundary (see Figure 2 of this Work Plan).

[2] Mine Area 2WX is on the southeast portion of the Mesabi Mining Project area, just north of Colby Lake and just northwest of the town of Hoyt Lakes.

LSDP = Large Scale Demonstration Plant

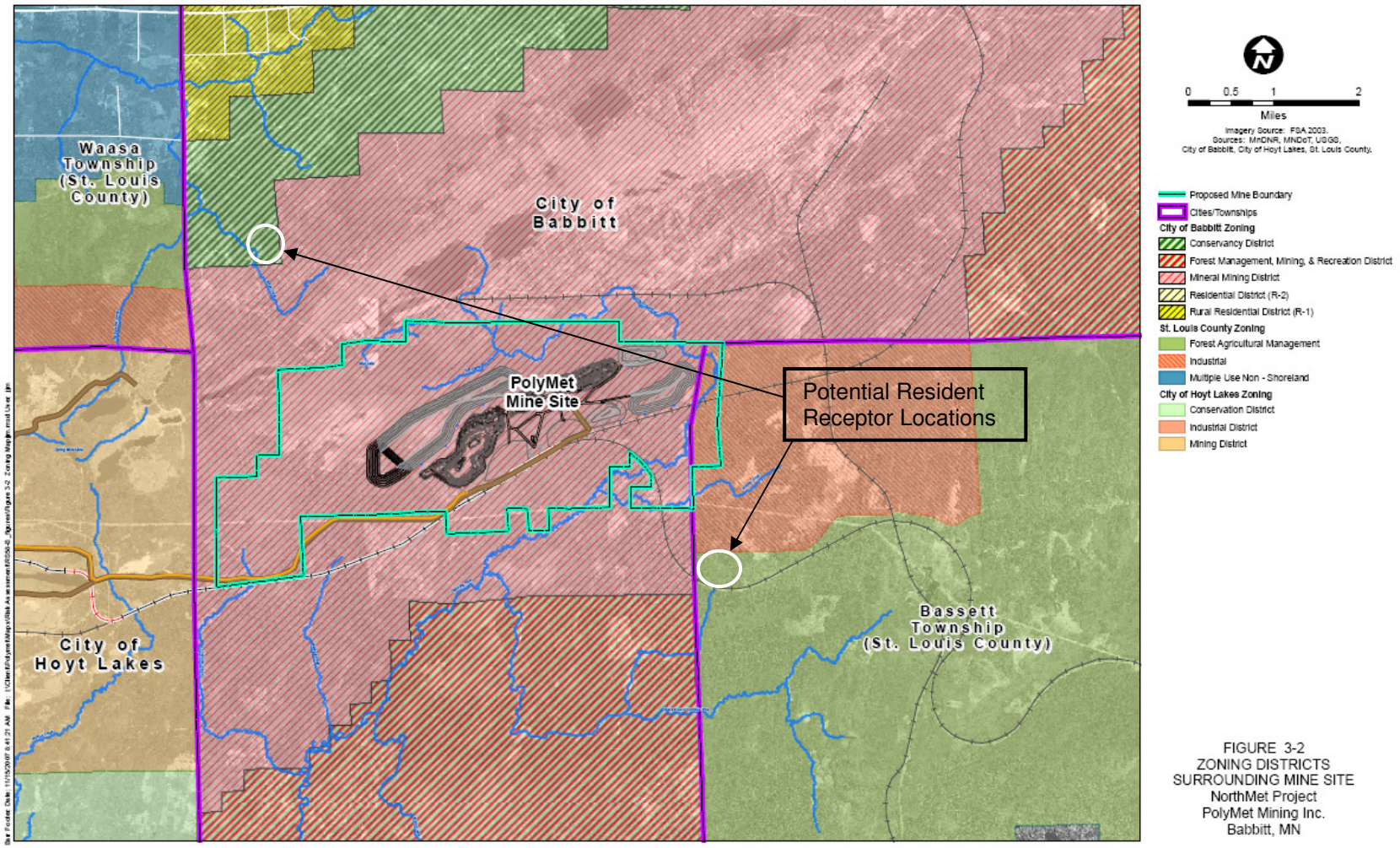



**Figure 2. Location of the Mine Site in relation to the Mineral Mining/Industrial District Boundary and Potential Locations for a Resident Receptor**
[Adapted from Figure 3-2 from the January 2008 Mine Site AERA]

**Table 6**
**Risk Driver Chemicals to be Assessed in the Cumulative Inhalation Risk Evaluation to be Conducted for the Mine Site Supplemental AERA**

("X" denotes the inhalation risk category to be evaluated)

| Risk Driver Chemical (Inhalation) [1] | Project / Facility [2] | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|---|
| Arsenic compounds | Plant Site (tailings basin) | X | X | X |
| Diesel particulate | Mine Site<br>Plant Site | N/a | X | N/a |
| Dioxins/furans | Mine Site<br>Plant Site | X | N/a | N/a |
| Manganese compounds | Mine Site<br>Plant Site<br>Mesabi Mining | N/a | X | N/a |
| Nickel compounds | Mine Site<br>Plant Site | X | X | X |
| $NO_2$ | Mine Site<br>Plant Site<br>Mesabi Mining<br>Syl Laskin Energy Center [3] | N/a | N/a | X |
| PAHs [4] | Mine Site | X | N/a | N/a |
| Silica, crystalline [5] | Mine Site<br>Plant Site<br>Mesabi Mining | N/a | X | N/a |

N/a = toxicity value not available; risk category not applicable

[1] Risk driver chemical identified as a chemical having incremental cancer risk of 1E-06 or greater, or incremental noncancer risk of 0.1 or greater.

[2] Other Projects / Facilities proposed for inclusion in the cumulative human health risk evaluation for the Mine Site:
a. Mesabi Mining (formerly the Mesabi Nugget Phase II project); The August 2009 AERA included emissions from the proposed mining and the Mesabi Nugget Large Scale Demonstration Plant (LSDP).
b. NorthMet Plant Site (updated AERA, 2011)
c. Minnesota Power, Syl Laskin Energy Center

[3] The Syl Laskin Energy Center was included in the air dispersion modeling and risk results for the cumulative inhalation evaluation conducted for the Mesabi Nugget Phase II Project; August 2009 Air Emissions Risk Analysis for the Post-Project Total Facility (LSDP Project + Mining). Emissions modeled for the Syl Laskin facility were $NO_2$, HCl, HF, PAHs and dioxins/furans. Maximum modeled air concentrations were input to the MPCA's RASS and only $NO_2$ was identified as a risk driver chemical for the Syl Laskin facility. $NO_2$ is the only chemical proposed to be evaluated from the Syl Laskin Energy Center as part of the cumulative analysis to be conducted for the Mine Site AERA.

[4] PAHs to be evaluated: dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene

[5] Crystalline silica to be assessed as part of the respective Supplemental Mine Site AERA and the Supplemental Plant Site AREA for the NorthMet Project. In addition, previously modeled air concentrations and estimated risks from the Mesabi Mining Project at the potential resident locations near the NorthMet Mine Site will be used in the cumulative analysis.

**Table 7**
**Proposed Format for Estimating Potential Cumulative Inhalation Risks for the Supplemental AERA to be Conducted for the Mine Site**

| Estimated Potential Risk | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background | | | |
| Ambient air monitoring (calculated by MPCA) | | | |
| Minnesota Power, Syl Laskin Energy Center ($NO_2$) | | | |
| | | | |
| Incremental | | | |
| Mine Site | | | |
| Plant Site | | | |
| Mesabi Mining Project (includes the LSDP) | | | |
| | | | |
| Total | | | |

LSDP = Mesabi Nugget, Large Scale Demonstration Project

## Reporting

A standard report will be prepared for the supplemental AERA that appropriately references to the January 2008 Mine Site AERA. Uncertainty in the risk analysis will be discussed, per MPCA (2007) guidance.

The cumulative inhalation risk results will be included as a separate section within the Supplemental Mine Site AERA report.

## References

1. PolyMet Mining, 2008. Air Emissions Risk Analysis – Mine Site. Prepared by Barr Engineering Company. January 2008.
2. MDNR, 2009. Draft Environmental Impact Statement for the NorthMet Project. Risk results reported in Section 4.6. Minnesota Department of Natural Resources, St. Paul, MN. October 2009.
3. PolyMet Mining, 2007. Stationary Point and Fugitive Source Emission Calculations for the NorthMet Project Mine Site (October 2007) and reformatted spreadsheet (December 2007). Prepared by Barr Engineering Company.

4. MPCA, 2009. Guidance, How to Conduct a Cumulative Air Emissions Risk Analysis. Aq-9-21. March 2009.
5. PolyMet Mining, 2011. Work Plan for a Supplemental Air Emissions Risk Analysis (AERA) to be conducted for the Plant Site. Prepared by Barr Engineering Company. April 2011 submittal to the MPCA; revised July 2011.
6. Mesabi Nugget, 2009. Air Emissions Risk Analysis for the Post-Project Total Facility (Phase I and Phase II). Prepared by Barr Engineering Company. August 2009. (Mesabi Nugget Phase II Project now referred to as the Mesabi Mining Project).
7. PolyMet Mining, 2007. Air Emissions Class II Area Cumulative Impacts Report. Prepared by Barr Engineering Company. March 2007.

**Attachment T**

**Work Plan for a Supplemental Air Emissions Risk Analysis (AERA) for the NorthMet Plant Site**

# PolyMet Mining Inc.

## Work Plan for a Supplemental Air Emissions Risk Analysis (AERA) for the NorthMet Plant Site

Version 2: August 12, 2011

## INTRODUCTION

In May 2005 an AERA for the Plant Site [1] was completed in support of the Scoping Environmental Assessment Worksheet (EAW). To address changes to the proposed facility after May 2005, a second AERA was completed in March 2007 [2] in support of the draft Environmental Impact Statement (DEIS). The potential incremental risks in the March 2007 AREA were at or below guideline values, similar to the risks estimated in the May 2005 AERA.

The project is now as described in Draft Alternative Summary Memo (March 4, 2011) prepared by the Lead Agencies and the NorthMet Project Description Version 2 submitted by PolyMet on April 15, 2011. The changes relative to the project evaluated in the DEIS are not expected to introduce new chemicals to the process and are not expected to increase emissions from those assessed in the March 2007 AERA. An updated chemical list and emission inventory will be completed for the revised project and compared to the chemical list and emission estimates in the May 2007 AERA.

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after acceptance by the Lead Agencies. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

## BACKGROUND

The March 2007 Plant Site AERA included the following components:

- Emission estimates from Plant Site sources, including 2 autoclaves, electrowinning, combustion sources ( including space heaters) and fuel tanks
- Chemicals of Potential Interest = 74 (Table 1); Chemicals quantitatively evaluated = 39 (Table 2)
- Receptor Types Evaluated
    - Resident/Farmer, chronic risks: Continuous outdoor exposure in one location 24 hours a day, 365 days per year at the industrial land boundary (the former LTV Steel Mining

Company (LTVSMC) ambient air boundary) (70 years inhalation risk; 30 years, resident multipathway risk; 40 years, farmer multipathway risk).

- Worker; Reasonable Maximum Exposure Off-Site Worker: Outdoor exposure 8 hours a day, 250 days per year, for 25 years. Potential acute (1-hr) and chronic inhalation risks were estimated at the PolyMet property boundary.
- Fisher (for potential mercury related risks); chronic risks based on fish consumption.

- Risk Estimation Methodology
  - Screening multi-pathway risks. AERMOD dispersion modeling; maximum modeled air concentrations input to the MPCA Risk Assessment Screening Spreadsheet (RASS).
  - Fish consumption, Mercury. Emissions of 8.4 pounds per year, primarily from the two autoclaves, were assessed using the MPCA Mercury Risk Estimation Method (MMREM).
    - Scenario 1: elemental Hg = 25%, oxidized Hg = 50%, particle-bound Hg = 25%. Scenario 2: elemental Hg = 80%, oxidized Hg = 10%, particle-bound Hg = 10%.
    - Heikkilla Lake, a small headwater lake within 3 kilometers of the Plant Site was evaluated.
- Incremental Risk Results (Table 3)
  - Cancer. Estimated risks were below the incremental guideline value of 1E-05. The risk driver chemical (individual risk 1E-06 or greater) was nickel.
  - Noncancer chronic. Estimated risks were below the guideline value of 1.0. The risk driver chemical (individual chemical risk of 0.1 or greater) was nickel.
  - Noncancer acute (Plant Site boundary). The highest estimated summed risk for all chemicals was 1.1. When the locations of maximum modeled air concentrations were taken into account, maximum potential risk was 0.9. Risk driver chemicals (individual risk of 0.1 or greater) were $NO_2$, nickel, and arsenic.

- Mercury. Potential incremental change in fish mercury = 0.004 to 0.015 ppm (0.6% to 2% of background). HQ's for the recreational and subsistence fisher ranged from 0.02 to 0.07 and 0.08 to 0.34, respectively.

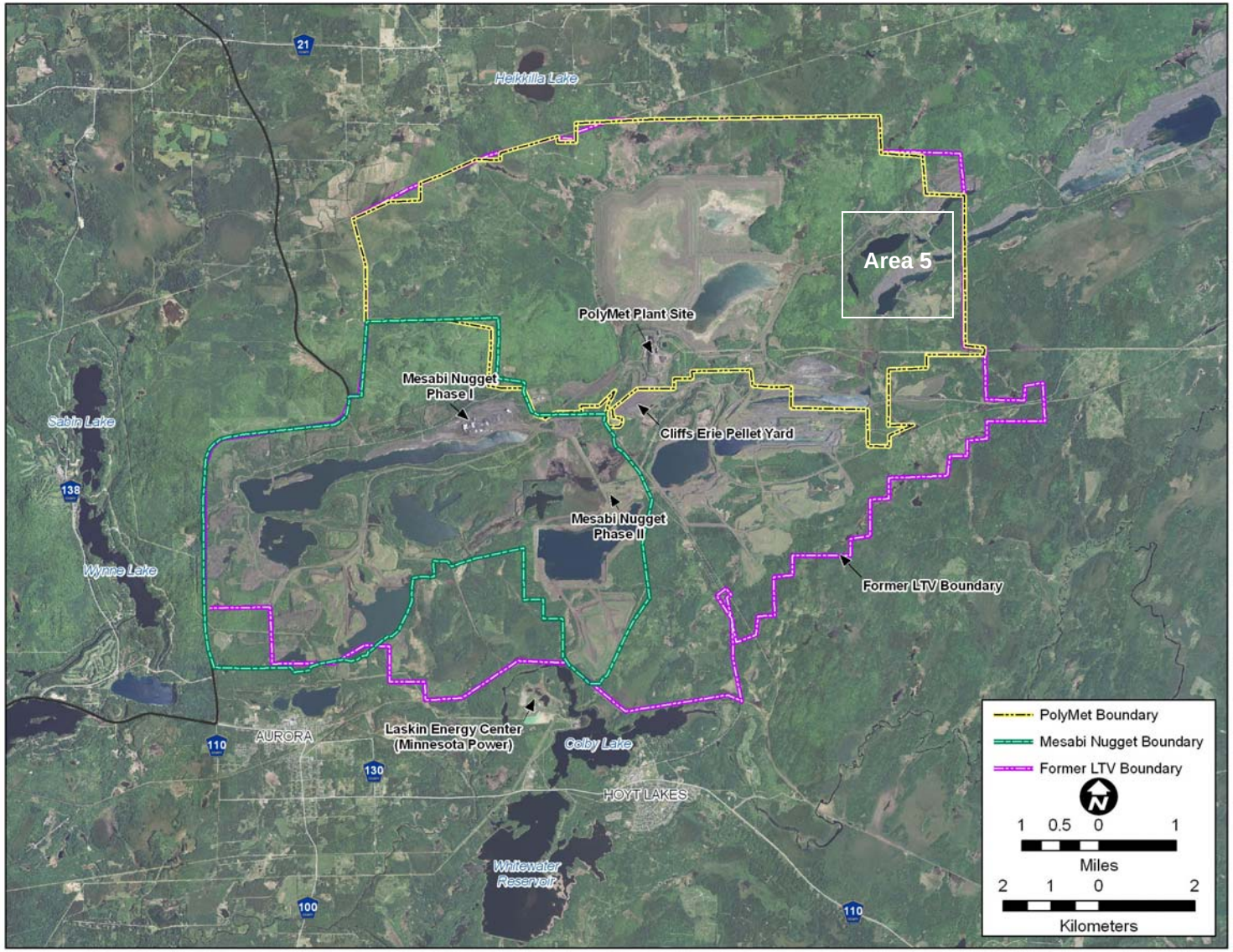

Area 5
PolyMet Plant Site
Mesabi Nugget Phase I
Cliffs Erie Pellet Yard
Mesabi Nugget Phase II
Former LTV Boundary
Laskin Energy Center (Minnesota Power)
Colby Lake
AURORA
HOYT LAKES
Whitewater Reservoir
Sabin Lake
Wynne Lake
Heikkila Lake
PolyMet Boundary
Mesabi Nugget Boundary
Former LTV Boundary
1 0.5 0 1
Miles
2 1 0 2
Kilometers

**Figure 1: Location of the Plant Site in Relation to other Nearby Facilities and Industrial Lands**

**Table 1**
**Chemicals Identified as Potentially Emitted from the Plant Site for the March 2007 AERA**
(from Table 2-1, March 2007 Plant Site AERA)

| | | |
|---|---|---|
| 1,3-Butadiene | Cadmium | Manganese |
| 2-Methylnaphthalene | Calcium Carbonate (Limestone) | Mercury |
| 3-Methylchloranthrene | Calcium Oxide (Lime) | Methyl Isobutyl Carbinol |
| 4-Nonylphenol branched | Carbon Disulfide | Molybdenum |
| 5-T-Nonyl-2-hydroxyacetophenone, oxime | Chromium (III) (chromium and compounds) | Naphthalene |
| 7,12-Dimethylbenzo(a)anthracene | Chromium (VI) | Nickel |
| Acenaphthene | Chrysene | Nitrous Oxide ($N_2O$) |
| Acenaphthylene | Cobalt | Oxides of Nitrogen (as $NO_2$) |
| Acetaldehyde | Copper | Phenanthrene |
| Acrolein | Crystalline Silica | Phosphorus |
| Anionic Acrylamide Copolymer | Dibenzo(a,h)anthracene | Polyacrylamide |
| Anthracene | Dichlorobenzene | POM |
| Anthracite | Fluoranthene | Propylene |
| Antimony | Fluorene | Pyrene |
| Arsenic | Fluorides | Selenium |
| Barium | Formaldehyde | Silica Sand |
| Benz(a)anthracene | Garnet | Sodium Hydrosulfide |
| Benzaldehyde, 2-hydroxy-5-nonyl, oxime | Guar Gum | Sodium Isopropyl Xanthate |
| Benzene | Hafnium | Sulfuric Acid |
| Benzo(a)pyrene | Hexane | Tellurium |
| Benzo(b)fluoranthene | Hydrogen Chloride | Toluene |
| Benzo(g,h,i)perylene | Hydrogen Fluoride | Vanadium |
| Benzo(k)fluoranthene | Hydrogen Sulfide | Xylene (mixed isomers) |
| Beryllium | Indeno(1,2,3-cd)pyrene | Zinc |
| Boron | Lead | |

74 chemicals

**Table 2**
**Chemicals Quantitatively Evaluated for Potential Incremental Human Health Risks in the March 2007 Plant Site AERA**
(From Table 2-2, March 2007 Plant Site AERA)

| | | |
|---|---|---|
| 1,3-Butadiene | Cadmium | Indeno(1,2,3-cd)pyrene |
| 7,12-Dimethylbenzo(a)anthracene | Carbon Disulfide | Isopropyl Alcohol |
| Acetaldehyde | Chromium (III) (chromium and compounds) | Lead |
| Acrolein | Chromium (VI) | Manganese |
| Antimony | Chrysene | Mercury |
| Arsenic | Copper | Naphthalene |
| Barium | Cumene | Nickel |
| Benz(a)anthracene | Dibenzo(a,h)anthracene | Oxides of Nitrogen (as $NO_2$) |
| Benzene | Dichlorobenzene | Propylene |
| Benzo(a)pyrene | Formaldehyde | POM |
| Benzo(b)fluoranthene | Hexane | Selenium |
| Benzo(k)fluoranthene | Hydrogen Chloride | Sulfuric Acid |
| Beryllium | Hydrogen Fluoride | Toluene |
| Boron | Hydrogen Sulfide | Xylene (mixed isomers) |

39 chemicals

## Table 3
## Estimated Potential Incremental Human Health Risks from the March 2007 Plant Site AERA
(Adapted from Table 3-3 in the March 2007 Plant Site AERA)

| | NorthMet Project Plant Site Operating Boundary | | | | LTVSMC Ambient Air Boundary |
|---|---|---|---|---|---|
| | South (maximum risk estimate) | | North [3] | Northwest [3] | Southeast [maximum risk estimate] |
| **Risk Category** | **Resident / Farmer (MEI) [1]** | **Off-Site Worker (RME_OSW) [2]** | **Resident / Farmer (MEI)** | **Resident / Farmer (MEI)** | **Resident / Farmer (MEI)** |
| Cancer [4] | | | | | |
| Inhalation | N/a | 3E-06 | 2E-06 | 9E-07 | 4E-06 |
| Indirect Pathway – Farmer | N/a | N/a | 7E-07 | 4E-07 | 1E-06 |
| Indirect Pathway – Resident | N/a | N/a | 9E-08 | 5E-08 | 2E-07 |
| | N/a | | | | |
| Total Multipathway – Farmer | N/a | N/a | 2E-06 | 1E-06 | 5E-06 |
| Total Multipathway – Resident | N/a | N/a | 2E-06 | 9E-07 | 4E-06 |
| Noncancer Chronic [5] | N/a | | | | |
| Inhalation | N/a | 0.45 | 0.08 | 0.04 | 0.2 |
| Indirect Pathway – Farmer | N/a | N/a | 0.000004 | 0.000002 | 0.000008 |
| Indirect Pathway – Resident | N/a | N/a | N/a | N/a | N/a |
| | N/a | | | | |
| Total Multipathway – Farmer | N/a | N/a | 0.08 | 0.04 | 0.2 |
| Total Multipathway – Resident | N/a | N/a | 0.08 | 0.04 | 0.2 |
| Noncancer Acute [5] [6] [7] | 1.1<br>0.97 | 1.1<br>0.97 | 0.1 | 0.04 | 0.2 |
| Fish Pathway - Mercury [8] | N/a | N/a | | | |
| Subsistence fisher (HQ) | | | 0.08 – 0.34 | 0.08 – 0.34 | 0.08 – 0.34 |
| Recreational fisher (HQ) | | | 0.02 – 0.07 | 0.02 – 0.07 | 0.02 – 0.07 |

MEI = Maximum Exposed Individual (potential exposure to maximum modeled air concentration)
RME_OSW = Reasonable Maximum Exposed Off-site Worker HQ = hazard quotient
RASS = Risk Assessment Screening Spreadsheet N/a = not applicable; not assessed

[1] The MEI non-cancer acute risks at the south Plant Site operating boundary are shown as a comparison to the risks at the southern portion of the former LTVSMC ambient air boundary. Potential farmer or resident risk is not applicable to the South Plant Site boundary because the industrial land use within the former LTVSMC ambient air boundary is expected to prohibit future residential or farming development.

[2] A potential off-site worker is at the boundary for a specified number of hours per day based on USEPA reasonable maximum exposure (RME) factors. Because the off-site worker does not live at the Plant Site and crops grown at the Plant Site are not consumed, the potential risk from indirect pathways is not applicable.

[3] The northwest and north portions of the Plant Site operating boundary coincide with the former LTVSMC ambient air boundary. Therefore, the estimated risks at the N and NW portions of the Plant Site operating boundary are directly comparable to the maximum risks estimated for the southeast portion of the former LTVSMC ambient air boundary.

[4] Incremental cancer risk guideline value is 1E-05, Minnesota Department of Health (MDH)

[5] Incremental noncancer (chronic and acute) guideline value is 1.0.

[6] The USEPA screening factor of 75% for conversion of NO to NO2 was applied to the $NO_x$ air concentration.

[7] The summed acute risk assumes all maximum 1-hour modeled air concentrations occur at one location. However, the arsenic 1-hour air concentration occurs approximately 0.9 miles east of the location where the other maximums occur. When the arsenic HQ is removed from the summed risks, the HI is reduced from 1.1 to 0.97 (rounded to 1.0).

[8] Screening results from the MPCA Mercury Risk Estimation Method (MMREM). Nearest lake is Heikkilla Lake, north of the Plant Site. Results are assumed to be applicable to locations outside of the former LTVSMC ambient air boundary. Compare incremental risk to: Background HQ for a subsistence fisher = 14.17 and recreational fisher = 2.99

# SCOPE OF WORK (proposed) – Supplemental Plant Site Air Emissions Risk Analysis

## I PROJECT ONLY ASSESSMENT

### Objective

Conduct a supplemental risk evaluation to the March 2007 AERA that incorporates the changes to the Plant Site operations and provides revised risk estimates for use in the Supplemental DEIS.

### Chemicals to be Included in the Quantitative Analysis

Evaluate risks associated with the following chemicals:

- Risk driver chemicals from the March 2007 Plant Site AERA (Table 4)
    - A "risk driver chemical" is a chemical with an individual cancer risk of 1E-06 or greater or an individual noncancer risk (hazard quotient) of 0.1 or greater.
        - Incremental cancer risk of 1E-06 or greater: nickel
        - Incremental noncancer risk of 0.1 or greater: arsenic (tailings basin), nickel, $NO_2$
- Chemicals not evaluated in the March 2007 Plant Site AERA because no toxicity values were available, but now have toxicity values available (Table 4): 3 chemicals (acetaldehyde, diesel particulate, and crystalline silica)
- Additional chemicals will also be evaluated if emission changes or toxicity value changes since the March 2007 AERA result in a potentially emitted chemical being considered a risk driver. Details for the screening calculations related to these changes are found in the sections related to emissions and toxicity values

**Table 4**

**Chemicals to be Evaluated in the Supplemental AERA for the Plant Site**

| Chemical | Reason Included | Update Assessment for: | | |
|---|---|---|---|---|
| | | Cancer | Noncancer Chronic | Noncancer Acute |
| Acetaldehyde | Acute Toxicity Value now Available | X | X | X |
| Arsenic compounds | Risk Driver March 2007 AERA (noncancer acute) | X | X | X |
| Diesel Particulate | Toxicity Value Available | N/a | X | N/a |
| Dioxins/furans (associated with diesel particulate) | Assess diesel particulate for potential carcinogenic risk | X | N/a | N/a |
| Manganese | Special request from MPCA | | X | |
| Nickel compounds | Risk Driver March 2007 AERA (all 3 risk cateogires) | X | X | X |
| Nitrogen oxides (NOx) (assess as $NO_2$) | Risk Driver March 2007 AERA (noncancer acute) | N/a | N/a | X |
| Silica, crystalline (silicon dioxide) | Toxicity Value Available | N/a | X | N/a |

N/a = toxicity value not available.

## Receptor Types and Assumed Exposure

Three receptor types will be evaluated (same as in the March 2007 AERA):

- Nearest Resident/Farmer Exposure. Assumed exposure to the maximum modeled air concentration for the one hour and annual averaging time periods at the boundary of industrial land use (also referred to as the former LTVSMC ambient air boundary).
    - Acute (one-hour) inhalation risks
    - Chronic multi-pathway risks (outdoors in one location for 24 hours per day, 365 days per year; AERA guidance assumes 35 years for a resident, 40 years for a farmer, 70 years for inhalation risk)
- Property Boundary Receptor; Off-Site Worker Exposure. Assumed exposure to the maximum modeled air concentration for the one hour and annual averaging time periods at the PolyMet property boundary.
    - Acute (one-hour) inhalation risks
    - Chronic inhalation risks (outdoors for 8 hour/day, 250 days per year, for 25 years; a "reasonable maximum exposure" according to USEPA (1993)).
- Fisher receptor (fish consumption pathway, mercury-related risks)
    - Subsistence fisher, consumption rate of 224 grams per day (~ 0.5 pounds per day; 180 pounds per year)

- Recreational fisher, consumption rate of 30 grams per day (~ 0.5 pounds per week; 25 pounds per year

## Estimated Emissions and Sources

Emission estimates for Plant Site sources and the Tailings Basin (includes the draft alternative incorporating bentonite addition to the side slopes as constructed and bentonite addition to beaches at closure), including diesel equipment and train, will be updated to reflect the changes in operations. Estimates of potential emissions for toxic air pollutants will be based on the approach used to estimate criteria pollutant air emissions for use in Class II modeling.

Revised emissions of toxic air pollutants will be compared to emission estimates evaluated in the March 2007 AERA. The percent change in emissions will be used to assess whether other chemicals evaluated in the March 2007 AERA should be evaluated as potential risk driver chemicals in the Supplemental AERA. Changes in emissions will be assessed for significance by a screening calculation.

Revised Incremental Risk = March 2007 risk x % change in emissions

If the revised potential incremental cancer risk for a chemical is 1E-06 or greater, or the revised noncancer risk is 0.1 or greater, then that chemical will be added to the list of chemicals to be evaluated in the Supplemental risk analysis.

Emission sources that have the potential to emit the risk driver chemicals will be modeled. The Supplemental AERA will assess potential emissions from the facility under typical operating scenarios. For example, upset conditions or breakdown/malfunction emission scenarios will not be evaluated. Some minor sources of emissions are also proposed to be excluded from modeling as well.

- *Emergency diesel generators* - Two diesel powered backup generators (EU 128 and EU 129) will be used at the Plant Site to provide backup in case of a power failure and an additional generator may be installed at the potential Waste Water Treatment Facility at Area 5 (Area 5 shown in Figure 1). The major pollutant to be emitted from these generators is $NO_X$. Some particulate metals may also be emitted. Due to the infrequent use and relatively short operating time potential emissions from these diesel generators are expected to be small and they will not be modeled in the AERA.

- *Diesel powered fire pumps* (EU 304 and EU 305) – Two diesel powered fire pumps will be used to pump water in case of a fire. Due to their infrequent use they will not be modeled in the AERA.
- *Fugitive dust from light vehicle traffic* – The AERA focuses on point sources of emissions in the plant area including: crushing/grinding of ore, flotation and concentrating, and the Hydrometallurgical Plant. Fugitive dust from vehicle traffic is not a large emission source compared to the potential emissions from the point sources and will not be modeled in the AERA.
- *Propane fired boiler and heaters* – A small propane fired boiler is located in the Area 2 Shop (EU 130). A propane fired infrared heater is located in the Area 1 Shop (EU 334). Additional propane heaters may be located at the potential Waste Water Treatment facility at Area 5 (Area 5 shown in Figure 1). Potential emissions associated with propane combustion are small and will not be modeled in the AERA.
- *Fuel combustion at a Waste Water Treatment Facility* – A small amount of fuel combustion may be part of the processes related to a potential Waste Water Treatment Facility at the Plant Site. It is expected that air emissions from this activity will be insignificant and they are proposed to be excluded from the quantitative risk analysis at this time. This decision may be reconsidered after potential emissions are calculated.
- *Natural gas or electric heater* – A natural gas or an electric heater will be required to heat the nitrogen used to reactivate the adsorbers in the oxygen plant. For the purpose of the emission calculations, it has been assumed that a natural gas fired heater would be used (EU 335). Potential emissions associated with this natural gas heater are small and will not be modeled in the AERA.

Potential emissions from these minor sources will be included in the emission inventory. MPCA's AERA guidance allows emissions to be eliminated from quantitative analysis if they are less than 1% of total emissions on a pollutant by pollutant basis. Therefore, estimated emissions for the risk driver chemicals for the individual sources will be compared to the MPCA's 1% threshold. If emissions for a risk driver chemical for a specific source exceed the 1% threshold, that source and the risk driver emissions will be included in the quantitative risk analysis.

Non-risk driver chemicals will be discussed qualitatively as needed in the AERA. The chemicals that are currently expected to be discussed qualitatively include iron and sulfuric acid aerosols. These chemicals will be included in the updated AERA report for the Plant Site.

## Toxicity Values

The toxicity values in the MPCA's current version of the RASS, as of April 2011, will be used to estimate potential human health risks for the Supplemental AERA.

For chemicals evaluated quantitatively in the March 2007 AERA, but are not listed in Table 4 of this Work Plan, chemical toxicity values used in the March 2007 AERA will be compared to current values. Changes in chemical toxicity values will be assessed for significance by a screening calculation.

$$\text{Revised Incremental Risk} = \text{March 2007 risk} \times \text{\% change in toxicity value}$$

If the revised potential incremental cancer risk for a chemical is 1E-06 or greater, or the revised noncancer risk is 0.1 or greater, then that chemical will be added to the list of chemicals to be evaluated in the Supplemental risk analysis.

In the case that a chemical has a change in emission rate and a change in toxicity value, the following screening calculation will be used to determine if the combined changes are significant enough to warrant further evaluation in this Supplemental AERA.

$$\text{Revised Incremental Risk} = \text{March 2007 risk} \times \text{\% change in emissions} \times \text{\% change in toxicity value}$$

If the revised potential incremental cancer risk for a chemical is 1E-06 or greater, or the revised noncancer risk is 0.1 or greater, then that chemical will be added to the list of chemicals to be evaluated in the Supplemental AERA.

## Air Dispersion Modeling and Estimating Potential Incremental Human Health Risks

Updated building dimensions, stack dimensions, road locations, etc. for the project will be used in the modeling. The modeling for the AERA will follow closely with the Class II modeling and will use the Class II receptor grid. The most recent version of the AERMOD model will be used to estimate one-hour and annual air concentrations. Surface meteorological data from Hibbing, MN (2006-2010) and concurrent mixing height data from International Falls will be used.

Maximum modeled air concentrations will be identified for each receptor and exposure time/duration. The modeled air concentrations will be input to the most recent version of the MPCA's Risk Assessment Screening Spreadsheet ("Concs" tab) and potential incremental risks estimated.

## Local Mercury Deposition Analysis

Project-only mercury emissions will be assessed using the MPCA's Mercury Risk Estimation Method (MMREM). Lakes within 10 kilometers of the project site to be assessed in the analysis are as follows:

- Sabin Lake
- Wynne Lake
- Heikkilla Lake
- Colby Lake
- Whitewater Reservoir

These are the same lakes to be assessed in the cumulative mercury deposition analysis. The MMREM analysis will follow the MPCA's guidance Results from the MMREM analysis will be included in the Supplemental AERA Report for the Plant Site.

## II CUMULATIVE INHALATION RISK EVALUATION

The MPCA has requested a cumulative inhalation risk assessment be performed as part of the Supplemental AERA. MPCA guidance [3] indicates that the cumulative analysis should focus on the location of the most impacted residential location from the proposed project. When reasonably foreseeable land use is considered, the nearest potential location for a resident receptor is approximately 2.9 miles (4.8 kilometers) to the north/northwest of the Plant Site (Table 5), on the property boundary, just south of Heikkilla Lake (Figure 2). The next closest location for a resident is on the southeast portion of the former LTVSMC air boundary, approximately 3.2 miles (5.3 kilometers) southeast of the Plant Site (Table 5; Figure 2).

The nearest resident in Hoyt Lakes (north side of town) is estimated to be about 5 miles (8.3 kilometers) from the Plant Site, while a nearest resident in Aurora (northeast portion of town) is estimated to be about 6.3 miles (10.5 kilometers) from the Plant Site (Table 5). At those distances, the Plant Site is not likely to be a significant contributor to modeled air concentrations in either town. Wind rose data (Figure 3) indicates a low probability for contributions from the Plant Site to a potential receptor in either Hoyt Lakes or Aurora. Because of the distance from the Plant Site and the low probability of contributions, a potential receptor in Hoyt Lakes and Aurora is not currently proposed for evaluation.

The August 2009 AERA for the Mesabi Mining Project [4] (formerly referred to as the Mesabi Nugget Phase II Project) identified that haul trucks on the southern and southeastern portion of that Project's property boundary, just north/northwest of Colby Lake (Figure 2), were the primary contributors to inhalation risk. Fugitive dust and vehicle-related emissions are typically not expected to be major contributors to receptors several miles away, such as the potential Resident Locations identified for the Plant Site (Figure 2). The AERA for the Mesabi Mining Project included the recently built Large Scale Demonstration Plan (LSDP) and the proposed mining and crushing/concentrating. [4] Modeling results from the Mesabi Mining Project were submitted to the MPCA and are considered to be publicly available. Those modeling results will be obtained for use in this cumulative evaluation.

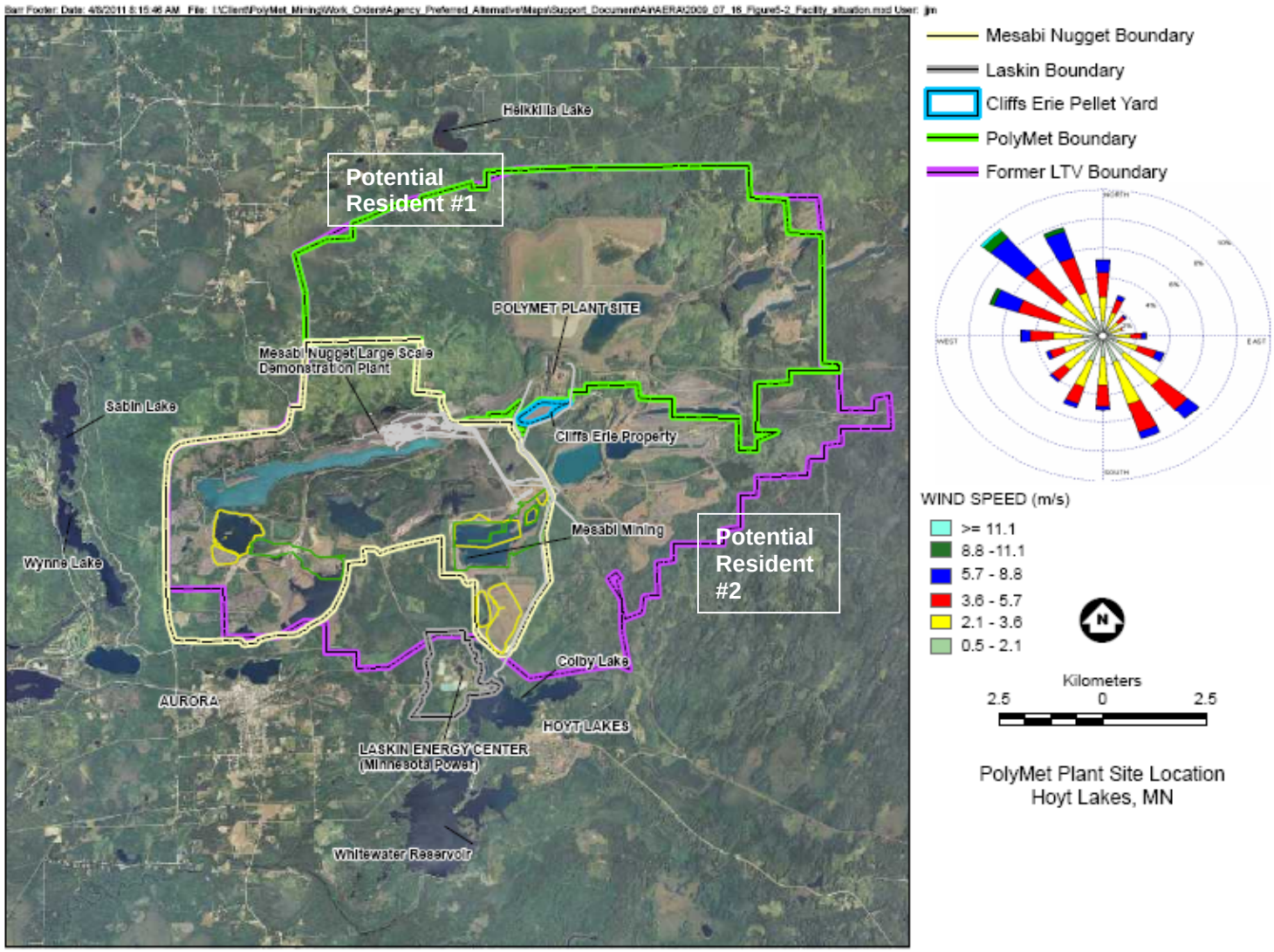
The Cliffs Erie Pellet Yard is not expected to be a significant source of emissions. [5] Therefore, it is excluded from the cumulative inhalation risk evaluation at this time. Furthermore, since the previous Plant Site AERA was conducted, a construction permit for expanded operations at the pellet yard has expired, so current permitted activities are minimal.

**Table 5**
**Estimated Distances of Potential Residential Receptors to Plant Site Air Emission Sources and Other Projects and Operating Facilities in the Hoyt Lakes Area**

| Potential Residential Receptor Location | Distance To: | Distance (approximate; (miles) | Distance (approximate; kilometers) |
|---|---|---|---|
| Northern portion of Plant Site Boundary | Plant Site | 2.9 | 4.8 |
| | Mesabi Nugget LSDP | 3.5 | 5.8 |
| | Mesabi Mining (crushing area) | 4.6 | 7.7 |
| | Mesabi Mining (mine area 2WX) [1] | >5 | >10 |
| | Laskin Energy Center | 7.7 | 12.8 |
| | | | |
| Southeast portion of the former LTVSMC air boundary | Plant Site | 3.2 | 5.3 |
| | Mesabi Nugget LSDP | 4.6 | 7.7 |
| | Mesabi Mining (crushing area) | 2.4 | 4 |
| | Mesabi Mining (mine area 2WX) [1] | 2.5 | 4 |
| | Laskin Energy Center | 3.8 | 6.4 |
| | | | |
| Hoyt Lakes (northern portion) | Plant Site | 5.0 | 8.3 |
| | Mesabi Nugget LSDP | 4.6 | 7.7 |
| | Mesabi Mining (crushing area) | 3.2 | 5.3 |
| | Mesabi Mining (mine area 2WX) [1] | 0.9 | 1.5 |
| | Laskin Energy Center | 1.4 | 2.3 |
| | | | |
| Aurora (northeast portion) | Plant Site | 6.3 | 10.5 |
| | Mesabi Nugget LSDP | 4.3 | 7.2 |
| | Mesabi Mining (crushing area) | 4.6 | 7.7 |
| | Mesabi Mining (mine area 2WX) [1] | 3.5 | 5.8 |
| | Laskin Energy Center | 2.7 | 4.5 |

LSDP = Large Scale Demonstration Plant

[1] Mine area 2WX is located in the southeast portion of the Mesabi Mining Project, just north of Colby Lake, and northwest of the city of Hoyt Lakes.




[Approximate locations of a nearest potential resident identified to the northwest and southeast of the Plant Site]

**Figure 2. Location of the Plant Site in relation to the City of Hoyt Lakes and other nearby projects.**

The Mine Site is located approximately 8 miles to the east of the Plant Site. The ambient air boundaries for the Mine Site and the Plant Site are adjacent, but the emission generating activities and the maximum modeled air concentrations are relatively far apart. Previously completed Class II air dispersion modeling has shown that $PM_{10}$ and $PM_{2.5}$ impacts from Mine Site sources are below the Significant Impact Level (SIL) on the Plant Site receptor grid.[6] The Class II Modeling Protocol [7] reiterated the findings from the 2008 modeling that the Mine Site is an insignificant contributor to the Plant Site modeling grid. Based on the previous Class II modeling results, the Mine Site sources are not expected to contribute significantly to potential air concentrations at the potential Resident Receptor locations near the Plant Site (Figure 2). Therefore, consistent with the Class II Modeling Protocol,[7] the Plant Site and Mine Site will be modeled separately for screening inhalation and multipathway risks and the Mine Site is not proposed to be included in the cumulative inhalation risk evaluation for the Plant Site.

The Mesabi Mining Project (formerly referred to as the Mesabi Nugget Phase II Project) conducted a cumulative inhalation risk evaluation. Several chemicals from the Syl Laskin Energy Center were included in that modeling effort (e.g., HCl, PAHs, dioxins/furans), including $NO_x$ emissions. Those modeling files were submitted to the MPCA and are considered to be publicly available. Cumulative risk results for the Mesabi Mining Project [4] indicated that only estimated $NO_x$ emissions for the Syl Laskin Energy Center were of interest from a cumulative analysis perspective. Therefore, only the potential acute inhalation risks from $NO_x$ emissions from the Syl Laskin Energy Center are proposed for inclusion in the cumulative analysis for the Plant Site.

Projects more than 25 kilometers from the Plant Site, such as the Keetac Expansion Project, the Essar Steel Project and the Mesaba Energy Project (West Range site) near Keewatin and Nashwauk on the west end of the Iron Range, are not expected to be significant contributors to air concentrations in the Hoyt Lakes area. The risk report will reiterate this information.

Existing facilities, such as Northshore Mining, that are not in close proximity to the Plant Site are assumed to be accounted for in the background air concentrations. The emissions from these facilities are indirectly included in the cumulative assessment though the use of the background air concentrations.

Chemicals of interest for the cumulative inhalation evaluation are presented in Table 6 and are predominantly arsenic, nickel and $NO_2$. The analysis will include risk drivers for the Plant Site (Table 4) and risk drivers for the other nearby facilities as well. Table 6 provides a summary of the chemicals for each project or existing facility to be included in the cumulative inhalation risk evaluation.

A table summarizing the cumulative inhalation risks will be prepared that follows MPCA guidance, similar to that identified in Table 7.

**Table 6**
**Risk Driver Chemicals to be Assessed in the Cumulative Inhalation Risk Evaluation to be Conducted for the Supplemental AERA for the Plant Site**

("X" denotes the inhalation risk category of significance for the chemical in previous project-specific analyses)

| Risk Driver Chemical (Inhalation) [1] | Project / Facility [2] | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|---|
| Arsenic compounds | Plant Site (tailings basin) | | | **X** |
| Nickel compounds | Plant Site | **X** | **X** | **X** |
| Manganese compounds | Plant Site<br>Mesabi Nugget LSDP<br>Mesabi Mining | **N/a** | **X [5]**<br>**X**<br>**X** | **N/a** |
| $NO_2$ | Mesabi Nugget LSDP<br>Mesabi Mining<br>Plant Site<br>Syl Laskin Energy Center **[3]** | **N/a** | **N/a** | **X**<br>**X**<br>**X**<br>**X** |
| Silica, crystalline | Mesabi Mining **[4]**<br>Plant Site **[4]** | **N/a** | **X**<br>**X** | **N/a** |

N/a = toxicity value not available

[1] Risk driver chemical identified as a chemical having incremental cancer risk of 1E-06 or greater, or incremental noncancer risk of 0.1 or greater.

[2] Projects / Facilities proposed for inclusion in the cumulative human health risk evaluation:

a. Mesabi Mining (formerly the Mesabi Nugget Phase II project); modeling conducted for the August 2009 AERA included the Mesabi Nugget Large Scale Demonstration Plant (LSDP).
b. NorthMet Project Plant Site (updated AERA, 2011)
c. Syl Laskin Energy Center

[3] The Syl Laskin Energy Center was included in the air dispersion modeling and risk results for the cumulative inhalation evaluation conducted for the Mesabi Nugget Phase II Project; August 2009 Air Emissions Risk Analysis for the Post-Project Total Facility (LSDP Project + Mining). Emissions modeled for the Syl Laskin facility were $NO_2$, HCl, HF, PAHs and dioxins/furans. Only $NO_2$ was identified as a risk driver chemical for the Syl Laskin facility. $NO_2$ is the only chemical proposed to be evaluated for the Syl Laskin Energy Center as part of the cumulative analysis to be conducted for the Plant Site AERA.

[4] Crystalline silica to be modeled as part of the Plant Site AREA (chemical that did not have a toxicity value when the Plant Site AERA (March 2007) was conducted, but now has an inhalation toxicity value). Previously modeled air concentrations from the Mesabi Mining Project will be used in the cumulative analysis as well.

[5] Potential manganese emissions from the NorthMet Plant Site were requested to be evaluated for inhalation risks by the MPCA in their review of the Work Plan for the Supplemental AERA for the Plant Site.

**Table 7**
**Proposed Format for Estimating Potential Cumulative Inhalation Risks for the Supplemental AERA to be Conducted for the Plant Site**

| Estimated Potential Risk | Cancer | Noncancer Chronic | Noncancer Acute |
|---|---|---|---|
| Background | | | |
| Ambient air monitoring (calculated by MPCA) | | | |
| Minnesota Power, Syl Laskin Energy Center (modeled, $NO_2$) | | | |
| | | | |
| Incremental | | | |
| Plant Site | | | |
| Mesabi Mining Project (includes the LSDP) | | | |
| | | | |
| Total | | | |

LSDP = Mesabi Nugget, Large Scale Demonstration Plant

## Reporting

A standard report will be prepared for the supplemental AERA that appropriately references to the March 2007 Plant Site AERA. Uncertainty in the risk analysis will be discussed, per MPCA (2007) guidance.

The cumulative inhalation risk results will be included as a separate section within the Supplemental Plant Site AERA report.

## References

1. PolyMet Mining, 2005. Air Emissions Risk Analysis, NorthMet Project. Prepared by Barr Engineering Company. May 2005.
2. PolyMet Mining, 2007. Air Emissions Risk Analysis – Plant Site. Prepared by Barr Engineering Company. March 2007.
3. MPCA, 2009. Guidance, How to Conduct a Cumulative Air Emissions Risk Analysis. Aq-9-21. March 2009.
4. Mesabi Nugget, 2009. Air Emissions Risk Analysis for the Post-Project Total Facility (Phase I and Phase II). Prepared by Barr Engineering Company. August 2009. (Mesabi Nugget Phase II Project now referred to as the Mesabi Mining Project).

5. PolyMet Mining, 2007. Air Emissions Class II Area Cumulative Impacts Report. Prepared by Barr Engineering Company. March 2007.
6. PolyMet Mining, 2008. Class II Air Dispersion Modeling Report for the NorthMet Project Plant Site. Prepared by Barr Engineering Company. January 2008.
7. PolyMet Mining, 2011. Class II Air Dispersion Modeling Protocol for the Plant Site. Prepared by Barr Engineering Company. April 2011.

| | | | | | | |
|---|---|---|---|---|---|---|
| **PolyMet Study Comment Form** | | | | | | |
| **Comments on Draft Document: <insert name here>** | | | | | | |
| **Compiled: <Date and Name of compiler if multiple commenters>** | | | | | | |
| **Comments by: <Name(s) of person(s) whose comments are reflected below>** | | | | | | |
| **Responses:** | Cliff Twaroski, Barr; Pat Sheehy, Barr | | | | | |
| | | | | | | |
| **Comment ID** | **Initials** | **Chapter** | **Page** | **Para/Sentence** | **Comment** | **PolyMet/Barr Response** |
| **00001** | KME | "Project Only Asssessment" | 7 | 1st Table | Oversight on the part of Kristie Ellickson. Please model diesel tail pipe emissions using methodologies from past projects (e.g. Mesabi Nugget, Keewatin Taconite). This would require additional chemical components of diesel particulates to be modeled such as PAHs, which have been risk drivers from diesel emissions in the past. The past comment (KME, #7) limited this analysis to dioxins/furans which was in error, and may have led to underestimates of risk based on past mining HH risk assessments. | Because PAHs were evaluated in the March 2007 AERA, according to the Work Plan PAHs were to be included in the screening equations to determine if they would now be risk driver chemicals due to the proposed changes in the NorthMet project. Therefore, as specified in the Work Plan for chemicals previously evaluated in the March 2007 AERA, revised PAH emissions will be run through the risk driver screen calculations. Individual PAH congeners that are identified as risk driver chemicals will be modeled as part of the quantitative risk analysis. If no PAH congener is identified as a risk driver chemical from the screening equations, then the PAH congener with the highest estimated potential risk will be modeled and act as a surrogate for the other PAH congeners. In this way, PolyMet is not tasked with performing unnecessary risk evaluations on chemicals that have insignificant risk and MPCA staff obtain a quantitative estimate of potential human health risk from PAHs for the NorthMet project. |

**Attachment U**

**Local Mercury Deposition and Bioaccumulation in Fish**

# *Cumulative Impacts Analysis*

## *Local Mercury Deposition and Bioaccumulation in Fish*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining Inc***

***July 2012***

# *Cumulative Impacts Analysis*

## *Local Mercury Deposition and Bioaccumulation in Fish*

## *NorthMet Project*

***Prepared for***
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# NorthMet Project
## Cumulative Impacts Analysis
## Local Mercury Deposition and Bioaccumulation in Fish

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# 1 Introduction and Summary

PolyMet Mining Inc. (PolyMet) plans to construct and operate a mine near the town of Babbitt, MN, to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailing Basin near Hoyt Lakes, MN, and to build a hydrometallurgical concentrate processing facility at the former LTVSMC site (Plant Site). The proposed project is referred to as the NorthMet Project (Project). The project description is provided in the March 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement and the NorthMet Project Description Version 3 Submitted September 13, 2011.

This report is an updated assessment of the cumulative effects of mercury deposition on nearby lakes, as required for the Supplemental Environmental Impact Statement (SDEIS). Therefore, this assessment not only takes into account the potential impacts of the Project, but also that of other past and "reasonably foreseeable" projects in the area. In this case, the only "reasonably foreseeable" project in the area with appreciable mercury emissions is the recently constructed Mesabi Nugget Large Scale Demonstration Plant (LSDP).

This document is a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

Based on the approved Minnesota Pollution Control Agency (MPCA) screening-level model, the mercury emissions from these two projects would, at most, increase mercury concentrations in the fish in the nearest lakes from between 0.3 percent to 1.8 percent over current levels. (The current levels of mercury in the fish in selected nearby lakes already exceed the levels that trigger a fish-consumption advisory.) These results do not account for emission reductions due to mercury emissions from coal-fired power plants and taconite plants in the area, which are targeted to be reduced by 75 percent by 2025 under the MPCA's current Statewide Mercury TMDL implementation strategy.

# 2 Statewide Mercury Total Maximum Daily Load

Many lakes throughout the United States have elevated concentrations of mercury in fish, including lakes in northern Minnesota. As a result, the Minnesota Department of Health issues fish consumption advisories for contaminated lakes that recommend limits on the amount and types of fish that can be safely eaten. These fish consumption advisories, in turn, trigger federal regulatory requirements intended to reduce the mercury contamination in these lakes. In Minnesota, the MPCA has recently developed a federally-approved long-term plan to help eliminate, or at least reduce, these mercury impairments. The MPCA plan is called a total maximum daily load (TMDL) plan. The U.S. Environmental Protection Agency (EPA) approved the MPCA Statewide Mercury TMDL (TMDL) in March, 2007. The TMDL is focused on reducing overall state emission rates. The TMDL plan includes a statewide goal of reducing total statewide mercury emissions to 789 pounds per year by 2025 (MPCA 2007).

More recently, the MPCA approved a *Strategy Framework for Implementation of Minnesota's Statewide Mercury TMDL*." This framework establishes various reduction targets, including one for taconite facilities that would reduce their overall emissions by 75 percent by the year 2025 (MPCA 2008a). Requirements are also included for new and expanding sources of mercury emissions.

## 2.1 Mercury Species

Minnesota's mercury TMDL includes extensive background on the chemistry, transport and environmental fate of mercury in the environment. In summary, the rate at which mercury is deposited after being emitted depends greatly on the type (or species) of mercury emitted. The common forms of mercury emissions are elemental (Hg (0)), oxidized (Hg (II)) and particle bound (Hg (p)). Most of the mercury in the atmosphere is elemental mercury, and being insoluble, it does not readily deposit after being emitted (EPA, 2006). Oxidized mercury, on the other hand, is water soluble and can deposit readily at the local and regional level (EPA 2006). Some particle-bound mercury may be deposited locally near an emission source as well. Therefore, local deposition of mercury is a greater concern for facilities that emit oxidized or particulate forms of mercury.

The elemental form of mercury, however, enters the global mercury pool and eventually re-deposits somewhere in the world in rain or through "dry deposition." Mercury sources both regional and throughout the world contributes to this global pool. This is why, even in the most remote areas, there can be elevated mercury levels in soils, water and fish.

## 2.2 St. Louis River Toxics TMDL

The St. Louis River is an important fishery and natural resource for the region. Many lakes in the St. Louis River watershed are included in the statewide mercury TMDL. The St. Louis River itself, however, is not included in the statewide TMDL. This is because to include a lake or river the MPCA must show that fish-tissue concentrations would be calculated to be below the statewide criterion of 0.2 milligrams of mercury per kilogram fish (mg/kg) if the stated emission reductions are achieved. The monitored fish-mercury concentrations in the St. Louis River currently exceed the threshold value (0.572 mg/kg) that would allow it to reach the 0.2 mg/kg criterion if the mercury reductions planned under the current statewide TMDL plan were achieved (MPCA 2007).

Therefore, a separate St. Louis River "toxics" TMDL process has been initiated recently by the U.S. Environmental Protection Agency. Other partners include the states (Wisconsin, Minnesota), the Fond du Lac Band, and other groups. The models being considered for this effort—such as the Watershed Analysis Risk Management Framework (WARMF) model—require considerably more data to assess the major inputs and processes for the St. Louis River TMDL than are currently available. The EPA contractor's work to date on the St. Louis River TMDL has been focused on model development, verifying current data, and identifying data gaps.

# 3 Modeling Approach and Assumptions

The link between the mercury emissions from a specific air pollution source and the mercury that accumulates in the fish in a specific lake is complex and not completely understood. In the absence of a generally applicable, validated model that accurately incorporates the complexities of atmospheric chemistry, watershed transport, methylation, and bioaccumulation in fish, the MPCA recommends using a simplified screening method called the Minnesota Mercury Risk Estimation Method (MMREM) (MPCA 2006). This method consists of using the standard air dispersion model AERMOD to assess local mercury air concentrations and a MPCA-developed screening-level spreadsheet model to assess how much of this mercury might accumulate in fish in nearby lakes. The underlying assumptions used in the MMREM are summarized below in Section 3.1.

This section of the report summarizes the inputs used to assess the impacts of the Project and the other nearby projects. The section is divided into the following subsections:

## 3.1 MPCA Mercury Risk Estimation Method

The November 2008 version of the MMREM spreadsheet was used for this analysis. The MMREM method assumes that there is a linear relationship between the atmospheric mercury deposition rate in a given lake and fish tissue methyl-mercury concentrations. Instead of trying to model the ratio of mercury loading to a lake and how much bioaccumulates in the fish in that lake, it uses fish data from lakes near new emission sources to determine that ratio. That ratio is then used to predict the impact of increased mercury loading from proposed new nearby mercury emission source(s). The basic approach of MMREM is very similar to how the USEPA assessed the impact of mercury emissions from electric utilities on mercury in fish in a 2011 technical support document, accessible at http://www.epa.gov/mats/pdfs/20111216MercuryRiskAssessment.pdf. The MMREM also estimates a potential incremental change in fish mercury concentrations and incremental hazard quotients for a recreational angler and a subsistence angler.

Major inputs to the MMREM spreadsheet include: (1) modeled mercury air concentration over the surface of a water body and its direct drainage watershed, respectively, (2) background mercury deposition, and (3) background fish mercury concentrations.

## 3.2 Emission Source Selection

Any impact on nearby lakes due to mercury emissions from existing stationary sources is already reflected in background fish concentrations. Therefore, the cumulative effects modeling is only needed to determine the

potentially overlapping impacts of the Project with recent or proposed nearby projects that could affect the same lakes.

The modeling for this analysis included the emissions from the Project and any other "reasonably foreseeable" projects located within 25-kilometers. The 25-kilometer distance was selected because projected emissions from new facilities that are more than 25-kilometers from the Plant Site are not expected to contribute significantly to modeled air concentrations within the modeling domain. This assumption is based largely on generic AERMOD modeling done for the Keetac Expansion Project. That modeling showed that mercury air concentrations drop by an order of magnitude—to less than 0.25% of background concentrations—within 10 kilometers from the emission source. Based on this analysis, it is assumed that mercury emissions from the Project could only significantly increase mercury deposition on local lakes that are within a 10-kilometer radius of the Plant Site. Similarly, the zone of local impact from any other nearby recent or planned projects would be about 10-kilometers. Therefore, for an overlapping (cumulative) impact to occur, the other source would have to be within 20-kilometers of the Plant Site. See Figure 1. The addition of a 5-kilometer "buffer" results in a total distance of 25-kilometers.

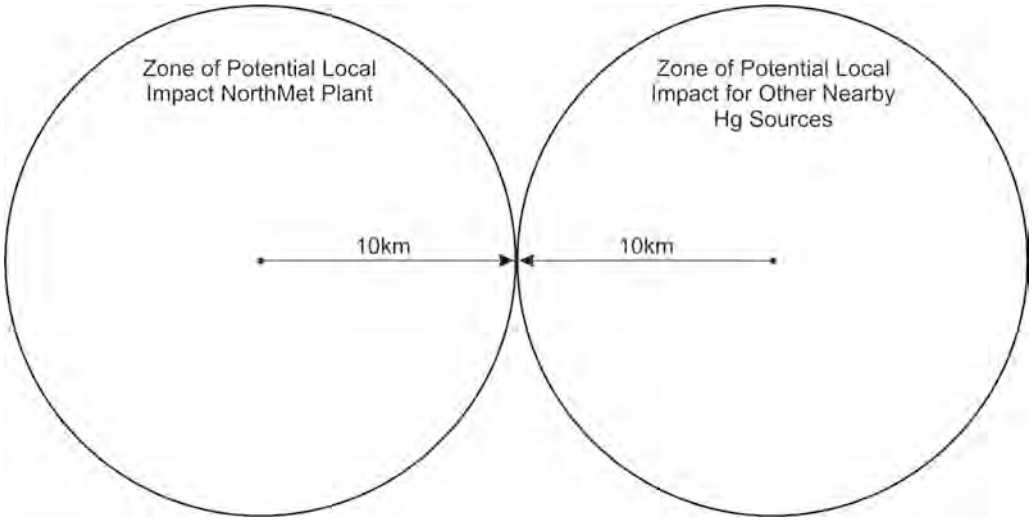



**Figure 1 Illustration of 20-kilometer distance to potential overlapping local mercury sources**

The only "reasonably foreseeable" project in the area with appreciable mercury emissions is the Mesabi Nugget LSDP, at an estimated 75 pounds per year. The other potential projects in the area either have minimal emissions (less than one pound per year), or have been canceled. For example, the potential mercury air emissions from the Mesabi Mining Project (mining, ore crushing and concentrating) and the Mine Site are less than one pound per year. Likewise, permitted emissions from the Cliffs Erie Pellet Yard are minimal. The

small amount of mercury emitted would be as mineral particles, which would not be readily bioavailable. Finally, any local deposition due to emissions from Minnesota Power's nearby Laskin Energy Center is already reflected in existing background fish-mercury concentrations.

Therefore, the following two projects are included in this cumulative mercury deposition analysis:

- NorthMet (Plant Site): approximately 4 pounds per year
- Mesabi Nugget LSDP: approximately 75 pounds per year (air permit limit)

## 3.3 Lake Selection

Five area lakes were selected for the analysis:

- Heikkilla Lake, part of the Embarrass River watershed
- Sabin Lake, part of the Embarrass River watershed
- Wynne Lake, part of the Embarrass River watershed
- Colby Lake, part of the Partridge River watershed
- Whitewater Lake, part of the Partridge River watershed

The location of these lakes is shown in Figure 2, below. Three of the lakes (Heikkilla, Colby, and Whitewater) are located within 10 km of the Plant Site. The two remaining lakes (Wynne and Sabin) are approximately 12 kilometers from the Plant Site. Because Heikkilla Lake, Sabin Lake and Wynne Lake are all part of the Embarrass River watershed, the watershed area for Sabin Lake includes Heikkilla Lake and its watershed. In turn, the watershed for Wynne Lake includes both of the other two lakes and their watersheds. Lake surface area and watershed areas have been calculated using GIS applications and are listed in Table 1.

**Table 1 Lake and Watershed Areas Identified for Inclusion in the Cumulative Mercury Deposition Analysis to be Conducted for the Project**

| Lake | Lake Area (acres) | Watershed Area (excludes lake area) (acres) |
|---|---|---|
| Heikkilla Lake [1,3] | 128 | 1,350 |
| Colby Lake [2,3] | 502 | 99,890 |
| Sabin Lake [3] | 299 | 121,370 |
| Wynne Lake [2,3] | 289 | 123,600 |
| Whitewater Lake [4] | 1,215 | 3,050 [5] |

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage

watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospacial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Barr Engineering, Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

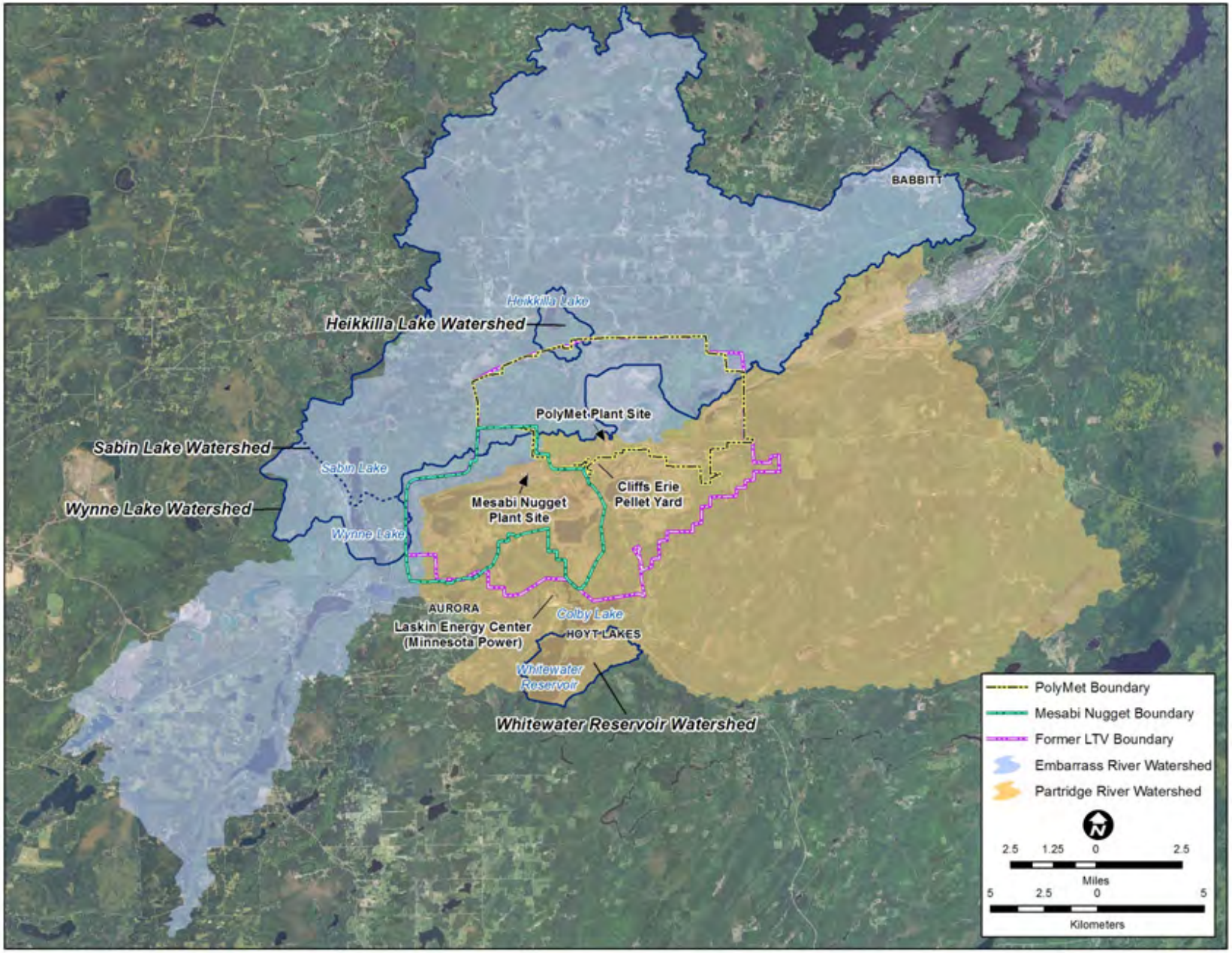



**Figure 2 Location of nearby lakes and watersheds included in the Cumulative Mercury Deposition Analysis**

## 3.4 St. Louis River and Watershed

All five of the lakes selected for modeling (and the proposed plant itself) are located within the St. Louis River watershed. Two of the modeled lakes—Colby Lake and Whitewater Lake—discharge directly to the St. Louis River. These two lakes are also the closest lakes to the Plant Site and the Mesabi Nugget LSDP, and therefore, would be the most potentially affected. In other words, the incremental increase of mercury loading and the associated change in fish concentrations in other popular fishing lakes in the St. Louis River watershed such as Seven Beaver Lake (the headwaters of the St. Louis River) would be less than that modeled at the selected lakes because these other lakes are located further from the two proposed projects. Seven Beaver Lake, for example, is about 14 miles east of the Plant Site. All the selected lakes and watersheds modeled for this analysis (Table 1) on the other hand, are within 7 miles of the Plant Site.

Similarly, the estimated change in mercury concentrations in fish in the St. Louis River itself due to the two projects using the MMREM would be far less than that predicted for the selected nearby lakes. This is because the mean air concentration of mercury (and the associated deposition rate) due to these two projects alone would be much lower when averaged across the entire St. Louis River watershed than the modeled air concentration at a nearby lake. In general, as watershed size increases, the impact of any one nearby source becomes less important and region-wide deposition dominates.

In this case, for example, the local area affected by the projects' mercury emissions (150 square miles, or a 10-km radius around each facility) is only about 4% of the much larger St. Louis River Watershed (which has an area of over 3,500 square miles). The current MPCA-estimated mercury deposition rate is 12.5 ug/m^2-year for northeastern Minnesota. This means that about 250 pounds of mercury currently deposits onto to the St. Louis Watershed every year due to regional deposition. Even assuming that the maximum modeled deposition rate due to the two proposed projects--0.2 ug/m^2-yr at Colby Lake (scenario 1)--occurred over the entire 150 square mile potentially affected area, the total annual deposition in the watershed from the two proposed projects would be about 0.17 pounds per year. This is less than 0.1% of the estimated 250 pounds per year of mercury already landing onto the St. Louis River watershed due to regional deposition. Because the change in mercury contamination of fish is thought to be ultimately proportional to the percent increase in load, this 0.1% increase in annual mercury deposition is not likely to result in a measureable change in the mercury concentration in the fish in the St. Louis River.

## 3.5 Existing Mercury Concentrations in Fish

Fish tissue mercury concentration data was obtained from the MPCA in November 2011. Background mercury concentrations in fish tissue were calculated in accordance with MMREM guidance. For Colby, Sabin, Whitewater and Wynne Lakes, with fish tissue data, 95% upper confidence limits (UCL) of the mean were calculated from recent data for top predator species using the latest version of EPA's ProUCL software. No fish tissue data is available for Heikkilla Lake, so the 95% UCL of the mean concentration was calculated using fish tissue data from the following 5 nearby lakes: Colby, Sabin, Whitewater, Wynne and Bear Island Lake.

Outliers were retained in the dataset for calculating the 95% UCL in order not to underestimate potential background concentrations.

MPCA's fish mercury database contains average values representing multiple samples. These average values were used in deriving the estimate of background fish mercury concentrations for a lake.

## 3.6 Dispersion Modeling Methods

The mercury speciation proposed for analysis for both projects is provided in Table 2. Because speciation from the autoclave is uncertain, two speciation scenarios were used: a conservatively high estimate of species that tend to deposit locally (Scenario 1) and a most likely estimate (Scenario 2). Total emission rates are from the Plant Site Emissions Inventory (Barr Eng. 2011).

The most recent version of the AERMOD air dispersion model was used to model estimated emissions from the Mesabi Nugget LSDP and the Plant Site. The model was run in regulatory mode (i.e., no plume depletion). Building heights and dimensions, and stack parameters, were obtained for the emission sources to be modeled (autoclave for the Project; rotary hearth furnace for the Mesabi Nugget LSDP).

Meteorological data used for other modeling analyses conducted for Iron Range sources was used in this modeling:

- 2006-2010 surface data from Hibbing (airport)
- Concurrent mixing height data from International Falls

**Table 2 Mercury Speciation Assumptions**

| Project | Mercury Speciation | Comments |
|---|---|---|
| NorthMet, Plant Site | | |
| Scenario 1 [1] | 25% elemental<br>50% oxidized<br>25% particle-bound | Conservative estimate for local deposition |
| Scenario 2 [1] | 80% elemental<br>10% oxidized<br>10% particle-bound | Estimated likely speciation |
| Mesabi Nugget LSDP [2] | 99.3% elemental<br>0.6% oxidized<br>0.1% particle-bound | Speciation from stack testing data for the pilot plant. |

[1] The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

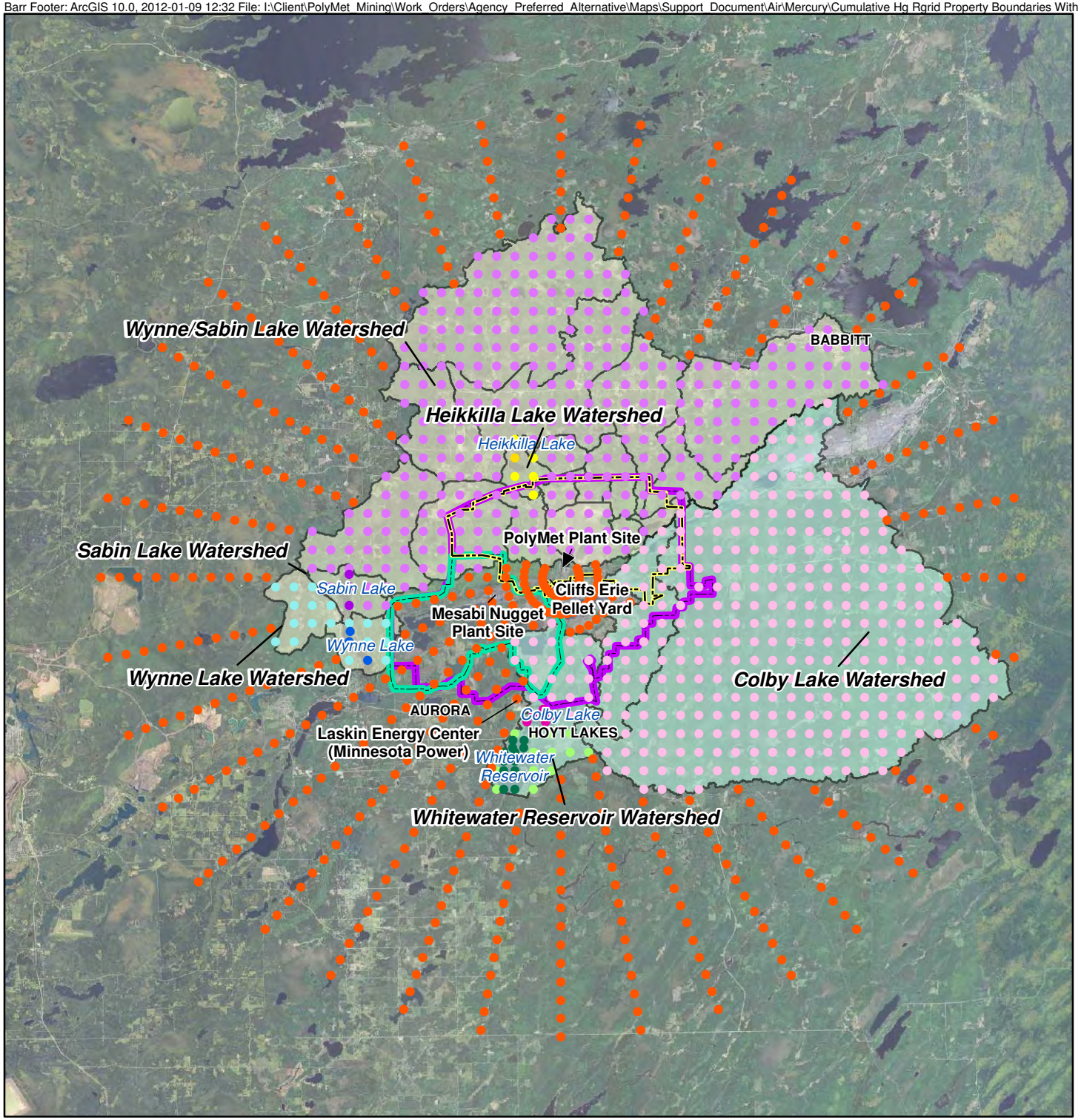
[2]This is the same speciation assessed for local mercury deposition in the Mesabi Nugget May 2005 AERA and in the Mesabi Nugget Phase II August 2009 AERA

A receptor grid for the modeling was designed to provide aerial coverage for each lake and watershed using had polar grid receptors extending out to 25 kilometers. One or more receptor nodes were placed over each lake's surface area and within each watershed. For lake surface area, the grid was modified so that one receptor was placed over the lake for every 100 acres of surface area. For watersheds, one receptor was placed over the watershed for every 1,000 acres of area. For example, for Colby Lake (500 acres) and its watershed (~100,000 acres), 5 receptors were placed over the lake and 100 receptors placed in the watershed. The Heikkilla Lake watershed is located partially within the Plant Site boundaries. Therefore, to capture the likely strong gradient close to the Plant Site, at least two receptors were used to characterize the Heikkilla Lake watershed, one of which was placed over the lake's surface area.

The average mercury air concentration over the lake and over the watershed were then calculated from the AERMOD modeling output using GIS tools as recommended in the MMREM guidance.

The different speciation for the two projects required separate modeling runs for each species, with output from the individual modeling runs being consolidated to provide a cumulative estimate of the potential average mercury air concentration (as total mercury) for each lake and watershed. Figure 3 shows the receptor coordinates used to model the mercury concentrations overlaid on to the studied watersheds.

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- 25km polar
- Colby Lake
- Colby WSHD
- Heikkilla Lake
- Heikkilla WSHD
- Sabin Lake
- Whitewater Lake
- Whitewater WSHD
- Wynne Lake
- Wynne WSHD
- Wynne/Sabin WSHD
- NorthMet Boundary
- Mesabi Nugget Boundary
- Former LTVSMC Boundary
- Embarrass River Watershed
- Partridge River Watershed

N

Kilometers

5 0 5

Figure 3

Cumulative Hg Receptors
NorthMet Project
Hoyt Lakes, MN

## 3.7 Bioaccumulation and Risk Modeling Methods

The most recent version of the MMREM spreadsheet was used to estimate potential cumulative incremental mercury deposition, fish mercury concentration and human health risks (as a hazard quotient).

The MMREM spreadsheet analysis consisted of the following five major steps:

1. Individual AERMOD modeling runs were conducted for each mercury species described in Table 2 to provide cumulative air concentrations for elemental, oxidized and particle-bound mercury, respectively, for the annual averaging period. Because there are two scenarios and three mercury species, six separate modeling runs were required.
2. A separate MMREM spreadsheet file was established for each lake/watershed to be assessed (2 spreadsheets set up for each lake/watershed).
3. The average speciated air concentrations were entered for the lake and watershed area, respectively. Therefore, the default mercury speciation in the MMREM spreadsheet was not used. Instead, the MMREM spreadsheet was adjusted to account for modeled speciated air concentrations to be input directly to specific cells.
    - Estimate of background fish mercury concentration was input
    - Estimate of lake area and watershed area was input
4. Incremental change in fish mercury concentration was calculated by the spreadsheet.
5. Incremental change in risk for a recreational fisher, a subsistence/tribal fisher and a subsistence fisher were evaluated based on the consumption rate for a fisher receptor.
    - Consumption rate for a recreational fisher was assumed to be 30 grams per day
    - Consumption rate #1 for a subsistence fisher was assumed to be 224 grams per day and approximates the allowed take of fish by a Tribal member (~ 180 pounds per year of fish).
    - Consumption rate #2 for a subsistence fisher was assumed to be 199 grams per day and approximately the 95$^{th}$ percentile value for a general population (USEPA 1997 Exposure Factors Handbook)

Detailed model inputs and assumptions are provided in Appendix B.

# 4 Dispersion Modeling Results

The percentage contribution from each of the two facilities to the air concentrations at each modeled lake are provided in Table 3, below. The modeling indicates that Heikkilla Lake is most impacted by the Project itself. At Heikkilla Lake, the Project's contribution is approximately 25% of the total modeled air concentration, with the remainder attributed to the Mesabi Nugget LSDP. The Project's contribution to the modeled cumulative impact at the other selected lakes ranges from 8% to 13% (lake surface) and 23% to 28% (watershed).

These results of the cumulative dispersion modeling of the combined emissions from both sources are shown graphically in Figure 4 and Figure 5. The highest cumulative total annual mercury concentrations under both scenarios are within 10 kilometers of the project sites.

Figure 6 and Figure 7 show the modeled contribution due to the Project alone for the two speciation scenarios. Although not shown in the figures, the highest modeled elemental mercury concentrations are southwest of the Plant Site and just east of the Mesabi Nugget LSDP. The highest oxidized and particle bound mercury concentrations are south of the Plant Site. Predicted concentrations drop off quickly within about 5 kilometers of the sources and then level off.

Figure 8 illustrates the contribution from both the Project and Mesabi Nugget LSDP for each speciation scenario. This figure illustrates that the modeled contribution from the Project is less than that from the Mesabi Nugget LSDP at the selected lakes.

**Table 3 Modeled Maximum Mercury Air Concentrations—Incremental Project Contributions and Incremental Cumulative Contributions**

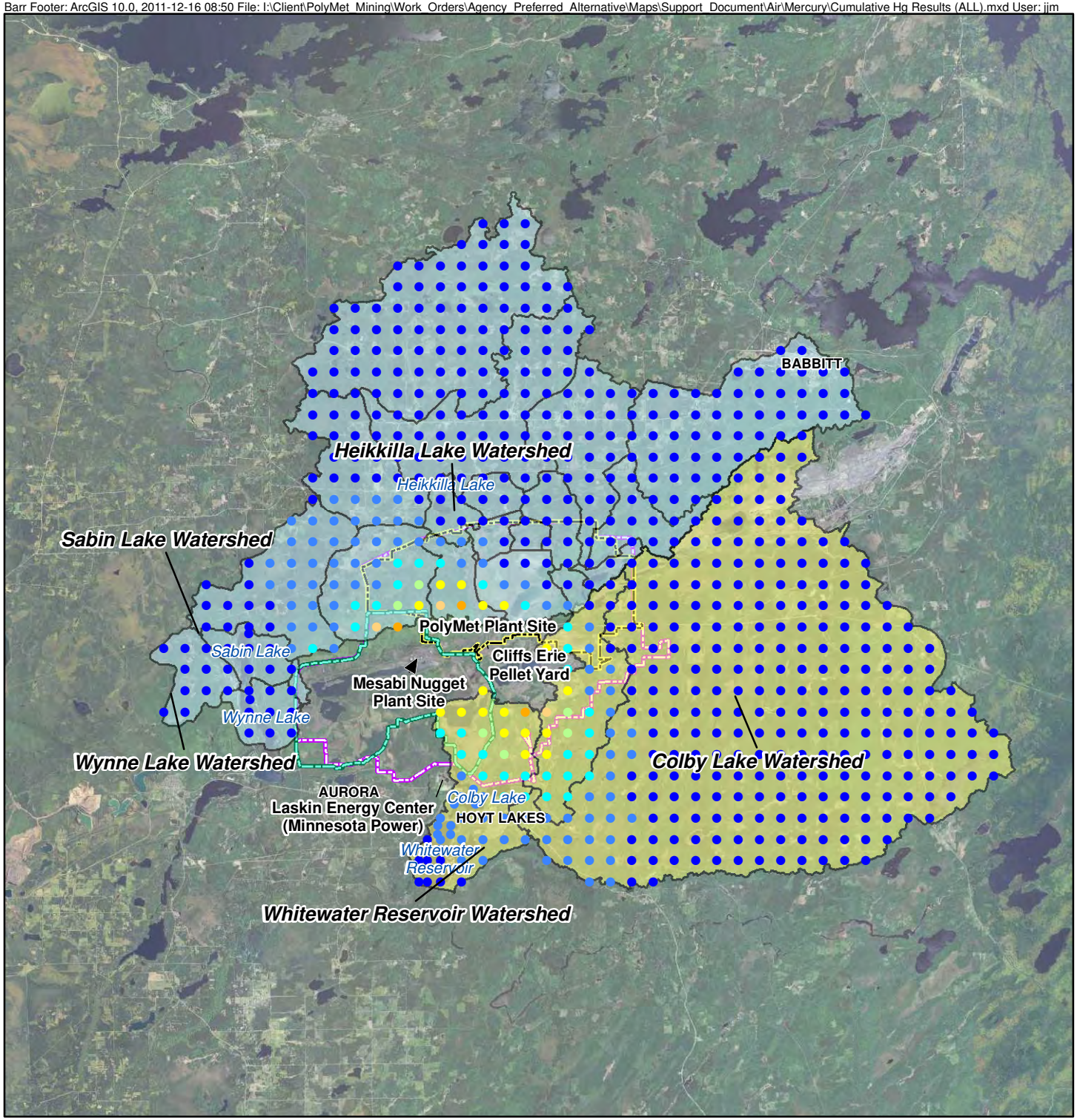
| | Scenario 1 | | | | | Scenario 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mesabi Nugget LDSP | | NorthMet | | Cumulative | Mesabi Nugget LSDP | | NorthMet | | Cumulative |
| Receptor | Max Annual (ug/m3) | % of Total | Max Annual (ug/m3) | % of Total | Max Annual (ug/m3) | Max Annual (ug/m3) | % of Total | Max Annual (ug/m3) | % of Total | Max Annual (ug/m3) |
| Colby Lake | 5.52E-06 | 90% | 6.13E-07 | 10% | 6.41E-06 | 5.52E-06 | 90% | 6.41E-07 | 10% | 6.07E-06 |
| Colby Lake Watershed | 2.62E-06 | 77% | 7.90E-07 | 23% | 3.81E-06 | 2.62E-06 | 77% | 8.03E-07 | 23% | 3.38E-06 |
| Heikkilla Lake | 3.11E-06 | 77% | 9.49E-07 | 23% | 4.34E-06 | 3.11E-06 | 76% | 9.67E-07 | 24% | 4.06E-06 |
| Heikkilla Lake Watershed | 3.11E-06 | 72% | 1.20E-06 | 28% | 4.71E-06 | 3.11E-06 | 72% | 1.22E-06 | 28% | 4.30E-06 |
| Sabin Lake | 3.17E-06 | 89% | 3.72E-07 | 11% | 3.75E-06 | 3.17E-06 | 89% | 3.77E-07 | 11% | 3.54E-06 |
| Sabin Lake Watershed | 2.66E-06 | 76% | 8.45E-07 | 24% | 3.78E-06 | 2.66E-06 | 76% | 8.55E-07 | 24% | 3.44E-06 |
| Whitewater Lake | 4.38E-06 | 92% | 3.86E-07 | 8% | 4.97E-06 | 4.38E-06 | 92% | 4.01E-07 | 8% | 4.76E-06 |
| Whitewater Lake Watershed | 4.71E-06 | 90% | 5.35E-07 | 10% | 5.51E-06 | 4.71E-06 | 89% | 5.55E-07 | 11% | 5.21E-06 |
| Wynne Lake | 2.03E-06 | 87% | 2.97E-07 | 13% | 2.49E-06 | 2.03E-06 | 87% | 3.01E-07 | 13% | 2.32E-06 |
| Wynne Lake Watershed | 2.66E-06 | 76% | 8.45E-07 | 24% | 3.78E-06 | 2.66E-06 | 76% | 8.55E-07 | 24% | 3.44E-06 |

Notes:

* AERMOD results, December 1, 2011. Sources were modeled using the regulatory default mode of AERMOD.

** MAX ANNUAL CONCENTRATION is the maximum annual concentration over the years modeled. The Cumulative MAX ANNUAL CONCENTRATION may not equal the sum of the MAX ANNUAL CONCENTRATION from each facility if the max occurred at different years.

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## Annual Concentration (ug/m3)

- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.305e-005

Embarrass River Watersheds

Partridge River Watersheds

N

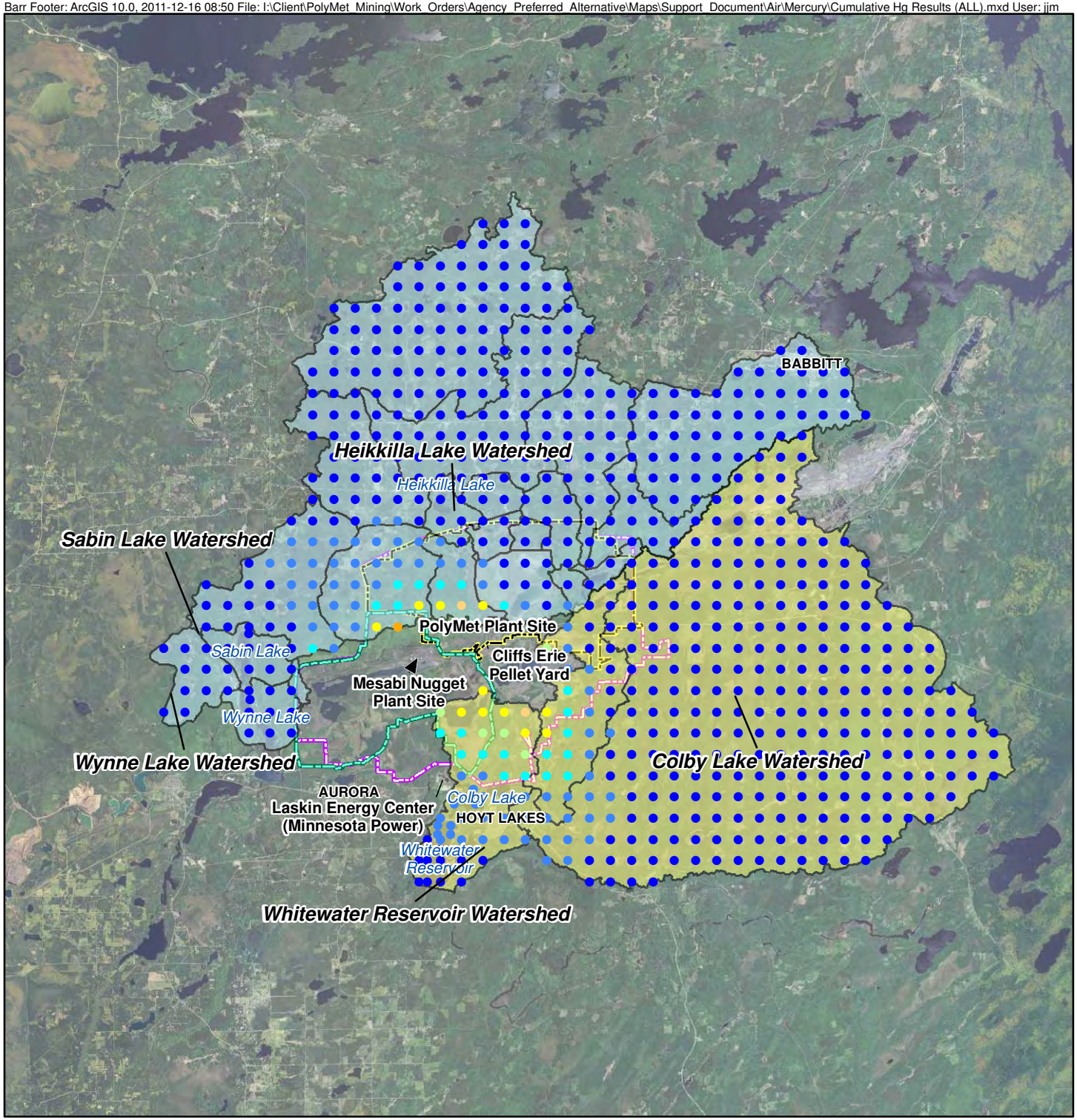
Kilometers

5 0 5

Figure 4

CUMULATIVE ANNUAL HG
Scenario 1 Results
NorthMet Project
Hoyt Lakes, MN

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## Annual Concentration (ug/m3)

- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.055e-005

Embarrass River Watersheds

Partridge River Watersheds

N

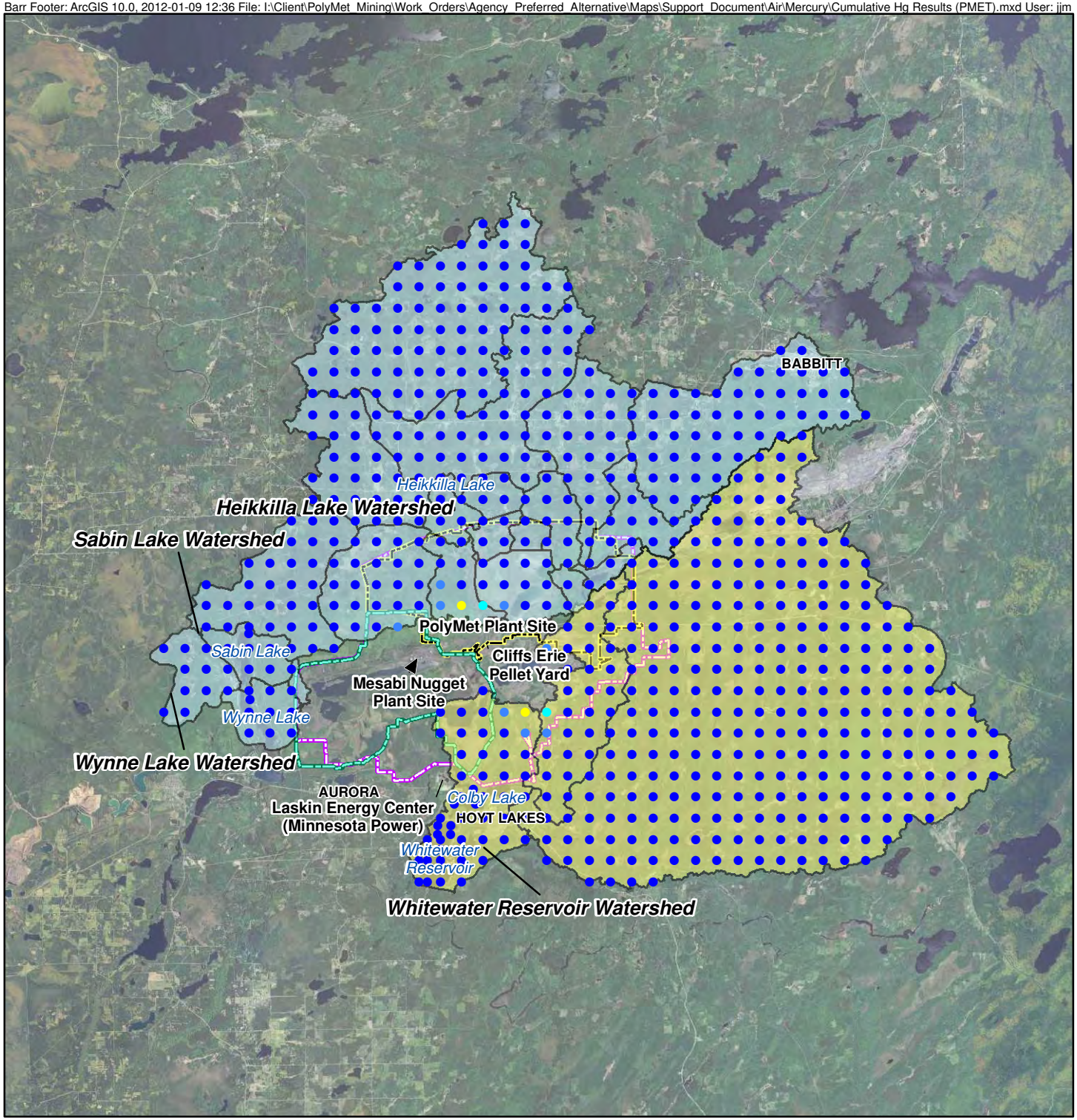
Kilometers

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Figure 5

CUMULATIVE ANNUAL HG
Scenario 2 Results
NorthMet Project
Hoyt Lakes, MN

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## Annual Concentration (ug/m3)

- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.350e-005

Embarrass River Watersheds

Partridge River Watersheds

N

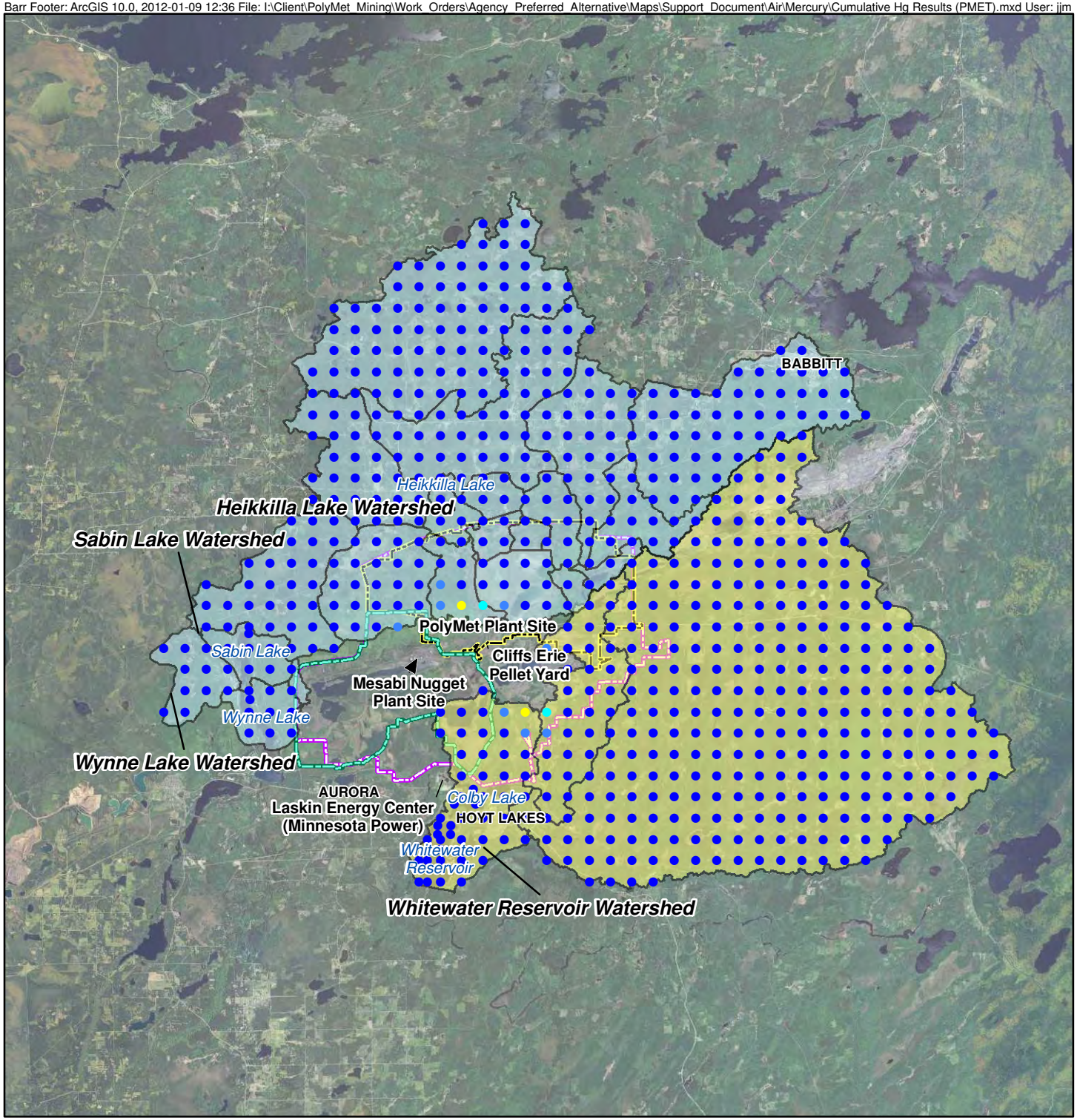
Kilometers

5 0 5

Figure 6

CUMULATIVE ANNUAL HG
Scenario 1 Results NorthMet Only
NorthMet Project
Hoyt Lakes, MN

Barr Footer: ArcGIS 10.0, 2012-01-09 12:36 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\Mercury\Cumulative Hg Results (PMET).mxd User: jjm




## Annual Concentration (ug/m3)

- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.055e-005

Embarrass River Watersheds

Partridge River Watersheds

N

Kilometers

5 0 5

Figure 7

CUMULATIVE ANNUAL HG
Scenario 2 Results NorthMet Only
NorthMet Project
Hoyt Lakes, MN

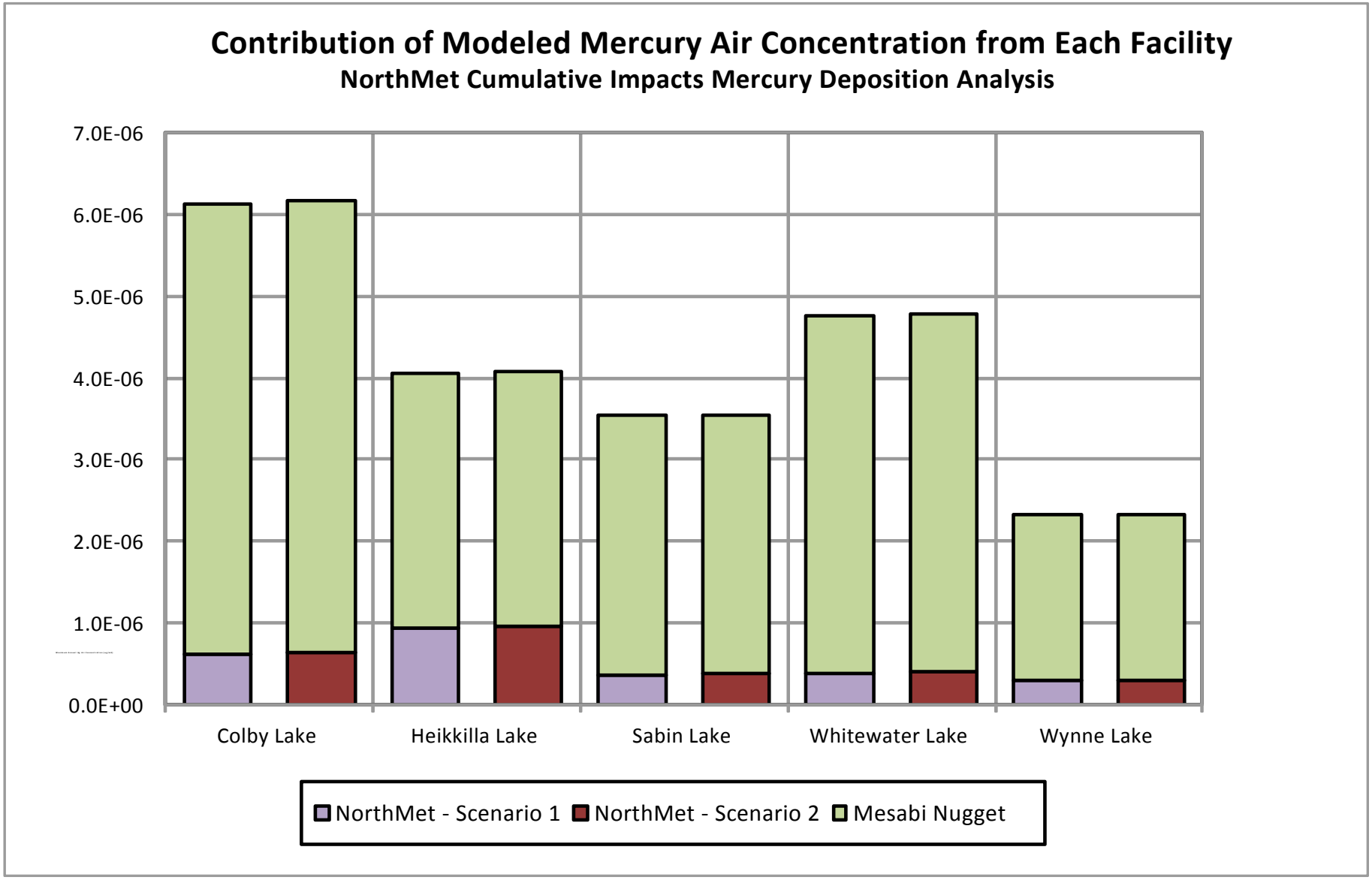



**Figure 8 Contribution of Modeled Mercury Air Concentration from Each Facility**

# 5 Fish Bioaccumulation and Health Risk

Based on the MPCA screening-level MMREM spreadsheet model, the predicted increase in mercury concentration in the air over nearby lakes translates into a worst case 0.3 to 1.8 percent increase in mercury deposition at the selected lakes (compared to the assumed 12.5 $\mu g*m^{-2}*year^{-1}$ existing deposition rate). Because the model assumes that the mercury concentration in fish is directly proportional to mercury deposition rate, this translates into a 0.3 to 1.8 percent incremental increase in the amount of mercury in the fish. The modeled incremental increase in mercury loading and fish concentration are shown in Table 4 for the two facilities together and for the Project alone. See Appendix B for detailed calculations.

Table 5 shows the existing and predicted incremental Hazard Quotient for all five lakes for the following three separate fish consumption scenarios:

1. a recreational angler (30 grams per day),
2. a subsistence/tribal angler (224 grams per day) and
3. for a subsistence angler (199 grams per day).

Figure 9, below, shows that the existing Hazard Quotient for recreational anglers is over 2.0 for each of the lakes under Scenario 1 and 2. (This is why there are existing consumption advisories on the lakes.) The existing health risk under Scenario 1 and 2 to subsistence/tribal and subsistence anglers eating three pounds or more per week of fish from these lakes would be significantly higher—up to fifteen times the EPA assumed safe intake level for a pregnant mother or child under the age of 15. (The majority of anglers fishing on these lakes are not subsistence anglers, however.)

The incremental risk is only about 0.3 to 1.8 percent increase over the existing risk levels, for recreational, subsistence/tribal and subsistence anglers. Therefore, the incremental risk due to the combined mercury emissions of these two projects, when compared to the existing risk, is barely visible on Figure 9.

Figure 10 shows the incremental risk-only due to the cumulative emissions of the both projects. The higher incremental increase in Colby, Wynne and Sabin Lakes is largely due to its large watershed size. In general, Figure 10 shows that the incremental risk from the project's emissions to a

recreational angler is less than one-tenth the 1.0 Hazard Quotient thresholds, for both Scenario 1 and 2.

The modeled incremental Hazard Quotient to a subsistence/tribal and subsistence angler at Wynne Lake is over 0.5 under the high particulate and oxidized mercury emission assumption (Scenario 1). Scenario 1, however, is conservative because it assumes the emitted mercury will be 25% particulate and 25% Hg(II) and the remainder Hg (0). In actual operation, it is expected that the venturi scrubber and packed bed scrubber installed in series will control Hg(II) and particle bound mercury by 90%. This means that most of the mercury (at least 80%) would be Hg (0). Under this more realistic Scenario 2 (10% particulate, 10% Hg(II), the associated Hazard Quotient is under 0.2. In summary, the modeled incremental cumulative risk from these two projects would not result in a measurable change in health risk to people eating fish from the selected lakes. The health risk due to increased mercury deposition at other area lakes, such as Seven Beaver Lake, would be even less than the lakes listed in this report because they are located further from the two projects. Nevertheless, the mercury concentration in the fish in these nearby lakes and many lakes in Minnesota already exceeds the State of Minnesota's health-based target of 0.2 ppm (See Table 4, Column B). The MPCA Statewide Mercury TMDL (TMDL) and Strategy Framework (described above in Section 2) is intended to provide the long-term framework to reduce the mercury in fish in Minnesota lakes. PolyMet intends to comply with any applicable provisions of the Minnesota Mercury TMDL in order to help reduce long-term mercury concentrations in the fish in these lakes and other impaired lakes in Minnesota.

**Table 4 Incremental Increase in Mercury Loading and Fish Concentration**

| A | | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | | | **Cumulative** | | **NorthMet Alone** | | |
| **Lake** | | Existing fish Hg Concentration (ppm) | Increase in fish Hg Concentration (ppm) MMREM Results | %Increase in Hg loading and fish Hg concentration Calculated from B and C | proportion due to NorthMet alone (%) Table 3 or below** | Increase in fish Hg Concentration (ppm) Calculated from C and E | %Increase in Hg loading and fish Hg concentration Calc from B and F |
| Colby Lake | Scenario 1 | 0.93 | 0.012 | 1.2% | 10.0% | 0.001 | 0.12% |
| | Scenario 2 | | 0.003 | 0.4% | 10.4% | 0.000 | 0.04% |
| Heikkilla Lake | Scenario 1 | 0.65 | 0.011 | 1.8% | 23.4% | 0.003 | 0.41% |
| | Scenario 2 | | 0.003 | 0.5% | 23.7% | 0.001 | 0.11% |
| Sabin Lake | Scenario 1 | 1.02 | 0.013 | 1.3% | 10.5% | 0.001 | 0.14% |
| | Scenario 2 | | 0.004 | 0.4% | 10.6% | 0.000 | 0.04% |
| Whitewater Lake | Scenario 1 | 0.35 | 0.003 | 0.8% | 8.1% | 0.000 | 0.07% |
| | Scenario 2 | | 0.001 | 0.3% | 8.4% | 0.000 | 0.03% |
| Wynne Lake | Scenario 1 | 1.34 | 0.018 | 1.3% | 12.8% | 0.002 | 0.17% |
| | Scenario 2 | | 0.005 | 0.4% | 12.9% | 0.001 | 0.05% |

**Table 5 Cumulative Impacts Mercury Deposition Analysis**

| | | | **Recreational Angler** | | **Subsistence/Tribal Angler** | | **Subsistence Fisher** | |
|---|---|---|---|---|---|---|---|---|
| **Lake** | **MN DNR #** | | **Existing HQ** | **Incremental HQ** | **Existing HQ** | **Incremental HQ** | **Existing HQ** | **Incremental HQ** |
| Colby Lake | 69024900 | Scenario 1 | 4.3 | 0.05 | 32.0 | 0.4 | 28.4 | 0.35 |
| | | Scenario 2 | | 0.02 | | 0.1 | | 0.10 |
| Heikkilla Lake | 69025300 | Scenario 1 | 3.0 | 0.05 | 22.3 | 0.4 | 19.8 | 0.35 |
| | | Scenario 2 | | 0.01 | | 0.1 | | 0.09 |
| Sabin Lake | 69043401 | Scenario 1 | 4.7 | 0.06 | 35.1 | 0.5 | 31.2 | 0.41 |
| | | Scenario 2 | | 0.02 | | 0.1 | | 0.11 |
| Whitewater Lake | 69037600 | Scenario 1 | 1.6 | 0.01 | 11.9 | 0.1 | 10.6 | 0.09 |
| | | Scenario 2 | | 0.01 | | 0.0 | | 0.03 |
| Wynne Lake | 69043402 | Scenario 1 | 6.2 | 0.08 | 46.2 | 0.6 | 41.0 | 0.54 |
| | | Scenario 2 | | 0.02 | | 0.2 | | 0.15 |

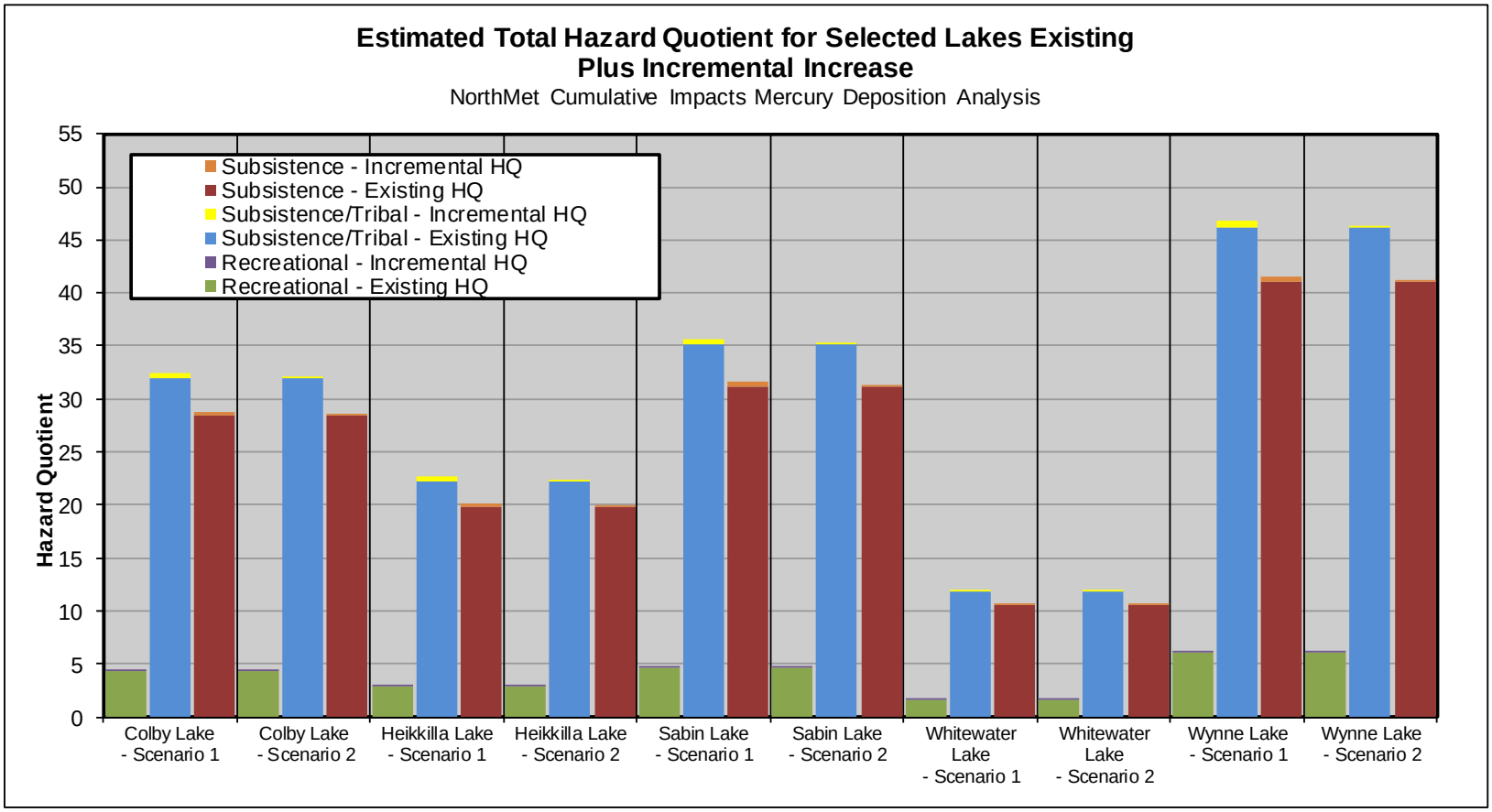



**Figure 9 Total Hazard Quotient (Existing Plus Incremental) NorthMet Cumulative Impacts Mercury Deposition Analysis**

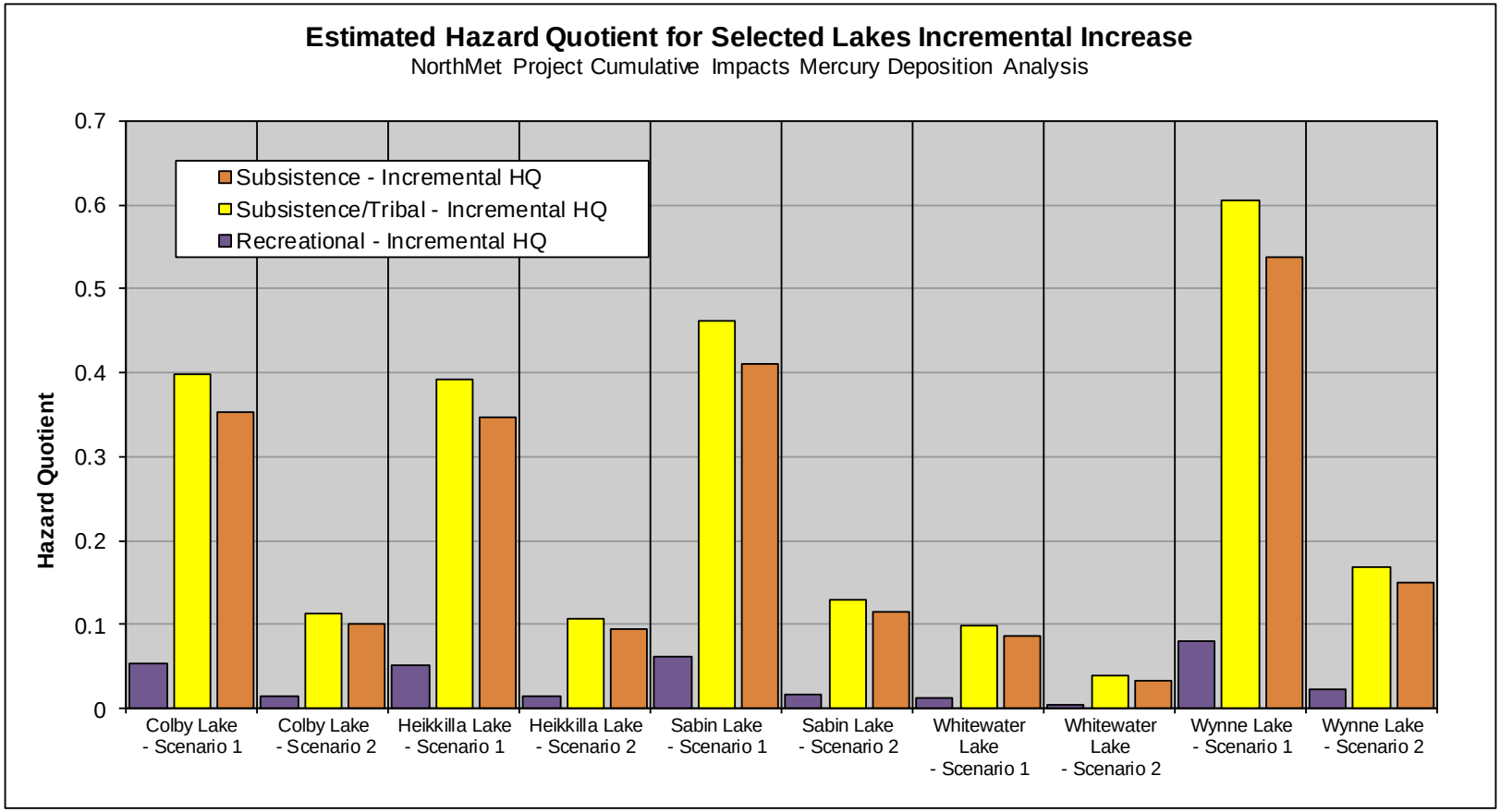



**Figure 10 Estimated Hazard Quotient for Selected Lakes Incremental Increase**

# 6 Other Factors

The MPCA's mercury risk estimation model assumes that the mercury concentration in the fish in a specific lake is proportional to the amount of mercury deposited to the lake and its watershed. However, this is only true if the other chemical, physical and biological factors that can affect the formation of methyl-mercury remain unchanged. These other factors include sulfur, iron, and organic matter cycling, pH, hydrology (including water level fluctuations)

These other factors greatly influence the extent of the mercury contamination problem. For example, the mercury concentrations in fish in northern Minnesota lakes vary by ten times or more even though the amount of mercury deposited from the atmosphere is nearly uniform across the region (MPCA 2007).

## 6.1 Sulfate

Sulfate-reducing bacteria are widely considered to be responsible for the bulk of mercury methylation in both aquatic and terrestrial habitats (Morel et al. 1998, Ullrich et al. 2001). In some cases higher sulfate concentrations could lead to increased methylation rates. However, other factors such as oxygen and organic carbon concentrations also influence whether sulfate availability is directly related to mercury methylation (Munthe et al 2007). Therefore, mercury methylation may be limited by sulfate concentrations in some lakes, but not in others. It is currently not possible to accurately model the relationship between sulfate concentrations and the mercury contamination in fish in a specific lake.

## 6.2 Wetlands

Wetlands are an important land cover in northern Minnesota and are also important sites of mercury methylation (MPCA 2007). Sulfate-reducing bacteria thrive in the oxygen-poor sediment found in wetlands. Also, methyl-mercury associated with dissolved organic carbon released from wetlands can be conveyed to surface waters (Driscoll et al. 1995). Consequently, wetland density can be correlated with mercury concentrations in water and fish (e.g., Greenfield et al. 2001, Grigal 2002). As with sulfate, however, it is not currently possible to accurately predict how wetland dewatering due to the Project and wetland hydrology impacts may affect methyl-mercury concentrations in water discharges.

## 6.3 Project Specific Factors

The former LTVSMC Tailings Basin, which will be used by the Project, is located in two local watersheds (Embarrass River Watershed and Partridge River Watershed). Surface seepage from the Tailings Basin flows south via a surface discharge station (SD026) toward Second Creek, which eventually flows into the Partridge River. In addition, discharge (SD033) from the northern portions of former LTVSMC mine Area 5 forms the headwaters of Spring Mine Creek, which flows north to the Embarrass River. Due to the nature of the industry, the effluent from these discharges contain sulfate

A sulfate and methylmercury investigation completed for the Project (Barr Eng. 2010) found that methylmercury concentration in two streams with elevated sulfate receiving seepage from the former LTVSMC Tailings Basin were similar to background streams with low sulfate (Bear Creek, PM20, upper Embarrass River, PM12).

# 7 Abbreviations, Acronyms, and Selected Definitions

## 7.1 Abbreviations and Acronyms

| | |
|---|---|
| AREA | Minnesota Power's Arrowhead Regional Emission Abatement Project |
| BACT | Best available control technology as defined at 40 CFR 52.21(b)(12) |
| BART | Best Available Retrofit Technology |
| BWCA | Boundary Waters Canoe Area (Wilderness); located in northeast Minnesota |
| CAA | Clean Air Act |
| CAIR | Clean Air Interstate Rule |
| CAMR | Clean Air Mercury Rule |
| CFR | Code of Federal Regulations |
| DRI | Direct Reduced Iron |
| EIS | Environmental Impact Statement |
| EPA | United States Environmental Protection Agency |
| Hg | mercury |
| IPM | Integrated Planning Model used for estimating impacts from CAMR |
| kg | kilogram |
| L | Liter |
| LTVSMC | LTV Steel Mining Company |
| $m^2$ | square meter |
| MACT | Maximum Achievable Control Technology |
| MDNR | Minnesota Department of Natural Resources |
| MERP | Xcel Energy's Metropolitan Emission Reduction Project |
| mg | milligram |
| MDN | Mercury Deposition Network |
| MPCA | Minnesota Pollution Control Agency |
| MPUC | Minnesota Public Utilities Commission |
| MW | Megawatt (1 megawatt equals 1,000,000 watts, or 1,000 kilowatts) |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| $NO_x$ | Nitrogen oxides – including all of the oxides of nitrogen |
| NP55 | standard length Northern Pike – 55 cm |
| ppm | parts per million |
| PSD | Prevention of Significant Deterioration |
| PTE | Potential-to-emit as defined at 40 CFR 52.21(b)(4) |
| $SO_2$ | Sulfur dioxide |

| | |
|---|---|
| SOx | Sulfur oxides – including all of the oxides of sulfur |
| SRB | sulfate reducing bacteria |
| TMDL | Total Maximum Daily Load |
| ton | Short ton = 2,000 pounds |
| ton, long | Long ton = 2240 pounds |
| ton, metric | Metric ton = 2204.6 pounds |
| µg | microgram |
| µg $m^{-2}$ $yr^{-1}$ | micrograms per square meter per year |
| U.S. | United States |
| VNP | Voyageurs National Park; located in northeast Minnesota |
| Yr | Year |

## 7.2 Selected Definitions (from MPCA 2007)

| | |
|---|---|
| **Anthropogenic Mercury Emissions** | the mobilization or release of geologically-bound mercury by human activity that results in a mass transfer of mercury to the atmosphere. |
| **Atmospheric deposition** | the mass transfer of gaseous, aerosol, or particulate contaminant from the atmosphere to the earth's surface (see mercury dry deposition and mercury wet deposition) |
| **Bioaccumulation** | increase in contaminant concentration through a food web; includes uptake through food and water or air. |
| **Bioconcentration** | uptake and increase in contaminant concentration only through the water or air, not food. |
| **Biomagnification** | increase in contaminant concentration between trophic levels. |
| **Class I Area** | Under the Clean Air Act, a Class I area is one in which air quality is protected more stringently than under the national ambient air quality standards; Federal Class I areas include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. Mandatory Federal Class I areas include certain national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres), and international parks that were in existence as of August 1977. |
| **Federal Class I Areas in Minnesota** | Boundary Waters Canoe Area Wilderness and Voyageurs National Park. |
| **Global Scale** | refers to emissions transported on a global scale; it does not refer to the sum of all emissions on Earth, but rather that portion of total emissions that are transported around the globe. |
| **Local scale** | The area within which emissions can travel in one diurnal cycle (generally within 100 km of a source). Local influences are characterized by measurable concentration gradients with relatively large fluctuations in air concentrations caused by meteorological factors such as wind direction (Expert Panel 1994). |

| | |
|---|---|
| **Mercury dry deposition** | mass transfer of gaseous, aerosol, or particulate mercury species from the atmosphere to the earth's surface (either aquatic or terrestrial, including trees and other vegetation) in the absence of precipitation. |
| **Mercury wet deposition** | mass transfer of dissolved gaseous or particulate mercury species from the atmosphere to the earth's surface (either aquatic or terrestrial) by precipitation. |
| **Mercury Methylation (Methylated)** | process of adding a methyl (CH3-) group to a mercury ion (Hg2+). Methylation can occur either biotically or abiotically, but sulfate-reducing bacteria are considered the primary methylators in aquatic systems (i.e., wetlands and lakes). |
| **Methylmercury CH3Hg+ or MeHg** | a cation that is the biologically active form of mercury; it has a very high affinity for sulfur-containing compounds, such as the amino acid cysteine; this is the form of mercury that accumulates in fish and is toxic to humans and wildlife. |
| **Natural mercury emissions** | mobilization or release of geologically-bound mercury by natural biotic and abiotic processes that result in mass transfer of mercury to the atmosphere. |
| **Regional scale** | the area requiring more than one diurnal cycle emission transport time (about 100 to 2000 km from a source). The regional scale describes areas sufficiently remote or distant from large emission sources so that concentration fields are rather homogeneous, lacking measurable gradients (Expert Panel1994). |
| **Standard length fish** | a set total fish length that is used to compare mercury concentrations among lakes and over time. The standard lengths used by the MPCA are 55 cm northern pike (NP55) and 40 cm walleye (WE40). Mercury concentrations for a standard length fish are determined from a linear regression of measured mercury fish tissue concentration versus fish length. |
| **Taconite** | low-grade iron ore processed by crushing and concentrating to yield a pellet for use in iron smelters. Taconite has low mercury concentrations but large volumes of the ore are heated during the pelletizing process, which releases ore-bound mercury into the atmosphere or scrubber water. |
| **TMDL – Total Maximum Daily Load.** | The maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDL also refers to the process of allocating pollutant loadings among point and nonpoint sources. |

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# Appendices

# Appendix A

## Cumulative Impacts Mercury Deposition Analysis

**Modeled Maximum Incremental Total Mercury Air Concentration and Watershed Inputs:**
**Cumulative Impacts Mercury Deposition Analysis**

**DATA INPUTS:**

| Lakes Evaluated | MDNR # | Existing Ambient Fish Tissue Concentration (mg/kg) | Area of Fishable Waterbody (acres) | Total Watershed Area (acres) | Area of Rest of Watershed (acres) | Area References |
|---|---|---|---|---|---|---|
| Colby Lake | 69024900 | 0.93 | 502 | 100,392 | 99,890 | 2,3 |
| Heikkilla Lake | 69025300 | 0.65 | 128 | 1,478 | 1,350 | 1,3 |
| Sabin Lake | 69043401 | 1.02 | 299 | 121,669 | 121,370 | 3 |
| Whitewater Lake | 69037600 | 0.35 | 1,215 | 4,265 | 3,050 | 4,5 |
| Wynne Lake | 69043402 | 1.34 | 289 | 123,889 | 123,600 | 2,3 |

**DATA SOURCES AND ASSUMPTIONS:**

**Fishable Waterbody and Watershed Areas**

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospacial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

**Modeled Increment to Mean Hg Air Concentration (ug/m3)**

The AERMOD air dispersion model was used to model estimated emissions from the Mesabi Nugget LSDP and the Plant Site.
The model was run in regulatory mode (i.e., no plume depletion).

A receptor grid for the modeling was designed to provide aerial coverage for each lake/watershed and will have polar grid receptors extending out to 25 kilometers. For lake surface area, one receptor was placed over the lake for every 100 acres of surface area. For watersheds, one receptor was placed over the watershed for every 1,000 acres of area. For example, for Colby Lake (500 acres) and its watershed (~100,000 acres), 5 receptors will be placed over the lake and 100 receptors placed in the watershed. The Heikkilla Lake watershed is located partially within the Plant Site boundaries. To capture the likely strong gradient close to the Plant Site, the receptor grid was designed to spread out with distance from the Plant Site.

The average mercury air concentration over the lake and over the watershed was then calculated by averaging the receptor concentrations over each area, as recommended in the MMREM guidance.

Individual AERMOD modeling runs were conducted for each mercury species to provide cumulative air concentrations for elemental, oxidized and particle-bound mercury, respectively, using the speciation shown below.

## Emission Sources and Hg Speciation

**Mercury Speciation for Projects Included in the Cumulative Mercury Deposition Analysis**

| Project | Mercury Speciation (%) | | Comments |
|---|---|---|---|
| NorthMet Plant Site - Scenario 1 [1] | 25 | elemental | Conservative estimate for local deposition analysis purposes only, because speciation data for the autoclave is not yet available |
| | 50 | oxidized | |
| | 25 | particle-bound | |
| NorthMet Plant Site - Scenario 2 [1] | 80 | elemental | Estimated likely speciation based on engineering assumptions and limited data from other autoclaves. |
| | 10 | oxidized | |
| | 10 | particle-bound | |
| Mesabi Nugget L SDP | 99.3 | elemental | Speciation from stack testing data for the pilot plant. |
| | 0.6 | oxidized | (This is the same speciation assessed for local mercury deposition in the Mesabi Nugget May 2005 AERA and in the Mesabi Nugget Phase II August 2009 AERA) |
| | 0.1 | particle-bound | |

[1] The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

**Existing Ambient Fish Tissue Concentrations**

Fish Tissue Concentrations were estimated for Colby, Sabin, Whitewater and Wynne Lakes based on the MDNR fish tissue database by calculating a 95% UCL of the mean using fish tissue data from each lake.

Fish Tissue Concentrations for Heikkilla Lake were estimated by calculating a 95% UCL of the mean using fish tissue data from the following 5 area lakes which have fish Hg data available: Colby, Sabin, Whitewater, Wynne and Bear Island Lakes.

# Appendix B

## Minnesota Mercury Risk Estimation Method

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Colby Lake** | **St. Louis** | **69024900** | **0.93** | **502** | **99890** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **3.38E-07** | 5.3% | 1.10 | 0.1 | 502 | 4046.9 | 2.4E+05 | 0.24 | 1.00 | 0.24 |
| Hg(0) | **5.91E-06** | 92.3% | 0.01 | 0.0 | 502 | 4046.9 | 3.8E+04 | 0.04 | 1.00 | 0.04 |
| Hg-p | **1.59E-07** | 2.5% | 0.05 | 0.00 | 502 | 4046.9 | 5.1E+03 | 0.01 | 1.00 | 0.0051 |
| Total | 6.41E-06 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **4.10E-07** | 10.8% | 1.10 | 0.14 | 99,890 | 4046.9 | 5.75E+07 | 57.53 | 0.26 | 14.96 |
| Hg(0) | **3.20E-06** | 84.0% | 0.01 | 0.0 | 99,890 | 4046.9 | 4.1E+06 | 4.08 | 0.26 | 1.06 |
| Hg-p | **2.00E-07** | 5.3% | 0.05 | 0.00 | 99,890 | 4046.9 | 1.3E+06 | 1.28 | 0.26 | 0.332 |
| Total | 3.81E-06 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 16.63 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 502 | 4046.9 | 2.5E+07 | 25.39 | 1.00 | 25.39 |
| Total deposition for the rest of the watershed | 12.5 | 99,890 | 4046.9 | 5.1E+09 | 5053.06 | 0.26 | 1313.80 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1339.19 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 16.6 | 1339.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.012 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 4.7 | 0.06 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0023 | 0.0025 | 70 | 2.84E-03 | 3.53E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 28.4 | 0.35 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0026 | 0.0028 | 70 | 3.20E-03 | 3.97E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 32.0 | 0.40 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0003 | 0.0004 | 70 | 4.28E-04 | 5.32E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.3 | 0.05 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

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Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Colby Lake** | **St. Louis** | **69024900** | **0.93** | **502** | **99890** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **9.25E-08** | 1.5% | 1.10 | 0.0 | 502 | 4046.9 | 6.5E+04 | 0.07 | 1.00 | 0.07 |
| Hg(0) | **5.91E-06** | 97.4% | 0.01 | 0.0 | 502 | 4046.9 | 3.8E+04 | 0.04 | 1.00 | 0.04 |
| Hg-p | **6.66E-08** | 1.1% | 0.05 | 0.00 | 502 | 4046.9 | 2.1E+03 | 0.00 | 1.00 | 0.0021 |
| Total | 6.07E-06 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **9.41E-08** | 2.8% | 1.10 | 0.0 | 99,890 | 4046.9 | 1.3E+07 | 13.20 | 0.26 | 3.43 |
| Hg(0) | **3.21E-06** | 94.8% | 0.01 | 0.0 | 99,890 | 4046.9 | 4.1E+06 | 4.09 | 0.26 | 1.06 |
| Hg-p | **8.16E-08** | 2.4% | 0.05 | 0.00 | 99,890 | 4046.9 | 5.2E+05 | 0.52 | 0.26 | 0.135 |
| Total | 3.38E-06 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 4.73 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 502 | 4046.9 | 2.5E+07 | 25.39 | 1.00 | 25.39 |
| Total deposition for the rest of the watershed | 12.5 | 99,890 | 4046.9 | 5.1E+09 | 5053.06 | 0.26 | 1313.80 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1339.19 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 4.7 | 1339.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.003 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 4.7 | 0.02 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0007 | 0.0007 | 70 | 2.84E-03 | 1.00E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 28.4 | 0.10 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0007 | 0.0008 | 70 | 3.20E-03 | 1.13E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 32.0 | 0.11 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 4.28E-04 | 1.51E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.3 | 0.02 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

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Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Heikkilla Lake** | **St. Louis** | **69025300** | **0.65** | **128** | **1350** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **4.93E-07** | 11.4% | 1.10 | 0.2 | 128 | 4046.9 | 8.9E+04 | 0.09 | 1.00 | 0.09 |
| Hg(0) | **3.60E-06** | 83.1% | 0.01 | 0.0 | 128 | 4046.9 | 5.9E+03 | 0.01 | 1.00 | 0.01 |
| Hg-p | **2.40E-07** | 5.5% | 0.05 | 0.00 | 128 | 4046.9 | 2.0E+03 | 0.00 | 1.00 | 0.0020 |
| Total | 4.34E-06 | 100.0% | | 0.2 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **6.19E-07** | 13.1% | 1.10 | 0.21 | 1,350 | 4046.9 | 1.17E+06 | 1.17 | 0.26 | 0.30 |
| Hg(0) | **3.78E-06** | 80.4% | 0.01 | 0.0 | 1,350 | 4046.9 | 6.5E+04 | 0.07 | 0.26 | 0.02 |
| Hg-p | **3.04E-07** | 6.5% | 0.05 | 0.00 | 1,350 | 4046.9 | 2.6E+04 | 0.03 | 0.26 | 0.007 |
| Total | 4.71E-06 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.43 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 128 | 4046.9 | 6.5E+06 | 6.48 | 1.00 | 6.48 |
| Total deposition for the rest of the watershed | 12.5 | 1,350 | 4046.9 | 6.8E+07 | 68.29 | 0.26 | 17.76 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 24.23 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.4 | 24.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.011 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 3.2 | 0.06 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0023 | 0.0024 | 70 | 1.98E-03 | 3.47E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 19.8 | 0.35 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0025 | 0.0027 | 70 | 2.23E-03 | 3.91E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 22.3 | 0.39 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0003 | 0.0004 | 70 | 2.99E-04 | 5.24E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 3.0 | 0.05 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

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Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

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Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Heikkilla Lake** | **St. Louis** | **69025300** | **0.65** | **128** | **1350** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **1.13E-07** | 2.8% | 1.10 | 0.0 | 128 | 4046.9 | 2.0E+04 | 0.02 | 1.00 | 0.02 |
| Hg(0) | **3.85E-06** | 94.8% | 0.01 | 0.0 | 128 | 4046.9 | 6.3E+03 | 0.01 | 1.00 | 0.01 |
| Hg-p | **9.80E-08** | 2.4% | 0.05 | 0.00 | 128 | 4046.9 | 8.0E+02 | 0.00 | 1.00 | 0.0008 |
| Total | 4.06E-06 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **1.38E-07** | 3.2% | 1.10 | 0.05 | 1,350 | 4046.9 | 2.61E+05 | 0.26 | 0.26 | 0.07 |
| Hg(0) | **4.04E-06** | 93.9% | 0.01 | 0.0 | 1,350 | 4046.9 | 7.0E+04 | 0.07 | 0.26 | 0.02 |
| Hg-p | **1.23E-07** | 2.9% | 0.05 | 0.00 | 1,350 | 4046.9 | 1.1E+04 | 0.01 | 0.26 | 0.003 |
| Total | 4.30E-06 | 100.0% | | 0.1 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.12 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 128 | 4046.9 | 6.5E+06 | 6.48 | 1.00 | 6.48 |
| Total deposition for the rest of the watershed | 12.5 | 1,350 | 4046.9 | 6.8E+07 | 68.29 | 0.26 | 17.76 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 24.23 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.1 | 24.2 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.003 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 3.2 | 0.02 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0006 | 0.0007 | 70 | 1.98E-03 | 9.49E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 19.8 | 0.09 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0007 | 0.0007 | 70 | 2.23E-03 | 1.07E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 22.3 | 0.11 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 2.99E-04 | 1.43E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 3.0 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Sabin Lake** | **St. Louis** | **69043401** | **1.02** | **299** | **121370** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **2.05E-07** | 5.5% | 1.10 | 0.1 | 299 | 4046.9 | 8.6E+04 | 0.09 | 1.00 | 0.09 |
| Hg(0) | **3.45E-06** | 92.0% | 0.01 | 0.0 | 299 | 4046.9 | 1.3E+04 | 0.01 | 1.00 | 0.01 |
| Hg-p | **9.62E-08** | 2.6% | 0.05 | 0.00 | 299 | 4046.9 | 1.8E+03 | 0.00 | 1.00 | 0.0018 |
| Total | 3.75E-06 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **4.37E-07** | 11.6% | 1.10 | 0.15 | 121,370 | 4046.9 | 7.45E+07 | 74.50 | 0.26 | 19.37 |
| Hg(0) | **3.13E-06** | 82.8% | 0.01 | 0.0 | 121,370 | 4046.9 | 4.8E+06 | 4.85 | 0.26 | 1.26 |
| Hg-p | **2.14E-07** | 5.7% | 0.05 | 0.00 | 121,370 | 4046.9 | 1.7E+06 | 1.66 | 0.26 | 0.430 |
| Total | 3.78E-06 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 21.16 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 299 | 4046.9 | 1.5E+07 | 15.13 | 1.00 | 15.13 |
| Total deposition for the rest of the watershed | 12.5 | 121,370 | 4046.9 | 6.1E+09 | 6139.65 | 0.26 | 1596.31 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1611.44 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 21.2 | 1611.4 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.013 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 5.1 | 0.07 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0027 | 0.0029 | 70 | 3.12E-03 | 4.10E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 31.2 | 0.41 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0030 | 0.0032 | 70 | 3.51E-03 | 4.61E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 35.1 | 0.46 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0004 | 0.0004 | 70 | 4.70E-04 | 6.18E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.7 | 0.06 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Sabin Lake** | **St. Louis** | **69043401** | **1.02** | **299** | **121370** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **5.60E-08** | 1.6% | 1.10 | 0.0 | 299 | 4046.9 | 2.3E+04 | 0.02 | 1.00 | 0.02 |
| Hg(0) | **3.45E-06** | 97.3% | 0.01 | 0.0 | 299 | 4046.9 | 1.3E+04 | 0.01 | 1.00 | 0.01 |
| Hg-p | **4.04E-08** | 1.1% | 0.05 | 0.00 | 299 | 4046.9 | 7.7E+02 | 0.00 | 1.00 | 0.0008 |
| Total | 3.54E-06 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **9.93E-08** | 2.9% | 1.10 | 0.03 | 121,370 | 4046.9 | 1.69E+07 | 16.92 | 0.26 | 4.40 |
| Hg(0) | **3.25E-06** | 94.6% | 0.01 | 0.0 | 121,370 | 4046.9 | 5.0E+06 | 5.04 | 0.26 | 1.31 |
| Hg-p | **8.70E-08** | 2.5% | 0.05 | 0.00 | 121,370 | 4046.9 | 6.7E+05 | 0.67 | 0.26 | 0.175 |
| Total | 3.44E-06 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 5.92 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 299 | 4046.9 | 1.5E+07 | 15.13 | 1.00 | 15.13 |
| Total deposition for the rest of the watershed | 12.5 | 121,370 | 4046.9 | 6.1E+09 | 6139.65 | 0.26 | 1596.31 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1611.44 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 5.9 | 1611.4 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.004 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 5.1 | 0.02 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0007 | 0.0008 | 70 | 3.12E-03 | 1.15E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 31.2 | 0.11 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0008 | 0.0009 | 70 | 3.51E-03 | 1.29E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 35.1 | 0.13 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 4.70E-04 | 1.73E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 4.7 | 0.02 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Whitewater Lake** | **St. Louis** | **69037600** | **0.35** | **1215** | **3050** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **2.19E-07** | 4.4% | 1.10 | 0.1 | 1,215 | 4046.9 | 3.7E+05 | 0.37 | 1.00 | 0.37 |
| Hg(0) | **4.65E-06** | 93.6% | 0.01 | 0.0 | 1,215 | 4046.9 | 7.2E+04 | 0.07 | 1.00 | 0.07 |
| Hg-p | **1.01E-07** | 2.0% | 0.05 | 0.00 | 1,215 | 4046.9 | 7.8E+03 | 0.01 | 1.00 | 0.0078 |
| Total | 4.97E-06 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **2.94E-07** | 5.3% | 1.10 | 0.10 | 3,050 | 4046.9 | 1.26E+06 | 1.26 | 0.26 | 0.33 |
| Hg(0) | **5.07E-06** | 92.2% | 0.01 | 0.0 | 3,050 | 4046.9 | 2.0E+05 | 0.20 | 0.26 | 0.05 |
| Hg-p | **1.38E-07** | 2.5% | 0.05 | 0.00 | 3,050 | 4046.9 | 2.7E+04 | 0.03 | 0.26 | 0.007 |
| Total | 5.51E-06 | 100.0% | | 0.1 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.84 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 1,215 | 4046.9 | 6.1E+07 | 61.46 | 1.00 | 61.46 |
| Total deposition for the rest of the watershed | 12.5 | 3,050 | 4046.9 | 1.5E+08 | 154.29 | 0.26 | 40.11 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 101.58 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.8 | 101.6 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.003 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 1.7 | 0.01 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0006 | 0.0006 | 70 | 1.06E-03 | 8.73E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 10.6 | 0.09 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0006 | 0.0007 | 70 | 1.19E-03 | 9.82E-06 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 11.9 | 0.10 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0001 | 70 | 1.59E-04 | 1.32E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 1.6 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Whitewater Lake** | **St. Louis** | **69037600** | **0.35** | **1215** | **3050** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **6.45E-08** | 1.4% | 1.10 | 0.0 | 1,215 | 4046.9 | 1.1E+05 | 0.11 | 1.00 | 0.11 |
| Hg(0) | **4.65E-06** | 97.7% | 0.01 | 0.0 | 1,215 | 4046.9 | 7.2E+04 | 0.07 | 1.00 | 0.07 |
| Hg-p | **4.29E-08** | 0.9% | 0.05 | 0.00 | 1,215 | 4046.9 | 3.3E+03 | 0.00 | 1.00 | 0.0033 |
| Total | 4.76E-06 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **7.99E-08** | 1.5% | 1.10 | 0.03 | 3,050 | 4046.9 | 3.42E+05 | 0.34 | 0.26 | 0.09 |
| Hg(0) | **5.07E-06** | 97.4% | 0.01 | 0.0 | 3,050 | 4046.9 | 2.0E+05 | 0.20 | 0.26 | 0.05 |
| Hg-p | **5.79E-08** | 1.1% | 0.05 | 0.00 | 3,050 | 4046.9 | 1.1E+04 | 0.01 | 0.26 | 0.003 |
| Total | 5.21E-06 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 0.33 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 1,215 | 4046.9 | 6.1E+07 | 61.46 | 1.00 | 61.46 |
| Total deposition for the rest of the watershed | 12.5 | 3,050 | 4046.9 | 1.5E+08 | 154.29 | 0.26 | 40.11 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 101.58 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 0.3 | 101.6 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.001 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 1.7 | 0.01 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0002 | 0.0002 | 70 | 1.06E-03 | 3.42E-06 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 10.6 | 0.03 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0003 | 0.0003 | 70 | 1.19E-03 | 3.85E-06 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 11.9 | 0.04 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0000 | 0.0000 | 70 | 1.59E-04 | 5.16E-07 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 1.6 | 0.01 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Wynne Lake** | **St. Louis** | **69043402** | **1.34** | **289** | **123600** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **1.61E-07** | 6.5% | 1.10 | 0.1 | 289 | 4046.9 | 6.5E+04 | 0.07 | 1.00 | 0.07 |
| Hg(0) | **2.25E-06** | 90.5% | 0.01 | 0.0 | 289 | 4046.9 | 8.3E+03 | 0.01 | 1.00 | 0.01 |
| Hg-p | **7.64E-08** | 3.1% | 0.05 | 0.00 | 289 | 4046.9 | 1.4E+03 | 0.00 | 1.00 | 0.0014 |
| Total | 2.49E-06 | 100.0% | | 0.1 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **4.37E-07** | 11.6% | 1.10 | 0.15 | 123,600 | 4046.9 | 7.59E+07 | 75.86 | 0.26 | 19.72 |
| Hg(0) | **3.13E-06** | 82.8% | 0.01 | 0.0 | 123,600 | 4046.9 | 4.9E+06 | 4.94 | 0.26 | 1.28 |
| Hg-p | **2.14E-07** | 5.7% | 0.05 | 0.00 | 123,600 | 4046.9 | 1.7E+06 | 1.69 | 0.26 | 0.438 |
| Total | 3.78E-06 | 100.0% | | 0.2 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 21.52 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 289 | 4046.9 | 1.5E+07 | 14.62 | 1.00 | 14.62 |
| Total deposition for the rest of the watershed | 12.5 | 123,600 | 4046.9 | 6.3E+09 | 6252.46 | 0.26 | 1625.64 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1640.26 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 21.5 | 1640.3 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.018 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 6.7 | 0.09 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0035 | 0.0038 | 70 | 4.10E-03 | 5.38E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 41.0 | 0.54 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0039 | 0.0042 | 70 | 4.62E-03 | 6.06E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 46.2 | 0.61 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0005 | 0.0006 | 70 | 6.18E-04 | 8.11E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 6.2 | 0.08 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bold | Calculated Outputs are in yellow | Fixed assumptions are not colored

**Facility Name:** Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

**Information on the water body for which these calculations are made:**

| Water body name | County Name | MN DNR lake # (if available) (xx-yyyy) | Existing Ambient Fish Concentration (mg/kg Hg) | Area of fishable waterbody (acres) | Area of rest of watershed (acres) |
|---|---|---|---|---|---|
| **Wynne Lake** | **St. Louis** | **69043402** | **1.34** | **289** | **123600** |

**Mercury calculations for the increment due to the project:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m$^3$ | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual Mass deposited (µg) | Annual Mass deposited (grams) | Fraction Reaching Waterbody | Annual Mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average concentration over the lake | | | | | | | | | | |
| Hg(II) | **4.17E-08** | 1.8% | 1.10 | 0.0 | 289 | 4046.9 | 1.7E+04 | 0.02 | 1.00 | 0.02 |
| Hg(0) | **2.25E-06** | 96.8% | 0.01 | 0.0 | 289 | 4046.9 | 8.3E+03 | 0.01 | 1.00 | 0.01 |
| Hg-p | **3.18E-08** | 1.4% | 0.05 | 0.00 | 289 | 4046.9 | 5.9E+02 | 0.00 | 1.00 | 0.0006 |
| Total | 2.32E-06 | 100.0% | | 0.0 | | | | | | |
| Average concentration over the rest of the watershed (excluding the lake) | | | | | | | | | | |
| Hg(II) | **9.93E-08** | 2.9% | 1.10 | 0.03 | 123,600 | 4046.9 | 1.72E+07 | 17.23 | 0.26 | 4.48 |
| Hg(0) | **3.25E-06** | 94.6% | 0.01 | 0.0 | 123,600 | 4046.9 | 5.1E+06 | 5.13 | 0.26 | 1.33 |
| Hg-p | **8.70E-08** | 2.5% | 0.05 | 0.00 | 123,600 | 4046.9 | 6.9E+05 | 0.69 | 0.26 | 0.178 |
| Total | 3.44E-06 | 100.0% | | 0.0 | | | | | | |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | | | | 6.02 |

**Mercury calculations for ambient condition (background), assuming no significant local source*:**

| | Deposition rate (flux) µg/m$^2$-yr | Area (acres) | Conversion factor (m$^2$ / acre) | Annual mass deposited (µg) | Annual mass deposited (grams) | Fraction reaching waterbody | Annual mass reaching waterbody (grams) |
|---|---|---|---|---|---|---|---|
| Total deposition for the fishable waterbody | 12.5 | 289 | 4046.9 | 1.5E+07 | 14.62 | 1.00 | 14.62 |
| Total deposition for the rest of the watershed | 12.5 | 123,600 | 4046.9 | 6.3E+09 | 6252.46 | 0.26 | 1625.64 |
| Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = | | | | | | | 1640.26 |

**Mercury Loading Summary**

| Grams Hg to water body from project | Grams Hg to water body from background |
|---|---|
| 6.0 | 1640.3 |

**Fish Increment**

| Incremental Hg in fish from project (mg/kg) |
|---|
| 0.005 |

**Water Quality Standard Comparison**

| Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg) | Ratio of: Incremental fish Hg conc. from project relative to WQ STD |
|---|---|
| 6.7 | 0.02 |

**Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.199 | 0.0010 | 0.0011 | 70 | 4.10E-03 | 1.50E-05 | 1.00E-04 |

**Subsistence Fisher #1 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 41.0 | 0.15 |

**Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.224 | 0.0011 | 0.0012 | 70 | 4.62E-03 | 1.69E-05 | 1.00E-04 |

**Subsistence Fisher #2 Hazard Quotient**

| Ambient Subsistence Fisher HQ | Incremental Subsistence Fisher HQ |
|---|---|
| 46.2 | 0.17 |

**Recreational Fisher Methylmercury Intake Calculations**

| Assumed daily fish consumed (kg) | Incremental daily Hg consumed (mg) | Incremental daily $HgCH_3$ consumed (mg) | Body weight (kg) | Ambient $HgCH_3$ Exposure mg/kg BW-day | Incremental $HgCH_3$ Exposure mg/kg BW-day | RfD (mg $HgCH_3$/kg bw-day) |
|---|---|---|---|---|---|---|
| 0.03 | 0.0001 | 0.0002 | 70 | 6.18E-04 | 2.27E-06 | 1.00E-04 |

**Recreational Fisher Hazard Quotient**

| Ambient Recreational Fisher HQ | Incremental Recreational Fisher HQ |
|---|---|
| 6.2 | 0.02 |

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

| Hg Species | Modeled Increment to Mean Air Conc. µg/m3 | Percent of each Mercury species (%) | Dep Velocity (cm/sec) | Calculated Deposition Rate (flux) µg/m2-yr |
|---|---|---|---|---|
| Fishable Waterbody | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |
| Rest-of-Watershed (excluding waterbody) | | | | |
| Hg(II) | 2.00E-05 | 1.2% | 1.10 | 6.9 |
| Hg(0) | 1.65E-03 | 97.6% | 0.01 | 5.2 |
| Hg-p | 2.00E-05 | 1.2% | 0.05 | 0.3 |
| Total | 1.69E-03 | 100.0% | | 12.5 |

# Appendix C

## NorthMet Project, Cumulative Mercury Deposition Analysis Work Plan, Version 2: September 22, 2011

**NorthMet Project**

**Cumulative Mercury Deposition Analysis Work Plan**

Version 2: September 22, 2011

## INTRODUCTION

The NorthMet Project (Project) is described in Draft Alternative Summary Memo (March 4, 2011) prepared by the Lead Agencies and the NorthMet Project Description Version 3 submitted by PolyMet on September 13, 2011. The changes in the project compared to that in the original DEIS are not expected to increase mercury emissions from those in the March 2007 Plant Site Air Emissions Risk Analysis (Plant Site AERA, RS38).

## BACKGROUND

The March 2007 AERA for the Plant Site included a project-only mercury deposition analysis for Heikkilla Lake using the MPCA's Mercury Risk Estimation Method (MMREM). Heikkilla Lake was selected because it is a headwater lake and was considered sensitive to atmospheric inputs. Mercury emissions from the Plant Site are primarily associated with the two autoclaves that were part of the project at that time; approximately 8.4 pounds per year. Two emission speciation scenarios were evaluated: 1) 50% oxidized mercury, 25% elemental and 25% particle-bound; 2) 10% oxidized mercury, 80% elemental, and 10% particle-bound.

Results reported in the March 2007 AERA indicated that potential changes in fish mercury concentrations were small (0.004 to 0.015 ppm) and estimated potential incremental risks (hazard quotient) were low (subsistence fisher, 0.08 – 0.34; recreational fisher 0.02 – 0.07).

## WORK PLAN

As part of the supplemental draft EIS, a cumulative assessment of potential mercury deposition from projects in the Hoyt Lakes area will be conducted. The cumulative deposition analysis will follow the guidance entitled "*MPCA's Mercury Risk Estimation Method (MMREM) for the Fish Consumption Pathway: Impact assessment of a nearby emission source*". Additional recommendations for the cumulative mercury deposition analysis from the Air Quality Work Group meeting from December 8, 2010 are included in this work plan.

### Components of the Analysis

#### *Emission Sources Proposed to be Included in the Analysis*

For this assessment, the potential cumulative impacts from other recently constructed and currently proposed ("reasonably foreseeable") projects that are within 25 kilometers of the NorthMet Plant Site will be evaluated. Mercury emissions from most existing plants such as Laskin Energy are already captured in existing background fish concentrations. Therefore, the cumulative effects modeling is only needed to determine the potentially overlapping impacts of the Project with more recent or proposed nearby projects.

The 25-kilometer distance was selected because projected emissions from new facilities that are more than 25-kilometers from the Plant Site are not expected to contribute significantly to modeled air concentrations within the modeling domain. This assumption is based largely on AERMOD modeling done for the Keetac Expansion Project. That modeling showed that mercury air concentrations drop by an order of magnitude—to less than 0.25% of background concentrations—within 10 kilometers from the emission source. Based on this analysis, it is assumed that mercury emissions from the Project could only significantly increase mercury deposition local lakes that are within a 10-kilometer radius of the Plant Site. Similarly, the zone of local impact from any other nearby recent or planned projects would be about 10-kilometers. Therefore, for an overlapping (cumulative) impact to occur, the other source would have to be within 20-kilometers of the Plant Site. See Figure 1. The addition of a 5-kilometer "buffer" results in a total distance of 25-kilometers.

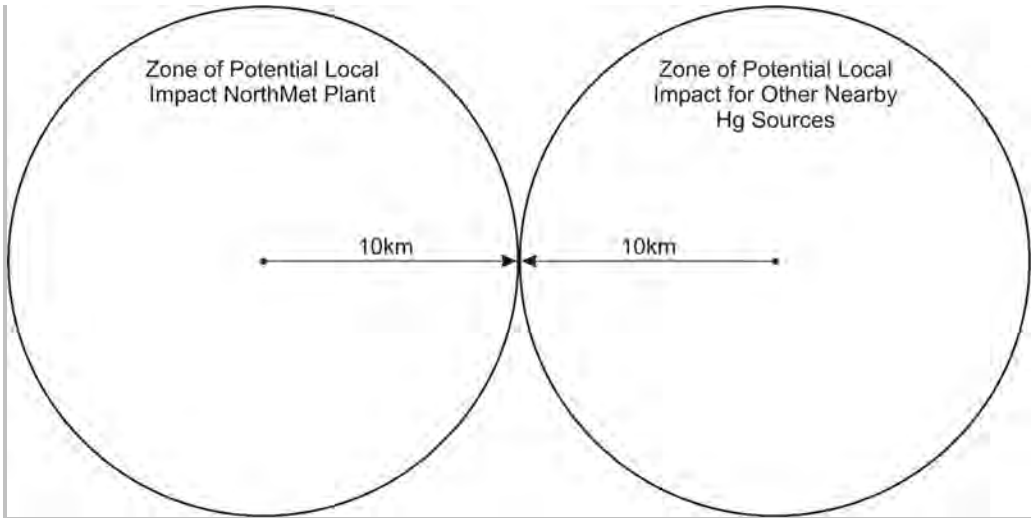



Figure 1. Illustration of 20-kilometer distance to other potential overlapping local mercury sources

The only "reasonably foreseeable" project within this area with appreciable mercury emissions is the Mesabi Nugget Large Scale Demonstration Plant (LSDP).

The other potential projects in this area either have minimal emissions (less than one pound per year), or have been canceled. The potential mercury air emissions from the Mesabi Mining Project (mining, ore crushing and concentrating) and the Mine Site are both less than one pound per year (pound/yr), respectively. Also, potential mercury air emissions from these projects are associated with lower temperature operations that are not likely to release mercury vapor to air (e.g., crushing, grinding). Any mercury air emissions are likely to be associated with mineral particles (i.e., part of the mineral matrix of the particles) and may not be bioavailable. Because potential mercury air emissions from mining activities in the mine pit, ore hauling and crushing/grinding/concentrating are generally small, these types of emissions have not been included in previous analyses and they are not currently proposed to be included in this analysis.

Because the construction permit for the Cliffs Erie Pellet Yard has expired, permitted emission generating activities at Cliffs owned facilities in the Pellet Yard area will be minimal, so the Cliffs Erie Pellet Yard is not included in the cumulative deposition analysis.

Finally, Excelsior Energy initially identified a potential east range site, near Hoyt Lakes, for its proposed coal-gasification electric generation facility (the Mesaba Energy Project). However, the Minnesota Public Utilities Commission issued a site permit for the project at a site on the west end of the range, near

Nashwauk and Grand Rapids. Because the east range location has been dropped, the Mesaba Energy Project is not included in the cumulative deposition analysis.

In summary, besides the Plant Site itself, the Mesabi Nugget LSDP is the only new project in the analysis area that has the potential to emit more than one pound/yr of mercury to the air. Therefore, the proposed projects included in this cumulative mercury deposition analysis are as follows:

- Plant Site: approximately 4 pounds/yr mercury emissions (preliminary estimate for one autoclave; emission calculations to be updated for all chemicals as part of the Emission Inventory work)
- Mesabi Nugget LSDP: approximately 75 pounds/yr mercury emissions based on emission levels from the air emission permit for the facility.

The local deposition analysis will focus on potential mercury emissions from combustion processes or processes with higher temperatures that can release mercury from raw materials. For this analysis the potential emissions from the proposed autoclave for the Plant Site and the rotary hearth furnace at the Mesabi Nugget LSDP will be assessed.

### *Lakes and Watersheds of Interest*

Five area lakes will be included in the analysis:

- Heikkilla Lake, part of the Embarrass River watershed
- Sabin Lake, part of the Embarrass River watershed
- Wynne Lake, part of the Embarrass River watershed
- Colby Lake, part of the Partridge River watershed
- Whitewater Lake, part of the Partridge River watershed

Three of the lakes (Heikkilla, Colby, and Whitewater) are located within 10 km of the Plant Site. The two remaining lakes (Wynne and Sabin) are approximately 12 kilometers from the Plant Site.

Lake surface area and watershed areas have been calculated using GIS applications and are listed in Table 1 and shown in Figure 1. Because Heikkilla Lake, Sabin Lake and Wynne Lake are part of the Embarrass River watershed, the downstream lakes will include lakes that are upstream from them. This means that the watershed area for Sabin Lake will include Heikkilla Lake and its watershed. In turn, the watershed for Wynne Lake, which is the next lake downstream of Sabin Lake in the Embarrass River watershed,

will include Sabin Lake and Heikkilla Lake and their respective watershed areas. Similarly, the watershed for Whitewater Lake will include Colby Lake and Partridge River watershed.

**Table 1**
**Lake and Watershed Areas Identified for Inclusion in the Cumulative Mercury Deposition Analysis to be Conducted for the Project**

| Lake | Lake Area (acres) | Watershed Area (excludes lake area) (acres) |
|---|---|---|
| Heikkilla Lake [1,3] | 128 | 1,350 |
| Colby Lake [2,3] | 502 | 99,890 |
| Sabin Lake [3] | 299 | 121,370 |
| Wynne Lake [2,3] | 289 | 123,600 |
| Whitewater Lake [4] | 1,215 | 3,050 [5] |

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospacial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Barr Engineering, Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

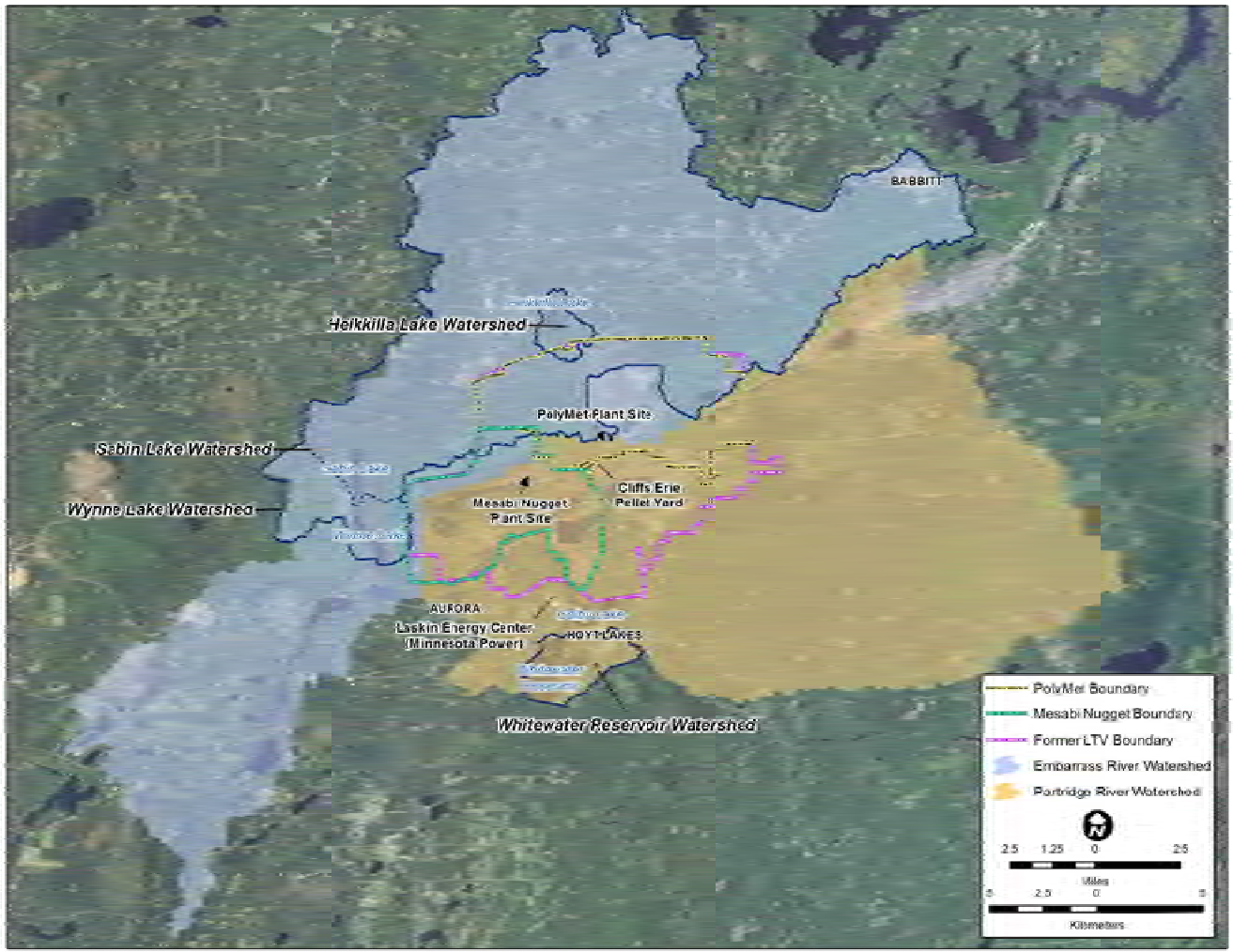



**Figure 1 Location of nearby lakes and watersheds to be included in the Cumulative Mercury Deposition Analysis to be conducted for the Project**

### *Background Fish Mercury Concentrations*

The most recent version of the fish mercury database will be obtained from the MPCA. Background mercury concentrations in fish tissue will be calculated in accordance with MMREM guidance. For lakes with sufficient fish tissue data, 95% upper confidence limits of the mean (95% UCL) will be calculated from recent data for top predator species using the latest version of USEPA's ProUCL software. Background concentrations for lakes that do not have adequate fish tissue data will use data for top predator species in five lakes near the water bodies under evaluation to calculate the 95% UCL. If the calculated 95% UCL is greater than the maximum detected fish tissue concentration, the maximum fish concentration will be used.

Outliers identified by the ProUCL software will be retained in the dataset for calculating the 95% UCL in order not to underestimate potential background concentrations.

MPCA's fish mercury database contains average values representing multiple samples. These average values will be used in deriving the estimate of background fish mercury concentrations for a lake. It is expected that MPCA will provide specific guidance and text for the final report if these average values are not to be used in the analysis or require different treatment than individual sample values.

### *Estimating Total Mercury Air Concentrations*

Mercury speciation proposed for analysis for each project is identified in Table 2. Because speciation from the autoclave is uncertain, two speciation scenarios are proposed to provide a conservative estimate of both a likely speciation and a high-end estimate for potential impacts to local lakes. Emission rates from the Plant Site will be based on the results of the Emissions Inventory.

The most recent version of the AERMOD air dispersion model will be used to model estimated emissions from the Mesabi Nugget LSDP and the Plant Site. The model will be run in regulatory mode (i.e., no plume depletion). Building heights and dimensions, and stack parameters, will be obtained for the emission sources to be modeled (autoclave for the Project; rotary hearth furnace for the Mesabi Nugget LSDP).

Meteorological data used for other modeling analyses conducted for Iron Range sources will be used in this modeling.[1]

- 2006-2010 surface data from Hibbing (airport)
- Concurrent mixing height data from International Falls

**Table 2**
**Mercury Speciation for Projects to be Included in the Cumulative Mercury Deposition Analysis to be Conducted for the Project**

| Project | Mercury Speciation | Comments |
|---|---|---|
| PolyMet, Plant Site | | |
| Scenario 1 [1] | 25% elemental<br>50% oxidized<br>25% particle-bound | Conservative estimate for local deposition analysis purposes only, because speciation data for the autoclave is not yet available |
| Scenario 2 [1] | 80% elemental<br>10% oxidized<br>10% particle-bound | Estimated likely speciation based on engineering assumptions and limited data from other autoclaves. |
| Mesabi Nugget Large Scale Demonstration Plant | 99.3% elemental<br>0.6% oxidized<br>0.1% particle-bound | Speciation from stack testing data for the pilot plant.<br>(This is the same speciation assessed for local mercury deposition in the Mesabi Nugget May 2005 AERA and in the Mesabi Nugget Phase II August 2009 AERA) |

[1] The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

A receptor grid for the modeling will be designed to provide aerial coverage for each lake/watershed and will have polar grid receptors extending out to 25 kilometers. One or more receptor nodes will be placed over each lake's surface area and within each watershed. For lake surface area, one receptor will be placed over the lake for every 100 acres of surface area. For watersheds, one receptor will be placed over the watershed for every 1,000 acres of area. For example, for Colby Lake (500 acres) and its watershed (~100,000 acres), 5 receptors will be placed over the lake and 100 receptors placed in the watershed. The Heikkilla Lake watershed is located partially within the Plant Site boundaries. Therefore, to capture the likely strong gradient close to the Plant Site, at least two receptors will be used to characterize the Heikkilla Lake watershed, one of which will be placed over the lake's surface area.

[1] PolyMet and Barr have proposed use of a different meteorological data set for particulate modeling. This proposal is currently under review by USEPA. If a different data set is used for particulate modeling this may or may not affect the data set used for the mercury modeling.

For both surface water and watersheds, the multiple receptor nodes will be arranged to provide aerial coverage of the respective areas. To provide representative coverage of a watershed, some receptor nodes will be placed within a project's property boundary.

The average mercury air concentration over the lake and over the watershed would then be calculated from the AERMOD modeling output using GIS tools as recommended in the MMREM guidance.

The different speciation for the two projects will require separate modeling runs for each species, with output from the individual modeling runs being consolidated to provide a cumulative estimate of the potential average mercury air concentration (as total mercury) for each lake and watershed.

### *Estimating Potential Incremental Change in Fish Mercury Concentration and Human Health Risks*

Potential cumulative incremental mercury deposition, fish mercury concentration and human health risks (as a hazard quotient) will be estimated using the MMREM calculation spreadsheet. The most recent version of the MMREM spreadsheet will be obtained from the MPCA.

The proposed steps for this part of the analysis are as follows:

- Individual AERMOD modeling runs will be conducted for each mercury species to provide cumulative air concentrations for elemental, oxidized and particle-bound mercury, respectively, for the annual averaging period.
    - The speciation in Table 2 will be used.
    - Number of modeling runs = 2 scenarios x 3 species = 6
- For each emission scenario to be evaluated, a separate MMREM spreadsheet file will be established for each lake/watershed to be assessed (2 spreadsheets set up for each lake/watershed).
    - Input the average speciated air concentrations for the lake and watershed area, respectively. This means that the mercury speciation in the MMREM spreadsheet will not be used. The pre-programmed MMREM spreadsheet will need to be adjusted to account for modeled speciated air concentrations to be input directly to specific cells.
    - Input estimate of background fish mercury concentration
    - Input estimate of lake area and watershed area

- Estimates of the potential incremental change in fish mercury concentration will be calculated by the spreadsheet.
- Estimates of the potential incremental change in risk for a recreational fisher and a subsistence fisher will be evaluated based on the consumption rate for a fisher receptor.
    - Consumption rate for a recreational fisher is assumed to be 30 grams per day
    - Consumption rate #1 for a subsistence fisher is assumed to be 224 grams per day and approximates the allowed take of fish by a Tribal member (~ 180 pounds per year of fish).
    - Consumption rate #2 for a subsistence fisher is assumed to be 199 grams per day and approximately the 95$^{th}$ percentile value for a general population (USEPA 1997 Exposure Factors Handbook)

## REPORTING

Analysis results will be reported to the MDNR and MPCA. The report will be summarized and referenced in the Air Data Package which is part of an overall document structure that includes the project information.

The report is also likely to contain the following information:

- A description of the methodology used
- Deposition and cumulative impact results in the form of two summary tables:
- Summary of air dispersion modeling results
- Summary of MMREM calculation results (e.g., potential change in fish Hg concentration)
- Qualitative discussion of the following:
    - Discussion of statewide mercury total maximum daily load
    - Potential effects to special fishing lakes in the area (e.g., Seven Beaver Lake, headwaters of the St. Louis River, or other lakes specifically identified for qualitative assessment)

Report appendices will contain the background fish mercury concentration used for each lake, the calculation results from the ProUCL software, and the individual MMREM calculation spreadsheets for each emission scenario evaluated.

**Attachment V**

**Local Mercury Deposition and Bioaccumulation in Fish Addendum 1**

**NorthMet Project – Local Mercury Deposition and Bioaccumulation in Fish**
**Addendum 01**
March 13, 2013 – version 2

## Background

The Cumulative Impacts Analysis; Local Mercury Deposition and Bioaccumulation in Fish; NorthMet Project (Version 3, July 2012) for the NorthMet Project (Project) estimated that the mercury air emissions from the Project and Mesabi Nugget together could increase mercury levels in fish in nearby lakes by less than two percent over existing levels. The estimated total mercury loading has not changed; however, the report contains an error regarding the relative contribution from the two facilities. The original report attributed nearly all of the impact to Mesabi Nugget. The corrected estimate shows that 80% to 90% of the potential impact to mercury levels in fish would be due to the Project. This addendum summarizes the error and provides a corrected Table 4.

The Plant Site Air Emissions Risk Analysis (AERA), Version 1, December 2012 report prepared for the Project included an analysis of the mercury deposition for the Project only. The information included in the AERA report reflects the corrected calculations included with this document.

## Calculation Error

One of the critical assumptions required to model mercury deposition is the distribution of mercury species emitted. This is because oxidized mercury (Hg(II)) and particle bound mercury (Hg(p)) are much more readily deposited from the air to the watershed than elemental mercury (Hg(0)). In this case, nearly all the emissions from Mesabi Nugget are assumed to be Hg(0)[1], with less than one percent as Hg(II) or Hg(p). On the other hand, Project emissions are assumed to be made up of much higher percentages of Hg(II) and Hg(p): up to 50 percent Hg(II) and 25 percent Hg(p) under one scenario. This conservative scenario was used because speciation from the Project's Autoclave is uncertain. Therefore, it represents a conservatively high assessment of the Project's potential impact to nearby lakes.

Because the assumed species distribution is different for the two facilities, the deposition rates of the three mercury species from each facility were modeled separately and then added together to estimate total loading to nearby lakes. This total has not changed. However, the portion of deposition to nearby lakes attributed to the Project was inadvertently based on the proportion of total mercury contributed to the air shed (Column E in the original report). This is only accurate when the species distribution from each facility is the same. In this case the species distribution is different.

## Revised Table 4

The corrected calculation is shown in a revised Table 4 below. The original Table 4 is also provided for reference. In summary, the total estimated potential cumulative increase in fish mercury levels in nearby lakes is unchanged (Column D). However, the corrected Table 4 shows that although most of the total mercury contributed to the air shed is from Mesabi Nugget, the Project is responsible for most of the estimated potential change in fish mercury concentration (Column F). This is due to the much higher percentage of Hg(II) and Hg(p) assumed for the Project.
Figure 1 shows these data in graphical form.

[1] Based on speciation data from pilot plant.

**Original Table 4:**

**Table 4 Incremental Increase in Mercury Loading and Fish Concentration**

| A | | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | | | Cumulative | | NorthMet Alone | | |
| Lake | Scenario | Existing fish Hg Concentration (ppm) | Increase in fish Hg Concentration (ppm) | % Increase in Hg loading and fish Hg concentration | Proportion due to NorthMet alone (%) | Increase in fish Hg Concentration (ppm) | % Increase in Hg loading and fish Hg concentration |
| | | | MMREM Results | Calculated from B and C | Table 3 or below** | Calculated from C and E | Calc from B and F |
| Colby Lake | 1 | 0.93 | 0.012 | 1.2% | 10.0% | 0.001 | 0.12% |
| | 2 | | 0.003 | 0.4% | 10.4% | 0.000 | 0.04% |
| Heikkilla Lake | 1 | 0.65 | 0.011 | 1.8% | 23.4% | 0.003 | 0.41% |
| | 2 | | 0.003 | 0.5% | 23.7% | 0.001 | 0.11% |
| Sabin Lake | 1 | 1.02 | 0.013 | 1.3% | 10.5% | 0.001 | 0.14% |
| | 2 | | 0.004 | 0.4% | 10.6% | 0.000 | 0.04% |
| Whitewater Lake | 1 | 0.35 | 0.003 | 0.8% | 8.1% | 0.000 | 0.07% |
| | 2 | | 0.001 | 0.3% | 8.4% | 0.000 | 0.03% |
| Wynne Lake | 1 | 1.34 | 0.018 | 1.3% | 12.8% | 0.002 | 0.17% |
| | 2 | | 0.005 | 0.4% | 12.9% | 0.001 | 0.05% |

**NorthMet Project – Local Mercury Deposition and Bioaccumulation in Fish**
**Addendum 01**
March 13, 2013 – version 2

**Revised Table 4**
**Incremental Increase in Mercury Loading and Fish Concentration**
**Cumulative Impacts Analysis**
**Revised November 20, 2012**

| A | | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | | | Cumulative | | NorthMet Alone | | |
| Lake | Scenario | Existing fish Hg Concentration (ppm) | Increase in fish Hg Concentration (ppm) | % of Cumulative Increase Above Existing Fish concentration | Proportion due to NorthMet alone (%) | Increase in fish Hg Concentration (ppm) | % Increase in Hg loading and fish Hg concentration |
| | | | MMREM Results | Calculated from B and C | Calculated from C and F | Calculated from C and E | Calc from B and F |
| Colby Lake | 1 | 0.93 | 0.012 | 1.2% | 90% | 0.010 | 1.1% |
| | 2 | | 0.003 | 0.4% | 79% | 0.003 | 0.3% |
| Heikkilla Lake | 1 | 0.65 | 0.011 | 1.8% | 92% | 0.010 | 1.6% |
| | 2 | | 0.003 | 0.5% | 84% | 0.003 | 0.4% |
| Sabin Lake | 1 | 1.02 | 0.013 | 1.3% | 91% | 0.012 | 1.2% |
| | 2 | | 0.004 | 0.4% | 79% | 0.003 | 0.3% |
| Whitewater Lake | 1 | 0.35 | 0.003 | 0.8% | 77% | 0.002 | 0.6% |
| | 2 | | 0.001 | 0.3% | 58% | 0.001 | 0.2% |
| Wynne Lake | 1 | 1.34 | 0.018 | 1.3% | 91% | 0.016 | 1.2% |
| | 2 | | 0.005 | 0.4% | 79% | 0.004 | 0.3% |

*MMREM Results for NorthMet alone obtained from the AERA evaluation for the Plant Site.

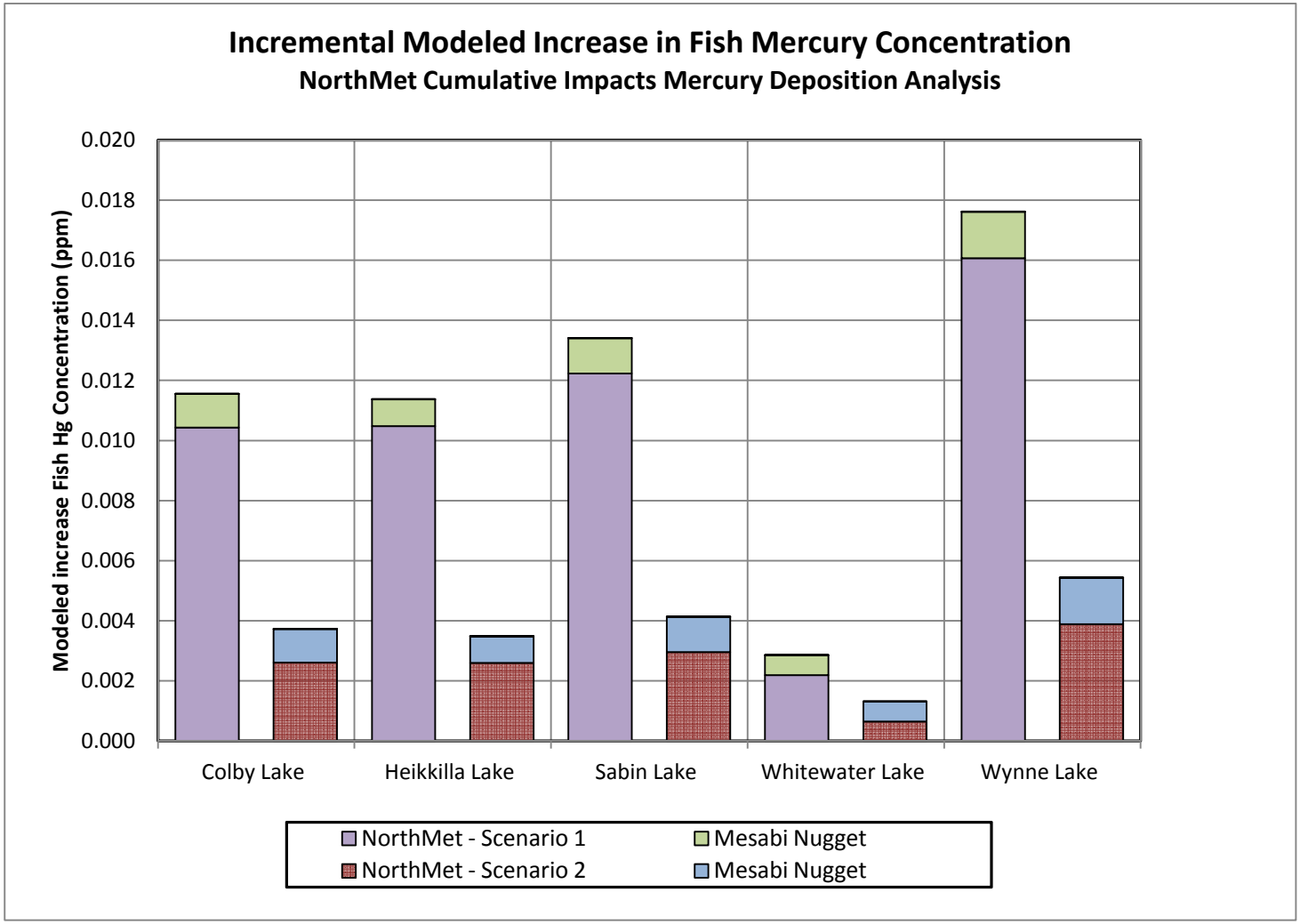



**Figure 1 Incremental Modeled Increase in Fish Mercury Concentration**

**Attachment W**

**Greenhouse Gas and Climate Change Evaluation v5**

# *Greenhouse Gas and Climate Change Evaluation*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining Inc.***

***June 2012***

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# Greenhouse Gas and Climate Change Evaluation

# June 2012

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# 1.0 Introduction

The first draft of a greenhouse gas (GHG) and climate change evaluation report was prepared and submitted in March of 2009 in support of the NorthMet Draft Environmental Impact Statement (DEIS). Comments on this draft were received from the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Natural Resources (MDNR). A second draft of the report was submitted in June of 2009 to address comments on the initial draft. In early March 2011 PolyMet and Barr proposed the scope of its planned updated carbon footprint analysis for the Supplemental Draft Environmental Impact Statement (SDEIS) primarily aimed at aligning the report with draft guidance issued by the White House Council on Environmental Quality (CEQ) in February 2010 for addressing climate change and GHGs under the National Environmental Policy Act (NEPA). The final scope was developed through the Impact Assessment Planning (IAP) process by the Air IAP group. Notable changes and updates to the June 2009 submittal included in this report are as follows:

- Emission estimates have been expanded to address CEQ's inclusion of "all phases and elements of the proposed action" in estimates of direct GHG emissions. In the context of the NorthMet Project (Project), this phrase has been interpreted to mean that construction and closure phases of the Project should be included in GHG analysis, along with emissions during the operating phase. Therefore, combustion emissions associated with the construction phase of the Project as well as emissions associated with wastewater treatment activities and the use of peat materials in closure/reclamation activities have been included in the GHG analysis.
- While GHG emission calculations were completed for the June 2009 report using multiple references and guidance documents including: World Resources Institute Greenhouse Gas Protocol Standard (WRI), The Climate Registry's General Reporting Protocol (TCR), MPCA's General Guidance for Carbon Footprint Development in Environmental Review, Intergovernmental Panel on Climate Change recommendations (IPCC), EPA guidance, and the professional judgment of the report preparers, the CEQ guidance calls for the use of EPA GHG Mandatory Reporting Rule (MRR) methodologies as a primary resource for calculating emissions. Through the scoping process, it was determined that methodologies and emission factors used in the June 2009 report are reputable and comparable to those used in the MRR and that no changes were necessary in this area.
- In addition to annual emissions, the CEQ guidance recommends quantifying emissions over the entire life of the Project. An estimate of total emissions over the life of the Project has been added to this updated report.

- CEQ guidance identifies the need for an evaluation of climate change impacts that may affect the design of the proposed action and alternatives. The June 2009 Climate Change Evaluation report does not directly address this issue. Therefore, this updated report includes a qualitative discussion of the potential affect of climate change on the Project. During scoping discussions, it was determined that the co-lead agencies would make an assessment and decide which impact analyses should consider potential climate affects and the level of detail needed in those analyses to aid in the preparation of the SDEIS.

Several additional changes/additions beyond those associated with the CEQ guidance were requested during scoping and have been included in this revised report including:

- Addition of a discussion of potential links between climate change and ozone
- Addition of a discussion of the applicability of clean diesel strategies to construction and operation of the facility
- Updates to background information on climate change and GHG policy and regulation to reflect changes and developments during the past two years
- Removal of the calculation/section attempting to relate the $CO_2$ emissions from the Project to a specific change in atmospheric $CO_2$ concentration as this calculation was neither reliable nor required

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Project Air Data Package will be resolved in favor of this document.

The issue of climate change and anthropogenic GHG emissions is a complex and evolving topic from both a scientific and regulatory standpoint. The Project SDEIS is being prepared in the context of new and evolving state and federal guidance related to GHG and climate change in environmental review. The analysis that follows addresses the environmental effects of GHG emissions from the Project and of global climate change. The analysis also recognizes data and analytical limitations. GHGs and climate change are evaluated in a manner that is consistent with available, reliable, scientifically-based information and approaches. Project GHG emissions, alternatives, and energy efficiency have been quantitatively assessed. Additionally, despite the high level of uncertainty associated with their calculation, GHG emissions from surface wetland removal and peat stockpiling, loss of carbon from excavated peat used in reclamation activities, loss of aboveground biomass carbon in impacted areas, and reductions in carbon sequestration capacity due to wetland and upland forest ground cover disturbance

have been quantitatively assessed. Given the limitations of climate models in addressing the impacts of GHG emissions at the project level on global, national, regional, and local climate, this impact analysis is largely qualitative in its treatment of the physical climate endpoints (e.g., temperature rise, frequency of precipitation events).

EPA has issued regulatory actions under the Clean Air Act and in some cases other statutory authorities to address issues related to climate change. These actions as well as state level actions are summarized in Section 2.1.1. Climate change policy and GHG regulation is a rapidly evolving issue and recent lawsuits, in addition to various pending congressional bills under which $CO_2$ emissions might be regulated will likely shape the future of GHG laws. The summary provided in Section 2.1.1 extends through December 2012 and cannot account for additional changes and developments that occur between the publication of this report and the development of the SDEIS document.

While the earth's climate naturally undergoes cyclical variations over time, increases in global average surface temperatures observed over recent decades have been attributed by the vast majority of climate scientists to observed increases in global atmospheric GHG concentrations resulting from anthropogenic GHG emissions. Some future climate change impacts have been projected to occur as the result of increases in global atmospheric GHG concentrations that have already occurred. The level of future global, national and regional anthropogenic GHG emissions will also likely exert a strong influence over the magnitude and extent of future climate change.

Minnesota is situated at the crossroads of four different biomes, a unique situation that makes Minnesota's ecological character particularly vulnerable to the potential effects of climate change. Climate change impacts such as temperature increases, changes in precipitation patterns, and shifts in the length of Minnesota's seasons could affect each of these unique biomes, impacting the type and distribution these ecosystems, quantity and quality of water resources, agricultural disposition and productivity, and human health over the next century.

Major components of the Project include mining, ore crushing/grinding and concentrating, and metal recovery. In metal recovery, the nickel-rich fraction of the flotation concentrate is routed to a pressurized autoclave as a part of the hydrometallurgical process. Energy is produced within the autoclave during sulfide oxidation and is used as the primary energy source for the hydrometallurgical process. This eliminates several steps typically associated with pyrometallurgical processing and reduces process energy demands. Overall, energy demand in hydrometallurgical processing such as PolyMet's proposed operation, is estimated to be about half of that associated with pyrometallurgical processes.

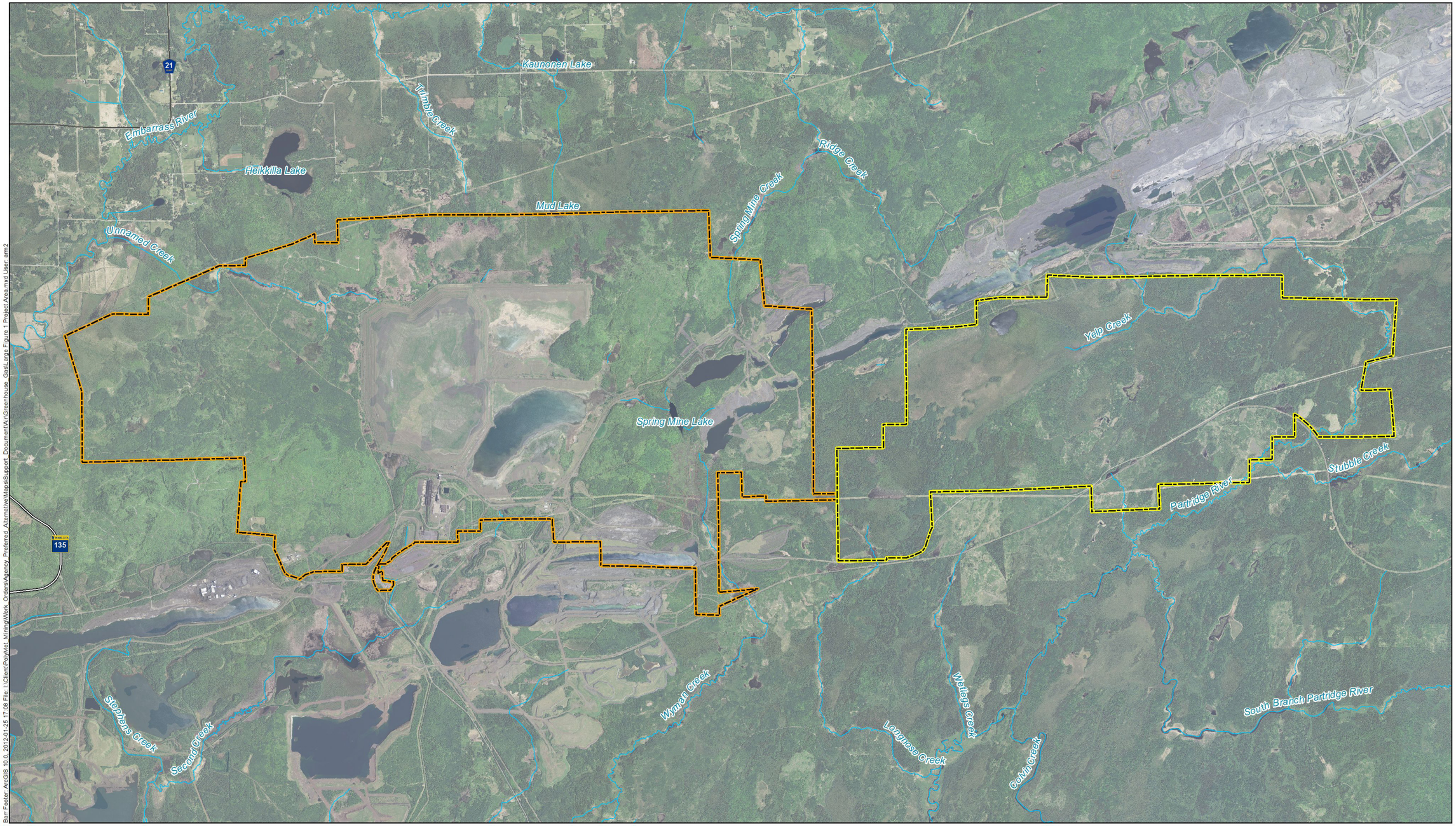
Total GHG emissions for the Project are comprised of direct emissions from the Mine Site, direct emissions from the Process Plant, and indirect emissions from the purchase of electricity. Additional emissions and effects on carbon sequestration due to the disturbance of ground cover may occur as described below. Figure 1 shows the location and layout of the Mine Site and Process Plant.

PolyMet is taking all practicable measures to minimize GHG emissions by ensuring a high level of energy and production efficiency. Whenever available, PolyMet will employ new premium efficiency motors rather than standard motors. Moreover, gravity transport of process slurries will be used where possible, instead of pumps. PolyMet also intends to configure the Process Plant such that the overall power factor for the facility is as close to one as practical. This will help minimize the current and therefore power losses on the power line servicing the facility. The primary production excavators and one of the two blast hole drills will be electric rather than diesel powered eliminating a source of direct GHG emissions. Instead of employing used conventional locomotives, PolyMet will purchase new Gen-Set locomotives, which are more efficient and use less fuel. Also, space heating in the Process Plant is a major contributor to total direct GHG emissions. To reduce GHG emissions, PolyMet will employ natural gas fired space heaters. Estimated maximum $CO_2$-equivalent ($CO_2$-e) emissions from natural gas are less than from other fuels, which will reduce direct and indirect GHG emissions. In addition to selecting a low emitting fuel for space heating, the exhaust from the emission controls utilizing cartridge type filtration will be recycled back into the buildings, where practical, to reduce heating demand.

Carbon cycle effects due to direct or indirect disturbance of site ground cover have been assessed separately, owing to the high levels of uncertainty surrounding their calculation. Quantitative assessments for six carbon cycle impact categories have been included in this report:

1. Total carbon stored in the above-ground vegetation of wetlands and forests that are lost to Project activities [treated as a one-time emission]
2. Total carbon stored in excavated peat, and annual emissions from its stockpiling
3. Potential carbon flux associated with removal of peat from stockpiles and use in cover material used for reclamation
4. Annual emissions from indirectly impacted wetlands due to lowered water levels
5. Loss of annual carbon sequestration capacity due to direct and indirect Project impacts on wetland and forest plant communities
6. Reduction in annual carbon sequestration capacity in indirectly impacted wetlands

The total above-ground carbon stock which is lost to Project activities represents a theoretical cap on the amount of carbon that can eventually be released from the above-ground vegetation. All vegetation in directly impacted areas has been assumed lost in this analysis. The only ongoing annual emission rates evaluated are those from peat excavation, stockpiling and use in reclamation, and indirectly impacted wetlands. The loss of carbon sequestration capacity differs from an emission rate in that it represents a loss of absorptive capacity rather than an actual emission; however, its net effect on atmospheric $CO_2$ levels is essentially the same. A summary of the terrestrial carbon cycle assessment is presented in Section 3.1.2 of this report. Detailed descriptions of the calculations used to derive these estimates can be found in Appendix A, along with a full quantitative analysis of GHG emissions, Project efficiency, and GHG reduction measures.




Barr Footer: ArcGIS 10.0, 2012-01-26 17:08, File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Documents\Air\Greenhouse_Gas\Large Figure 1 Project Area.mxd User: aim2

Ambient Air Boundary - Mine Site
Ambient Air Boundary - Plant Site
Rivers & Streams

0 0.5 1 2
Miles

NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN

**Figure 1 NorthMet Project Property Boundaries**

## 2.1. Background Information on Climate Change

### 2.1.1. Climate Change and GHGs in Federal and State Policy and Law

Climate change policy and GHG regulation is a rapidly evolving issue. EPA has issued regulatory actions under the Clean Air Act (CAA) and in some cases other statutory authorities to address issues related to climate change. The MPCA has recently modified its air permit rules to incorporate new federal permit requirements for GHG emissions and currently requires an evaluation of GHG emissions in the environmental review process for proposers of projects that must obtain stationary source air permits. In addition, from the state level to the international level, many governments are setting goals and taking steps toward GHG emission reductions.

#### 2.1.1.1 Federal Policy and Law

From a national policy perspective, consideration of GHG emission goals and targets has been ongoing since the United States' ratification of United Nations' Framework Convention on Climate Change (UNFCCC) in 1992. As a participating member of the UNFCC, the United States made a commitment to implement policies intended to help stabilize GHG concentrations in the atmosphere at a level that would "prevent dangerous anthropogenic interference with the climate system." The U.S. entered a non-binding agreement to gather and share information on GHG emissions and national policies and best practices. The United States also agreed to develop national strategies for addressing GHG emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries.[1]

In 1997, delegates from nearly 200 nations gathered in Kyoto, Japan, and made a collective commitment to reduce GHG emissions by about 5 percent below 1990 levels by 2012, under a treaty known as the Kyoto Protocol. The Clinton Administration participated in negotiations, but ultimately U.S. lawmakers declined to ratify the protocol.

The Kyoto protocol is set to expire at the end of 2012 and some major countries, including Canada, Japan and Russia, have indicated that their participation in any successor treaty to the protocol would hinge on more similar reduction requirements across developing and developed nations. The European Union, the

[1] United Nations, 1992. United Nations Framework Convention on Climate Change (GE.05-62220 (E) 200705) (available at: http://unfccc.int/resource/docs/convkp/conveng.pdf)

major developing countries, and most African and Pacific island nations have suggested an extension of the Kyoto process as a prelude to a more ambitious, binding international agreement that would take effect 2020.

Efforts to resolve the fate of the Kyoto Protocol during an international gathering on climate change held in Durban, South Africa, in December 2011 resulted in an agreement, known as the Durban Platform, under which an Ad Hoc Working Group would be established to develop, by 2015, a replacement protocol for the Kyoto Protocol that would come into effect no later than 2020 and be binding on all industrial and developing nations. Under the Durban Platform, the Kyoto Protocol would remain in effect during the interim.

The Obama administration has pledged to reduce U.S. emissions 17 percent below 2005 levels by 2020, but their preferred approach, a nationwide cap-and-trade system, has not been approved by the Congress. 2010 efforts to pass a nationwide cap-and-trade bill resulted defeat in the Senate in after being passed by the House the year before.

At the federal regulatory level, EPA has taken regulatory action under the Clean Air Act and in some cases other statutory authorities to address issues related to climate change. Over the last several years, these measures have raised difficult regulatory questions and generated a great deal of discussion regarding the authority of the EPA to regulate GHGs under the CAA. In April 2007, the U.S. Supreme Court issued a decision in *Massachusetts v. EPA*, 549 U.S. 497, 127 S.Ct. 1438 (2007). EPA had denied a petition by a group of states and environmental organizations asking that EPA regulate GHG emissions from new motor vehicles under the CAA. In its decision, EPA found that the CAA does not authorize regulations to address global climate change and that, even if it was determined that EPA had the authority to issue such regulations, it would be unwise for EPA to regulate GHG emissions at this time. The Court held that GHGs satisfy the definition of air pollutant under the CAA and that EPA has the statutory authority to regulate GHG emissions from automobiles. The Supreme Court authorized EPA to regulate emissions from motor vehicles should EPA form a judgment that the emissions contribute to climate change.[2]. The Court remanded the decision to EPA for reconsideration.

[2] 127 S.Ct. at 1462.

One year after the Supreme Court's decision in *Massachusetts*, a petition for writ of mandamus was filed to force EPA to formally decide whether to regulate GHGs from vehicles under the CAA[3]. In July 2008 the EPA issued an Advance Notice of Proposed Rulemaking ("ANPRM") concerning the implementation of such regulations, which included extensive analysis of the science related to climate change, of technologies for reducing GHG emissions and of the statutory provisions that may be triggered by an endangerment finding under Section 202 of the CAA.[4]

Although *Massachusetts* dealt specifically with whether EPA must promulgate regulations for GHG emissions from motor vehicles, the ANPRM recognized that the opinion may have a broader application.[5] EPA's sister federal agencies provided comments expressing concern regarding the benefits of GHG regulation through the CAA. The U.S. Department of Energy noted that "improving our energy security and addressing global climate change are the most pressing challenges of our time" but urged that before EPA were to proceed down the path of CAA regulation of GHGs, there should be a full and fair discussion of the true burdens of that path.[6]

In November 2008, discussions of $CO_2$ regulation under CAA continued with the Sierra Club's administrative appeal of a prevention of significant deterioration (PSD) permit issued by EPA Region 8 to Deseret Power Electric Cooperative. The Sierra Club argued that, under the Supreme Court's ruling in *Massachusetts v. EPA*, the PSD permit should have included Best Available Control Technology (BACT) emission limits for $CO_2$.[7] With the Supreme Court's definition of $CO_2$ as an "air pollutant" under CAA, and given federal $CO_2$ monitoring and reporting requirements, the Sierra Club contended that $CO_2$

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[3] United States Court of Appeals For the District of Columbia Circuit. Commonweath of Massachusetts, et al. Petitioners, v. U.S. Environmental Protection Agency, et al. Respondents. Docket No. 0.-0361 (& consolidated cases) Petition for Wit of Mandamus to Compel Compliance with Mandate. (available at: http://www.atg.wa.gov/uploadedFiles/Home/News/Press_Releases/2008/Mass%20vs%20EPA%20Mandamus%20petition.pdf)

[4] 2-1A Treatise on Environmental Law Section 1A.05 ***Treatise on Environmental Law*** Copyright 2008, Matthew Bender & Company, Inc., a member of the LexisNexis Group.

[5] EPA 40 CFR Chapter I. EPA-HQ-OAR-2008-00318; FRL-8694-2. TIN 2060-AP12. Regulating Greenhouse Gas Emission s under the Clean Air Act. (available at http://www.epa.gov/climatechange/emissions/downloads/ANPRPreamble.pdf).

[6] Id at 26.

[7] Before the Environmental Appeals Board United States Environmental Protection Agency Washington, D.C. In re: Deseret Power Electric Cooperative PSD Permit No. PSD-OU-0002-02.00 PSD Appeal No. 07-03. Decided November 13, 2008. Order Denying Review in Part and Remanding in Part (Before Environmental Appeals Judges Edward E. Reich, Kathie A. Stein and Anna L. Wolgast (available at http://yosemite.epa.gov/oa/EAB_Web_Docket.nsf/PSD%20Permit%20Appeals%20(CAA)/C8C5985967D8096E85257500006811A7/$File/Remand...39.pdf).

qualified as an "air pollutant subject to regulation under the CAA."[8] Sierra Club argued that the permit violated Sections 165(a)(4) and 169(3) of the Act, which require BACT emission limits for "each air pollutant subject to regulation under the CAA."

EPA countered that it had the discretion to interpret the phrase "subject to regulation" and that historically, EPA interpreted the term to describe pollutants subject to statutory or regulatory emission controls. EPA argued that it did not have authority to impose a $CO_2$ BACT limit because $CO_2$ regulations under the CAA require only monitoring and reporting, not actual emission controls.

The EPA Environmental Appeals Board determined that EPA had the authority to interpret the term "subject to regulation," but found that the record was not sufficient to support EPA's interpretation.

In December 2008, former EPA Administrator Stephen L. Johnson issued a memorandum to all EPA Regional Administrators discussing the application of the CAA to GHG emissions.[9] EPA Administrator Johnson stated that under federal PSD regulations, EPA will interpret the definition of "regulated NSR pollutant" to exclude pollutants for which EPA has established only monitoring and reporting requirements. [10]

On October 30, 2009, the Final Mandatory GHG Reporting Rule was published in the *Federal Register* under 40 CFR part 98, commonly referred to as "Part 98".[11] The final rule requires certain facilities and suppliers to submit GHG emissions information and supporting information to quantify and verify the reported emissions. Part 98 requires facilities in 29 categories to report for calendar year 2010 and an additional 12 categories commence reporting for calendar year 2011.As initially proposed, the final rule required the first annual GHG emission report on March 31, 2011, for 2010 emissions. To allow EPA to further test the data submittal system and give industry proper time to test the submittal tool, on March 18, 2011 EPA extended the reporting deadline to September 30, 2011 for calendar year 2010. Subsequent reporting years will subject to a reporting deadline of March 31. Following publication of the Mandatory GHG Reporting Rule, the EPA has issued technical corrections and amendments to several subparts.

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[8] Part 70 of Title 40 of the Code of Federal Regulation adopted in accordance with section 821 of the Clean Air Act Amendment of 1990 requires monitoring of $CO_2$ from power plants

[9] United States Environmental Protection Agency Memorandum To: Regional Administrators From: Stephen L. Johnson, Administrator, Re: EPA's Interpretation of Regulations that Determine Pollutants Covered By Federal Prevention of Significant Deterioration PSD permit Program (available at: http://www.epa.gov/nsr/documents/psd_interpretive_memo_12.18.08.pdf)

[10] Under federal regulations only newly constructed or modified major sources that emit one or more New Source Review (40 C.F.R. 52.21(b)(50)) pollutants are subject to PSD program requirements including BACT.

[11] Part 98 of Title 40 of the Code of Federal Regulations – Mandatory Reporting of Greenhouse Gases Final Rule

The final rule requires that suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions submit annual reports to EPA. The gases covered by the final rule are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride ($SF_6$), and other fluorinated gases including nitrogen trifluoride ($NF_3$) and hydrofluorinated ethers (HFE).

In response to the 2007 Supreme Court ruling 549 U.S. 497 (2007), Proposed Endangerment and Cause or Contribute Findings for GHGs under the CAA were signed by the EPA administrator on April 17, 2009 and were open for public comment for a 60 day period following publication in the Federal Register. The proposals contained two findings regarding GHGs under section 202(a) of the CAA: that the current and projected concentrations of the mix of six key GHGs in the atmosphere threaten the public health and welfare of current and future generations; and that the combined emissions of $CO_2$, $CH_4$, $N_2O$, and HFCs from new motor vehicles and motor vehicle engines contribute to the atmospheric concentrations of these key GHGs and hence to the threat of climate change These findings were a prerequisite to finalizing the GHG standards for light-duty vehicles. On April 1, 2010, EPA and the Department of Transportation's National Highway Safety Administration issued the first national rule limiting GHG emissions from cars and light trucks. This rule confirmed that January 2, 2011 is the earliest date that a 2012 model year vehicle meeting these rule requirements may be sold in the United States.

Under the December 2008 "PSD Interpretive Memo" a pollutant is "subject to regulation" only if it is subject to either a provision in the CAA or regulation adopted by EPA under the CAA that requires actual control of emissions of that pollutant and that CAA permitting requirements apply to a newly regulated pollutant at the time a regulatory requirement to control emissions of that pollutant "takes effect". Based on this interpretation, the GHG requirements of the vehicle rule would trigger CAA permitting requirements for stationary sources on January 2, 2011. Under CAA rules, new major stationary sources and major modifications at existing major stationary sources that meet emissions applicability thresholds outlined in the CAA and in existing PSD regulations are required to obtain a PSD permit. Included is a requirement that PSD-permitted facilities apply BACT to GHG emitting sources. BACT is determined on a case-by-case basis taking into account, among other factors, the cost and effectiveness of the control.

On May 13, 2010, the EPA issued a final rule that set GHG thresholds for permits for new and existing facilities under the New Source Review Prevention of Significant Deterioration and Title V Operating Permit programs. The nation's largest GHG emitters are included, covering approximately 70% of national GHG emissions from stationary sources. This rule is commonly referred to as the GHG Tailoring Rule.

The rule establishes a schedule that will initially focus CAA permitting programs on the largest sources with the most CAA permitting experience. The rule then expands to cover the largest sources of GHG that may not have been previously covered by the CAA for other pollutants, as follows:

- **Step 1** (January 2, 2011- June 30, 2011): During this period, now past, no sources were subject to CAA permitting due solely to GHG emissions. Only sources currently then subject to the PSD permitting program were subject to permitting requirements for their GHG emissions under PSD, and among these only projects with GHG increases of ≥75,000 tpy CO2-e needed to determine BACT for GHG emissions. Similarly, for operating permits, only sources currently then subject to the program were subject to title V requirements for GHG.
- **Step 2** (July 1, 2011- June 30, 2013): During this period, new sources can be subject to CAA permitting solely due to GHG emissions if they meet certain thresholds. EPA estimates this will impact approximately 550 new title V permits and 900 additional PSD permitting actions each year. New construction projects that emit GHG emissions of at least 100,000 tpy will become subject to PSD and Title V and existing facilities that increase GHG emissions by at least 75,000 tpy will need to determine BACT.

EPA will undertake another rulemaking (to begin in 2011 and conclude no later than July 1, 2012) that will phase-in GHG permitting. This will not include sources with emissions below 50,000 tpy and no permits requirements for smaller sources will be considered by EPA until at least April 30, 2016.

EPA proposed two rules on August 12, 2010 to make sure that new, large facilities or major expansions are able to obtain NSR PSD permits that address GHGs. Under the CAA, states are required to develop and follow state implementation plans (SIPs), which include requirements for issuing PSD permits. In some states, neither the EPA nor the state has authority to issue a PSD permit for sources of GHGs. In the first proposed rule, EPA requires states to revise their SIPs so that state-administered PSD programs cover GHG emissions. In the second rule, EPA outlined a federal implementation plan (FIP) for those instances when a state is not able to submit SIP revisions. These rules were finalized on December 23, 2010.

On January 12, 2011 EPA proposed a three-year deferral to the plan that would require GHG permitting requirements for $CO_2$ emissions from biomass-fired and other biogenic sources.[12] This deferral was

[12] US EPA Office of Air and Radiation, March 2011. Guidance for Determining best available Control Technology for Reducing Carbon Dioxide Emissions from Bioenergy Production.

finalized in July 2011. It is expected in late 2011 or early 2012, that EPA will promulgate emission standards for power plants and oil refineries.

Concurrent with EPA actions, a series of Congressional proposals at the national level have been developed in an attempt to shape the future of U.S. climate policy. GHG emissions legislation considered during the 109th and 110th sessions of the U.S. Congress ranged from carbon taxes to cap-and-trade and from energy efficiency requirements to moratoriums on coal fired power plant approvals[13]. Notable recent legislative actions include the following[14]:

- **Lieberman-Warner Climate Security Act of 2007 (S. 2191)**: This bill was reported by committee in December 2007, but never voted on. One aim of the bill was to direct the EPA Administrator to establish a program to decrease emissions of GHGs.
- **Boxer-Lieberman-Warner Climate Security Act Substitution Amendment (S. 3036)**: This bill was reported on by committee in May 2008. 157 amendments were made to the bill, but it was never voted on. The bill proposed 19% GHG reduction (from 2005) by 2020, 71% by 2050. The bill also included proposals for a federal GHG registry, cap-and-trade system and emissions monitoring/reporting, trading emission allowances, energy efficiency and HFC reductions.
- **American Clean Energy and Security Act of 2009 (Waxman-Markey – H.R. 2454)**: This bill passed in the House on June 26, 2010 (219:212) and has not received a Senate vote. The bill was considered to be more comprehensive and ambitious than Lieberman-Warner. It included titles for Clean Energy, Energy Efficiency, Reducing Global Warming Pollution, Transition to a Clean Energy Economy and Agricultural and forestry related offsets. The bill included proposals for cap-and-trade program to control GHG emissions, federal government limits on GHGs and a 17% reduction in GHGs below 2005 GHG levels by 2020
- **Clean Energy Jobs and American Power Act (Kerry-Boxer (S. 1733)):** This bill was reported by committee in November 2009. The bill included a proposed a cap-and-trade regime and emissions reductions (from 2005) of 20% by 2020 and 83% by 2050.
- **Kerry-Lieberman**: This bill was introduced as a bi-partisan bill on May 12, 2010, after eight months of negotiation. The bill proposed reduction targets from 2005 (17% by 2020; 83% by

[13] Yacobucci, B., 2006. "Climate Change Legislation in the 109th Congress. CRS Report for Congress. Order Code RL32955; Parker et al.., 2007. "Greenhouse Gas Reduction: Cap-and-Trade Bills in the 110th Congress". CRS Report for Congress. Order Code RL33846

[14] This list is intended to provide a summary of notable policy actions as of June 2010. This does not provide an exhaustive listing, nor does it provide a complete and detailed account of all of the features of each action.

2050) under a cap-and-trade scheme. The bill targeted power plants first (2012) and other major industrial sources beginning in 2016. It proposed to generate revenue through sale of allowances with a price collar. The bill also proposed permanent pre-emption of states' ability to implement mandatory GHG reductions and restricted EPA's ability to regulate GHGs.

#### 2.1.1.2 Minnesota State Policy and Law

At the state level, efforts to curb statewide and regional GHG emissions are underway. More than half of U.S. states have joined in regional efforts to reduce GHG emissions. Minnesota has committed (along with Illinois, Iowa, Kansas, Michigan, Wisconsin and Manitoba) to long term GHG reduction targets of 60 to 80 percent below current emission levels as part of the Midwestern Greenhouse Gas Reduction Accord. Participants have agreed to pursue the implementation of a regional cap and trade system as well as a consistent regional GHG emissions tracking system.[15]

In the last several years Minnesota has taken steps to address statewide GHG emissions. In December 2006, Minnesota Governor Pawlenty announced the state's Next Generation Energy Initiative, which included the development of an aggressive plan to reduce GHG emissions in Minnesota. Governor Pawlenty created the Minnesota Climate Change Advisory Group in April 2007 as a part of the Next Generation Energy Initiative § 216H.02, subd. 3.[16] The Next Generation Energy Act of 2007 articulates the "goal of the state to reduce statewide GHG emissions across all sectors" to a level of at least fifteen percent below 2005 levels by 2015, at least thirty percent below 2005 levels by 2025, and at least eighty percent below 2005 levels by 2050. Minn. Stat. § 216H.02, subd. 1 [17]

In January 2008, the Minnesota Climate Change Advisory Group announced its approval of a mixture of strategies to reduce the state's GHG emissions to a level at least 30 percent below 2005 levels by 2025. In April 2008, the Minnesota Climate Change Advisory Group issued its final report with recommendations to the Governor for reducing Minnesota's GHG emissions.[18] Following the release of the Minnesota Climate Change Advisory Group's final report, the Minnesota Senate and House approved bills setting

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[15] Midwest Governors Association, 2007. Energy, Security and Climate Stewardship Platform for the Midwest (available at: http://www.midwesterngovernors.org/Publications/MGA_Platform2WebVersion.pdf) and Midwest Governors Association, 2007. Midwestern Greenhouse Gas Accord (available at: http://www.midwesterngovernors.org/Publications/Greenhouse%20gas%20accord_Layout%201.pdf)

[16] Minnesota Statutes, 2008 Chapter 216H. Greenhouse Gas Emissions (available at https://www.revisor.leg.state.mn.us/statutes/?id=216H&view=chapter)

[17] Minnesota Statutes, 2008 Chapter 216H. Greenhouse Gas Emissions (available at https://www.revisor.leg.state.mn.us/statutes/?id=216H&view=chapter)

[18] Minnesota Climate Change Advisory, April 2008. Minnesota Climate Change Advisory Group Final Report: A Report the Minnesota Legislature (available at: http://www.mnclimatechange.us/MCCAG.cfm)

general guidelines for the Legislature's role in a regional, market-based system to control GHG emissions. The House version of the Green Solutions Act of 2008 directs the Legislature to approve any regional cap-and-trade accord and authorizes studies of the program's effects on the environment, the economy, and public health. In May 2008, the Governor signed legislation requiring the Minnesota Department of Commerce and the MPCA to track GHG emissions and to make interim reduction recommendations toward meeting the state's goal of reducing GHG emissions to a level at least fifteen percent below 2005 levels by 2015, thirty percent below 2005 levels by 2025, and eighty percent below 2005 levels by 2050.[19] Developments in Minnesota's climate change and GHG policy will likely continue to take shape as Minnesota strives to meet the GHG reduction goals established in the Next Generation Energy Act.

On January 24, 2011, MPCA issued temporary rules to implement the new GHG permit requirements set by the EPA. Permanent rules must be adopted within two years. Primarily this rulemaking requires calculation of GHG emissions to determine if a permit is required. Additionally, insignificant activities were revised to reflect the GHG regulations.[20] , The MPCA plans to implement EPA's final decision to defer including biogenic $CO_2$ emissions in permitting through permanent rulemaking for biogenic sources for PSD and Title V purposes in late 2012. However, MPCA's temporary rules do not exclude biogenic $CO_2$.

In addition to policies directed at reducing statewide GHG emissions, Minnesota has instituted policies requiring the evaluation of GHG emissions as a part of the environmental review process for certain projects that require stationary source air emissions permits. In July 2008, MPCA issued a General Guidance for Carbon Footprint Development in Environmental Review. The MPCA guidance requests that project proposers, in the course of environmental review under the Minnesota Environmental Policy Act, prepare a GHG inventory for proposed projects that will require stationary source air emissions permits.

#### 2.1.1.3 Applicability of GHG Permitting Requirements to Project

PolyMet plans to permit the Project as a synthetic minor source of green house gasses by limiting emissions below 100,000 tons per year of carbon dioxide equivalents. The general proposed approach is described in version 2 of NorthMet Proposed Synthetic Minor Limits, submitted November 4, 2011.

[19] Minnesota Statutes 216H.

[20] Minnesota Pollution Control Agency Environmental Analysis and Outcomes Division, 2010. Notice Document: Notice of Intent to Adopt Temporary Rules Under the Good Cause Exemption, Minnesota Statutes Section 14.388, Subdivision 1, Clause 2.

It is important to note that the scope of the carbon footprint assessment in this report is considerably broader than the emissions used to determine applicability under the Federal Prevention of Significant Deterioration (PSD) program. This report includes estimates for mobile source and biogenic emissions which are not included when determining PSD applicability. In addition, this document reports maximum potential emissions. A project proposer can request permit limits to reduce allowable emissions that are the basis for PSD applicability determinations for new facilities. In the case of the Project, projected actual greenhouse gas emissions are much lower than estimated maximum potential emissions and are below the PSD major source level, which indicates the practicality of accepting permit limits. Emission levels applicable to PSD permitting are shown in the Table 1 below. Note: for permitting purposes, emissions are expresses in short tons per year; the emissions are also provided in Table 1 in metric tons for comparison to the carbon footprint calculations in this report which follow the standard convention and are reported in metric tons. The emissions provided in Table 1 are based on the most recently submitted versions of the Mine Site and Plant Site emission inventory at the time of the preparation of this report (Version 8; May 29, 2012 and Version 5; May 29,2012 respectively). Additional revisions to the emission calculations may occur as a result of the completion of air dispersion modeling.

**Table 1 Point Source Emissions Comparison to Major Source Level**

| Source | Maximum Potential Emissions ($CO_2$-e, metric tons/yr) | Maximum Potential Emissions (CO2-e short tons/yr) | PSD Permitting Threshold ($CO_2$-e short tons/yr) | Project Actual Emissions ($CO_2$-e short tons/yr) |
|---|---|---|---|---|
| Mine Site Point Sources | 1,600 | 1,764 | | 773 |
| Plant Site Point Sources | 138,641 | 152,825 | | 64,316 |
| Project Totals | 140,241 | 154,589 | 100,000 | 65,089 |

The two main types of greenhouse gas emission sources associated with the Project are carbon dioxide emissions from the use of limestone for acid neutralization in the Hydrometallurgical Plant and fuel usage. The oxidation of sulfur in the Autoclave is used to provide energy to the hydrometallurgical process, so process fuel usage is minimal. Most of the Project fuel usage is for support operations such as building heat and backup power generation which are not run continuously at full capacity. Therefore, projected actual greenhouse gas emissions are much lower for fuel combustion sources than potential emissions. As an example, potential emissions from building heating are based on assuming that the space

heaters run at full capacity 8760 hours per year. In actual operation, the heaters only run about six months out of the year and they will only run at full capacity on the coldest winter days.

### 2.1.2. The Science of Climate Change

The information presented in the sections that follow draws on scientific consensus documents and peer-reviewed publications including documents of the Intergovernmental Panel on Climate Change (IPCC Reports), U.S. Environmental Protection Agency, U.S. Climate Change Science Program, MPCA and MDNR. Data presented in the sections that follow was obtained from nationally and internationally recognized data sources as well as from the Minnesota State Climatology Office[21]. The growing level of international attention to climate change has resulted in a high level of ongoing scientific study and analysis. The body of scientific knowledge of the issue is evolving relatively rapidly. The information contained herein may become out-dated quickly, but serves as a "snapshot" of the state-of-knowledge at this time. The reports referenced herein, and any subsequent reports provided by IPCC or other governmental bodies, should be consulted for more detailed or the most up-to-date information.

#### 2.1.2.1 Climate Change Overview

A growing body of evidence indicates that the Earth's atmosphere is warming. The past 100 years have seen global average temperature increases of about 1.5°F.[22] The global average temperature has increased by about 1.2 to 1.4° F since 1890, with the ten warmest years of the past century occurring between 1998 and 2011[23].

While Earth's climate has exhibited variability and has changed over time due to a variety of earth system processes, most of the observed global average surface temperature increases since the middle of the 20th century are very likely (greater than 90% probability)[24] attributable to the observed increases in global atmospheric GHG concentrations resulting from anthropogenic GHG emissions. Observations of widespread warming of the earth's atmosphere and oceans as well as observations of ice mass loss and changes in wind patterns and temperature extremes are very likely not attributable to natural causes alone.

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[21] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].
[22] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)
[23] Hansen et. al., January, 2012. "Global Temperature in 2011, Trends, and Prospects." NASA GISS Surface Temperature Analysis. (available at: http://data.giss.nasa.gov/gistemp/2011/).
[24] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].

The discussion that follows highlights the processes that have regulated Earth's climate over geologic history as well as more recent anthropogenic impacts on the Earth's climate. The discussion of processes that have regulated Earth's climate over geologic history provided below is not intended to detract from the importance of anthropogenic climate forcings in the more recent term. The discussion of longer term climate systems is intended to provide important background and context to more clearly highlight the magnitude and extent of anthropogenic impacts on the Earth's climate system. It is primarily through study of natural forcings and climate trends over geologic history that climate scientists have been able to identify the extent of anthropogenic influence on the climate system, the deviation of current climate trends from expected climate cycles, and the potential risks of abrupt climate change. A discussion of anthropogenic climate change without knowledge of longer term climate drivers and climate trends would be unproductive and without context.

#### 2.1.2.2 Causes of Climate Change

##### *2.1.2.2.1 The greenhouse effect*

The earth's climate is largely regulated by the presence of gases and particulates that trap heat inside the earth's atmosphere or shade it from the sun. In addition changes in the sun's intensity also affect the earth's climate. Energy from the sun enters the earth's atmosphere where some of this energy is absorbed, warming the earth's surface. Some of this solar radiation is reflected from the earth's surface back into the earth's atmosphere. A fraction of the outgoing solar radiation, as well as some of the energy that is emitted from the warmed surface of the earth, is trapped by atmospheric gases (water vapor, carbon dioxide, and other gases). This heat trapping mechanism helps stabilize the earth's energy balance keeping surface temperatures relatively stable and amenable to life (see Figure 2). Large amounts of aerosols and particulates released to the atmosphere (such as those released due to large volcanic eruptions) can also have a short term cooling effect due to shading from the sun.

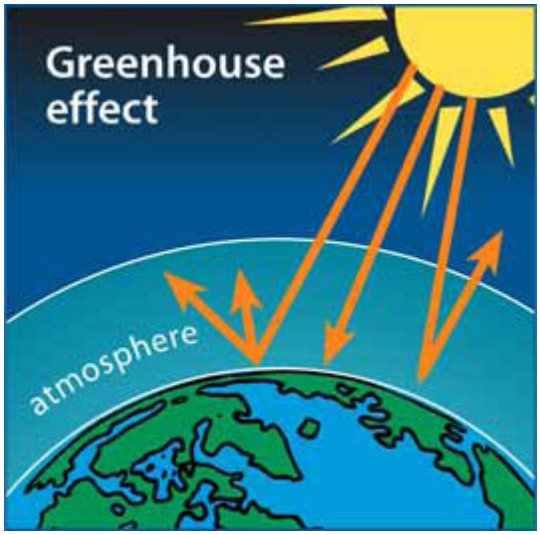



**Figure 2 Diagram of the greenhouse effect[25]**

#### *2.1.2.2.2 Variations in Earth's orbit and solar intensity*

Over long timescales, the earth's climate is controlled by interactions between solar radiation and the heat trapping constituents of the earth's atmosphere. Over geologic timescales, changes in the intensity of solar radiation, changes in the earth's orbit and tilt relative to the sun, and changes in the concentrations of the gasses in the earth's atmosphere that absorb, scatter and reflect solar radiation can result in changes in the earth's climate.

While information available from the EPA indicates that, "Changes occurring within (or inside) the sun can affect the intensity of the sunlight that reaches the Earth's surface. The intensity of the sunlight can cause either warming (for stronger solar intensity) or cooling (for weaker solar intensity)"[26], the magnitude of solar variability's impact on climate change is likely very small. The mechanisms and exact magnitude of the influence of solar variability on global climate change are uncertain and are the subject of ongoing scientific research and debate[27]. Over very long time scales changes in solar luminosity are hypothesized to have influenced Earth's radiation balance. Model calculations suggest that when the Sun first formed 4.6 billion years ago, it should have been approximately 70% as luminous as it is today. The

[25] Minnesota Pollution Control Agency, 2007. "Global Climate Change. Air Quality #1.13 May 2007.
[26] http://epa.gov/climatechange/science/pastcc.html. (see Appendix B)
[27] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]. (Section 2.7)

so-called "faint young sun paradox" points out that, if all other factors were constant, the early Earth would have been colder than it is today as a result of the lower intensity of the Sun.[28]

Solar variability over shorter timescales has received a great deal of attention due to the potential relevance of reliable estimates of solar influence in helping to isolate anthropogenic climate impacts. Available observations of total solar irradiance show variations ranging from a few days up to an 11 year solar cycle (variation between sunspot minimum and sunspot maximum of approximately 1 $Wm^{-2}$) and may or may not indicate a small drift on longer (e.g., 30 year) time scales[29]. The role of solar activity in climate changes remains an unproven and likely second-order effect, however, further observations and research are needed to improve the scientific understanding of solar forcing mechanisms and their impacts on the Earth's climate[30]. Nonetheless, uncertainties in solar radiative forcing are very small relative to the estimated radiative forcing due to anthropogenic changes, and modeled surface temperature impacts associated with the solar cycle are very small relative to anthropogenic changes.[31]

Changes in the Earth's orbit impact global climate via their influence on the radiation balance of the planet. Systematic, cyclical variations in the in the eccentricity (or ellipticity) of the Earth's orbit as well as the tilt and the precession (or the "wobble" in the earth's rotation about its axis) of the earth's orbit affect the earth's radiative budget over very long time scales as well. These natural changes in earth's orbital processes alter the proximity of the earth to the sun and the seasonal distribution of solar energy, a change of particular climatological importance at high latitudes and particularly in the northern hemisphere. These orbital processes function in cycles, known as Milankovitch cycles, of 100,000 (eccentricity), 41,000 (tilt), and 19,000 to 23,000 (precession) years and are hypothesized to be the primary drivers of ice ages.[32]

#### *2.1.2.2.3 Geologic processes controlling natural levels of GHGs and aerosols*

Natural geologic processes that occur on the earth's surface can exert a strong control over the concentration of GHG constituents present in the earth's atmosphere resulting in more efficient trapping of the sun's energy even under conditions where solar forcing is unchanged. Over geologic timescales,

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[28] Kump, Kasting and Crane. The Earth System. 2nd ed., 2004. Pearson Education, Upper Saddle River, NJ. (p. 14).
[29] Gray, L. J., et al. (2010), Solar influences on climate, Rev. Geophys., 48, RG4001, doi:10.1029/2009RG000282. Gray et al. point out that instrument stability and intercalibration must be studied in detail before one can be confident that the longer time scale drifts are real
[30] E. Bard, M. Frank, 2006. Earth and Planetary Science Letters 248, 1–14.
[31] Gray, L. J., et al. (2010), Solar influences on climate, Rev. Geophys., 48, RG4001, doi:10.1029/2009RG000282.
[32] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]. (page 449)

for example, the large scale weathering of silicate minerals can result in a gradual draw down of atmospheric GHG concentrations and long term sequestration of carbon from the earth's atmosphere in carbonate minerals[33]. Similarly, over geologic timescales large amounts of organic carbon have been removed and sequestered from the earth's atmosphere as large deposits of organic material have decayed under anerobic conditions and have been trapped under high temperature and pressure. Changes in the size and distribution of land masses on earth have exerted a primary influence over earth's climate over geologic history. On shorter timescales, geologic events such as volcanic eruptions can affect climate due the release of aerosols, particulates, and carbon dioxide into the atmosphere. Volcanic aerosols tend to reflect the sun's radiation as it enters the earth's atmosphere, resulting in a short term cooling effect. The carbon dioxide emissions from volcanoes generate a longer term warming effect that persists well beyond the cooling effect generated by aerosol emissions. A number of other natural terrestrial processes contribute to variations in earth's climate due to their influence on atmospheric GHG levels. These processes include things such as natural variations in the types and extent of vegetation, large scale forest fires followed by periods of regrowth, and impacts of other natural disasters[34].

#### *2.1.2.2.4 Earth system feedbacks*

Warming which results from changes in earth's radiative balance can be exacerbated by numerous positive feedbacks in the earth's climate system. For example, greater amounts of incoming solar radiation can lead to warming which may trigger snow and ice melt and a corresponding loss of albedo[35], and even more warming. Or, for example, greater amounts on incoming solar radiation can lead to warming which may trigger outgassing of $CO_2$ from the world's oceans leading to higher levels of this GHG in the earth's atmosphere. This feedback might generate additional increases in temperature,

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[33] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].(Chapter 7)

[34] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]. (Chapter 7)

[35] Albedo is the fraction of solar radiation reflected by a surface of object, often expressed as a percentage. Snow-covered surfaces have a high albedo, the surface albedo of soils ranges from high to low, and vegetation-covered surfaces and oceans have a low albedo. The Earth's planetary albedo varies mainly through varying cloudiness, snow, ice leaf area and land cover changes. (IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].)

snowmelt, loss of albedo and so on. These same feedbacks can work in the opposite direction to magnify slight changes in orbital forcing that create a cooling effect[36].

#### *2.1.2.2.5 Anthropogenic GHG emissions*

A growing body of scientific evidence points to anthropogenic GHG emissions as a key factor in recent global climate change. The IPCC's Fourth Assessment Report concluded that: "global atmospheric concentration of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years." A more detailed discussion of anthropogenic GHG emissions can be found below. Relatively rapid increases in global atmospheric $CO_2$ emissions, corresponding with the rise of the industrial revolution near the turn of the 19th century and continuing into the present, are evident in the record. The present atmospheric concentration of carbon dioxide has been judged to be higher than any time in the last 650,000 years. Approximately 650,000 years ago is the far limit of the time period over which atmospheric carbon dioxide estimates are available based on ice core data.

The strong relationship observed between rising atmospheric $CO_2$ levels and anthropogenic emissions of GHGs is further corroborated by observations of systematic shifts in the isotopic signature of atmospheric $CO_2$. Fossil fuel burning releases isotopically light carbon into the atmosphere. Fossil fuel emissions have $\delta^{13}C$ values between -20 and -30 parts per mil because they were created from organic materials which preferentially incorporate $\delta^{12}C$ into their tissues[37]. The massive anthropogenic release of this isotopically light carbon allows isotopic changes in the carbon cycle, as well as changes in reservoir masses of carbon to be traced. The signature of anthropogenic GHGs emitted to the atmosphere as the result of fossil fuel burning in the atmosphere can be observed via isotopic measurements of atmospheric carbon isotope (C-13) concentrations made on air collected in flasks at the CSIRO GASLAB[38] worldwide network. This data shows rising atmospheric $CO_2$ levels with a persistent anthropogenic fossil fuel GHG signature trending toward isotopically lighter $\delta^{13}C$. While this isotopic evidence may seem extraneous to some readers, the discussion has been included in this report to provide a more comprehensive

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[36] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].
[37] Andres et al., 2000. Carbon Dioxide Emissions from Fossil Fuel Consumption and Cement Manufacture 1751-1995; and an Estimate of their Isotopic Composition and Latitudinal Distribution. The Carbon Cycle. Cambridge University Press.
[38] Allison, C.E., R.J. Francey and P.B. Krummel, April, 2003. del-13C in CO2 from sites in the CSIRO Atmospheric Research GASLAB air sampling network in Online Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center (CDIAC). Oak Ridge, TN

explanation of the link between anthropogenic emissions, rising atmospheric GHG levels, and climate change.

The IPCC Fourth Assessment Report concluded that most of the observed global average surface temperature increases since the middle of the 20th century are very likely attributable to the observed increases in global atmospheric GHG concentrations resulting from anthropogenic GHG emissions. The IPCC report also concludes that observations of widespread warming of the earth's atmosphere and oceans as well as observations of ice mass loss are best explained by a combination of natural and anthropogenic forcings and they note that the observed widespread warming of the earth's atmosphere and oceans are very likely (>90%) not due to natural causes alone (<10% probability). These trends as well as changes in wind patterns and temperature extremes are very likely not attributable to natural causes alone. According the fourth IPCC report it is likely (>66% probability) that anthropogenic forcing is responsible for increased temperatures of the most extreme hot nights, cold nights and cold days. It is likely that rapidly rising GHG concentration would have caused more than the observed warming if not for the offsetting effects of volcanic and anthropogenic aerosols. Observed trends toward tropospheric warming and stratospheric cooling are very likely due to the combined influences of anthropogenic GHG emissions and stratospheric ozone depletion.

#### 2.1.2.3 Historic temperature trends

##### *2.1.2.3.1 Earth's Equilibrium Temperature Sensitivity*

The responsiveness of the Earth's climate system to perturbations in the Earth's radiation balance is key in assessing the potential implications of anthropogenic forcing. "Equilibrium climate sensitivity", the global mean surface warming in response to a doubling of the atmospheric $CO_2$ concentration after the system has reached a new steady state, is one measure of the sensitivity of the climate system to changing atmospheric greenhouse gas (GHG) concentrations. Equilibrium climate sensitivity is of particular interest because many model-simulated aspects of climate change scale approximately linearly with climate sensitivity[39].

The concept of climate sensitivity draws on the basic features of the energy balance of the Earth system. The difference between positive perturbations to the energy balance of the system ($\Delta F$) and the increased

[39] Knutti and Hegerl, 2008. The equilibrium sensitivity of the Earth's temperature to radiation changes, Review Article. Nature Geoscience 1, 735 – 743. Knutti and Hegerl point out however the importance of spatial and temporal aspects of climate change that equilibrium climate sensitivity does not necessarily capture.

outgoing long-wave radiation that is assumed to be proportional to the surface warming ($\Delta T$) results in an increase in heat flux ($\Delta Q$) in the system as illustrated in Equation (1) below:

$$\Delta Q = \Delta F - \lambda \Delta T \quad (1)$$

For a constant forcing, the system will reach an equilibrium state with $\Delta Q$ equal to zero and where radiative forcing is balanced by additional emitted long-wave radiation. The inverse of the ratio of forcing to equilibrium temperature change ($1/\lambda = \Delta T/\Delta F$) is defined as the climate sensitivity parameter (S) (in °C $W^{-1}m^2$) and the equilibrium climate sensitivity is the equilibrium temperature change associated with a doubling of atmospheric $CO_2$[40].

Climate sensitivity cannot be measured directly; rather, it is derived. One common approach is to use a "bottom–up" strategy, relying on present understanding of the physics of the climate system to model changes in radiation balance and associated positive and negative feedbacks, thereby arriving at an estimate of climate sensitivity. A second strategy is a "top–down" approach that relies on evidence of past climate responses to forcing to derive estimates of climate sensitivity. For example, existing work using this bottom-up approach has drawn on data for the last glacial maximum (LGM) to estimate climate sensitivity. Both approaches have advantages and disadvantages. As a potential way to capitalize on the benefits that each approach has to offer, one recent study has developed a "hybrid" approach, combining a basic understanding of the physics with data from past climate evolution, to generate an ensemble of many climate model versions that to span the range of uncertainty about the physics of the climate system, and then using the available data to constrain the range of model responses that are consistent with evidence of past climate behavior[41].

The results of these efforts are a range of potential values for climate sensitivity that vary, typically centering around a climate sensitivity value of about 3 °C, with a likely range of about 2–4.5 °C[42].

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[40] Knutti and Hegerl, 2008. The equilibrium sensitivity of the Earth's temperature to radiation changes, Review Article. Nature Geoscience 1, 735 – 743. For more detailed explanation, caveats and further discussion please see this reference.

[41] T.S. von Deimling et al., 2006: Climate sensitivity estimated from ensemble simulations of glacial climate. Climate Dynamics 27: 149–163.

[42] IPCC, 2001: Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton et. al., eds.]

However, the physics of the response and uncertainties in forcing lead to fundamental difficulties in ruling out higher values[43].

#### *2.1.2.3.2 Global temperature trends*

The last ice age, which occurred 18,000 years ago, yielded temperatures 7-10 degrees Fahrenheit cooler than they are today.[44] The past 17,000 years have been characterized by a slow increase in global temperatures from the ice age to the beginning of the 20th century. Scientists have identified three departures from these relatively stable climactic conditions. The Medieval Climate Anomaly was a global event with warming in Europe and Asia, drought in parts of North America and Africa, and wetter conditions in Central America. The Little Ice Age was a period of relative cooling in Europe and other effects in other parts of the world including drought in Central America and parts of China. The final anomaly begins with the Industrial Revolution. The Industrial Era has been characterized by emissions of GHGs from human activities. The past 100 years have seen average temperature increases of about 1.5°F.[45] The global average temperature has increased by about 1.2 to 1.4° F since 1890, with the ten warmest years of the past century occurring between 1997 and 2008[46]. Global temperature trends over the instrumental period and the global mean surface temperature anomaly are shown in Figure 3 that follows.

[43] Knutti and Hegerl, 2008. The equilibrium sensitivity of the Earth's temperature to radiation changes, Review Article. Nature Geoscience 1, 735 – 743. For more detailed explanation, caveats and further discussion please see this reference.
[44] Minnesota Pollution Control Agency, 2007. "Global Climate Change. Air Quality #1.13 May 2007.
[45] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)
[46] http://data.giss.nasa.gov/gistemp/2008/ (see Appendix B)

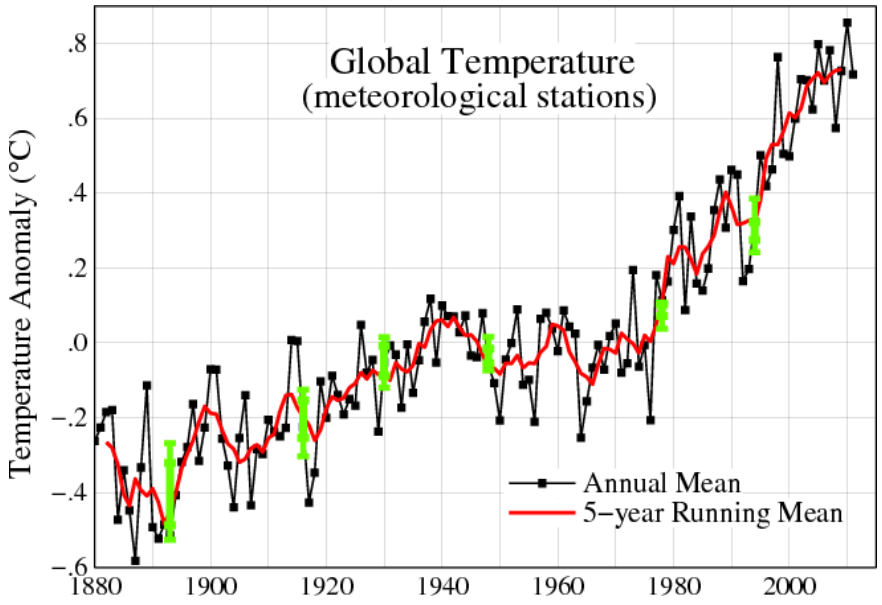



**Figure 3 Global temperature trends from the instrumental record**[47]

This warming trend has continued through the turn of the century, with records of the warmest years occurring in1998-2011.

#### *2.1.2.3.3 U.S. temperature trends*

The observed increases in global average surface temperature can also be seen in the records of average annual temperatures at the regional and state level. Over the period from 1901-2009 temperatures across the lower 48 states have risen at an average rate of 0.13° F per decade. Average temperatures have risen more quickly since the late 1970s (0.35 to 0.51°F per decade). Seven of the top 10 warmest years on record for the lower 48 states have occurred since 1990, and the last 10 five-year periods have been the 10 warmest five-year periods on record.[48] The North, the West, and Alaska have seen the greatest temperature increases, while some parts of the South have experienced little change. However, not all of these regional trends are statistically meaningful.[49] Temperatures in the U.S. over the period 1901-2009 are shown in Figure 4. In keeping with the global trend, winters in the United States have warmed more

[47] http://data.giss.nasa.gov/gistemp/graphs/ (see Appendix B). This plot of global meteorological station data shows annual-mean surface air temperature change derived from the meteorological station network [This is an update of Figure 6(b) in Hansen, J.E., R. Ruedy, Mki. Sato, M. Imhoff, W. Lawrence, D. Easterling, T. Peterson, and T. Karl (2001), A closer look at United States and global surface temperature change, J. Geophys. Res., 106, 23947-23963, doi:10.1029/2001JD000354.] Green uncertainty bars (95% confidence limits) are shown for both the annual and five-year means and account only for incomplete spatial sampling of data.

[48] US EPA, 2010 Climate Change Indicators in the United States EPA-430-E-10-007

[49] US EPA, 2010 Climate Change Indicators in the United States EPA-430-E-10-007

dramatically than summers, with a marked decrease in the number of days that achieved below freezing temperatures.[50]

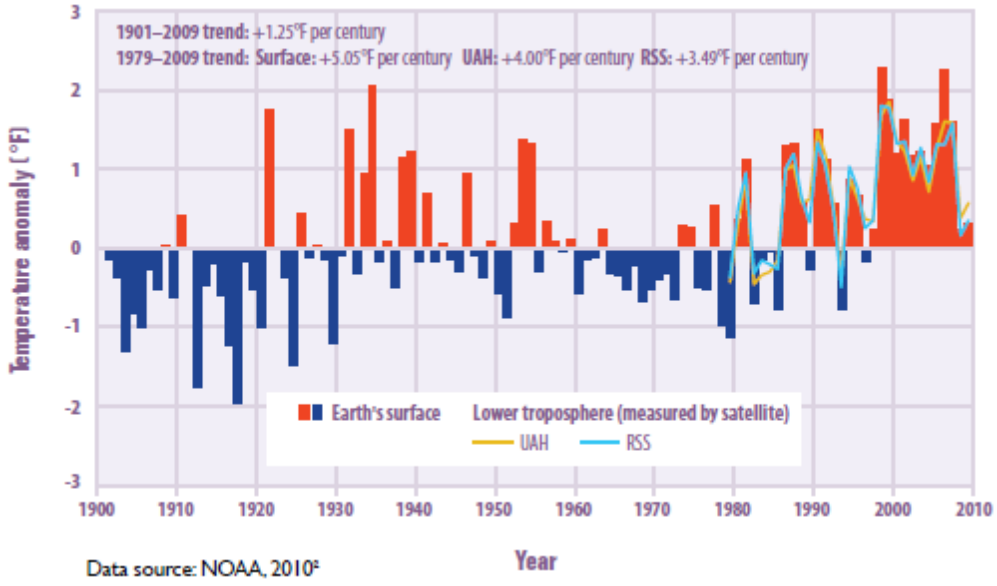



**Figure 4 Temperature anomaly in the lower 48 states, 1901-200951**

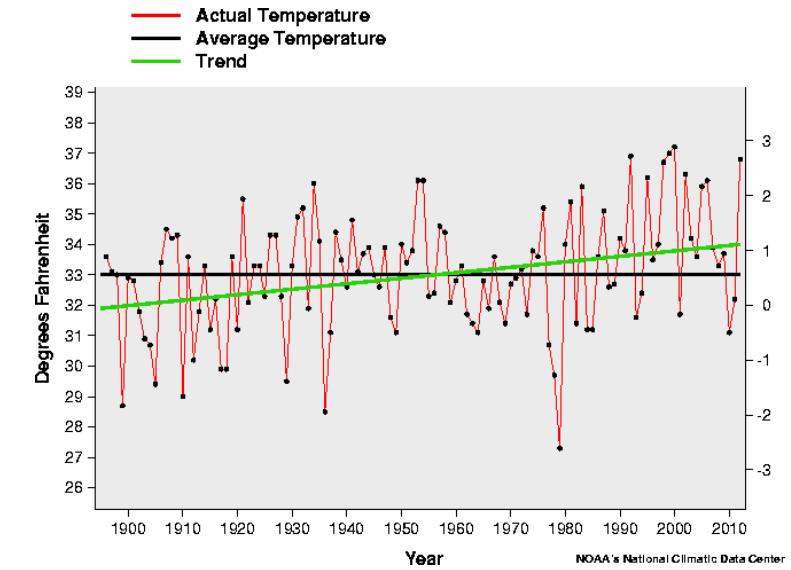
Temperature trends can also be observed in seasonal average temperatures in the United States. Figure 5 below shows the spring, summer, winter and fall warming trends in national average temperatures over the instrumental record. Winters in the United States have shown the strongest trend in temperature increases with an estimated increase of 0.17°F per decade trend over the period 1895-2012. Much of this temperature increase has occurred over the last few decades, with the period from 1982-2012 showing a temperature trend of 0.46°F/decade. Spring temperatures in the U.S. have increased an average of 0.13°F per decade over the period 1895-2012. Average U.S. summer temperatures have shown a slightly lower trend of 0.11°F average per decade, although the most recent three decades on record show a steeper trend

[50] U.S. Global Change Research Program, 2009. Global Climate Change Impacts in the United States: A state of Knowledge Report from the U.S. Global Change Research Program. Cambridge University Press. ISBN 978-0-521-14407-0

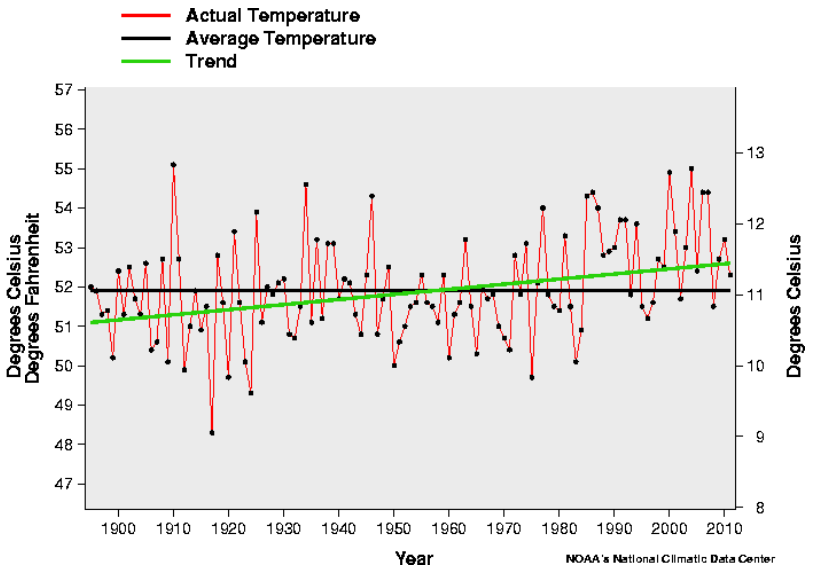
[51] Figure from US EPA, 2010 Climate Change Indicators in the United States EPA-430-E-10-007, the report notes: This figure shows how average temperatures in the lower 48 states have changed since 1901. Surface data come from land-based weather stations, while satellite measurements cover the lower troposphere, which is the lowest level of the Earth's atmosphere (see diagram on p. 20). "UAH" and "RSS" represent two different methods of analyzing the original satellite measurements. This graph uses the 1901 to 2000 average as a baseline for depicting change. Choosing a different baseline period would not change the shape of the trend.

of 0.52°F average per decade. Fall temperatures over the instrumental record show a trend of 0.08°F average per decade with the last three decades averaging a 0.65°F increase per decade.[52]

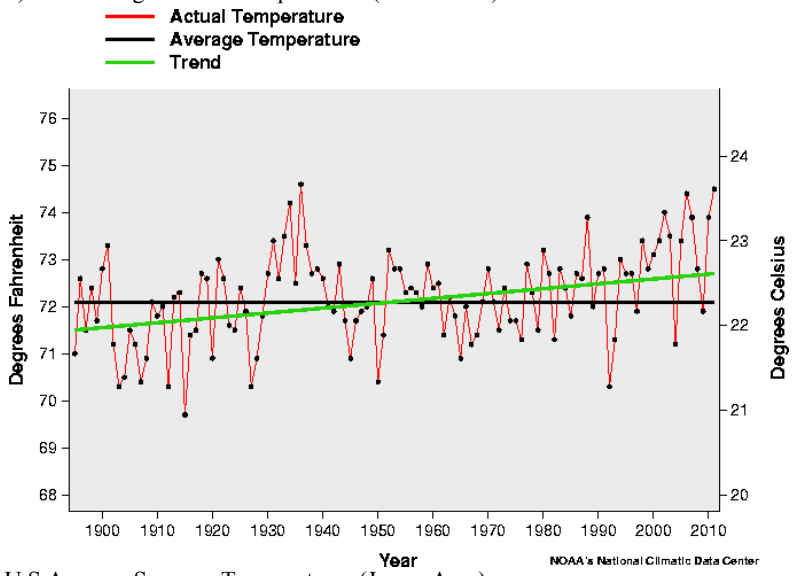
[52] http://www.ncdc.noaa.gov/oa/climate/research/cag3/na.html (see Appendix B)



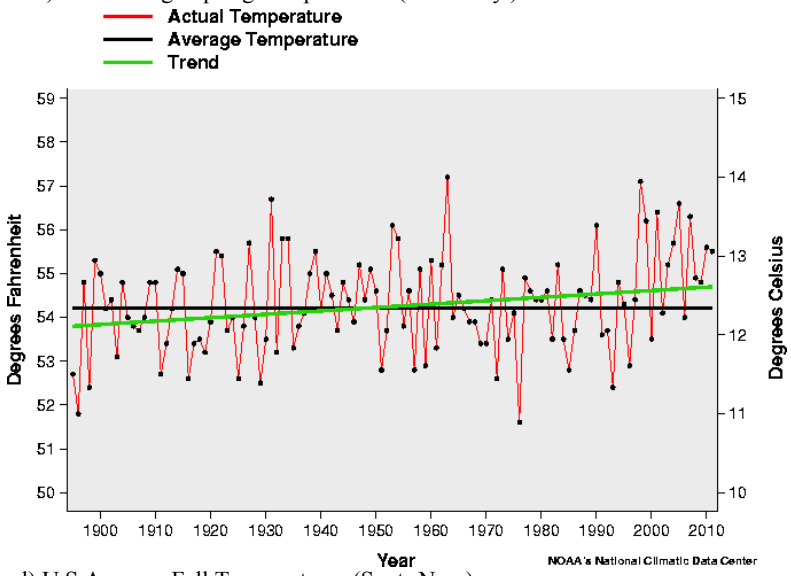

a) U.S Average Winter Temperatures (Dec. – Feb.)




b) U.S Average Spring Temperatures (Mar.-May.)




c) U.S Average Summer Temperatures (Jun. – Aug.)




d) U.S Average Fall Temperatures (Sept.-Nov.)

**Figure 5 Seasonal Temperature Trends for U.S. over the instrumental period in Degrees Fahrenheit[53]**

[53] http://www.ncdc.noaa.gov/oa/climate/research/cag3/na.html

#### *2.1.2.3.4 Minnesota Temperature Trends*

The annual average temperature of Minnesota has increased approximately one degree F in the last century, from 43.9° F (1888-1917 average) to 44.9° F (1963-1992 average).[54] The winter season has brought even more dramatic increases of up to 5°F in parts of northern Minnesota.[55] Much of the warming observed in Minnesota has occurred over the last few decades. The observed rate and total increase in temperatures appears more extreme when the more recent years on record are averaged. For example, the observed trend in warming is more than 5°F per century when average statewide temperatures from only 1980 to the present are considered[56]. Departures in average 1997-2006 temperatures from the 1970-2000 normal in Minnesota are shown in Figure 6.

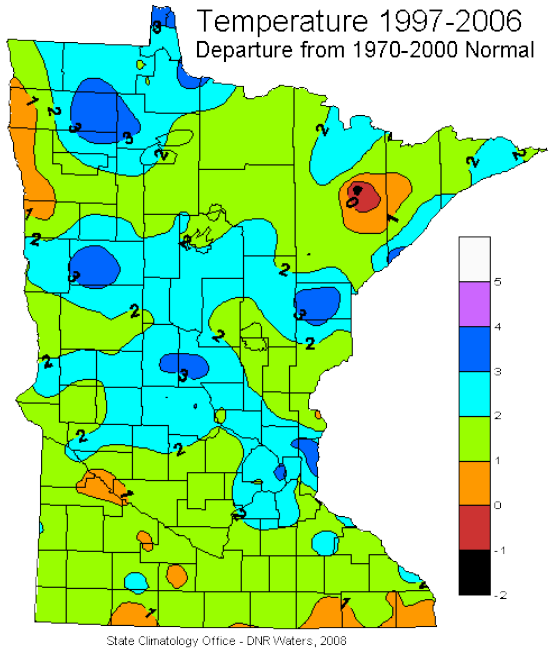



**Figure 6 1997-2006 average temperatures deviation from 1970-2000 normal57**

Shortened winter seasons have also been observed in the past two decades. Since 1981 Minnesota has recorded eight of the 20 warmest years in the state's history. Three of the warmest winters were recorded

[54] Zandlo, 2008. Climate Change and the Minnesota State Climatology Office: Observing the Climate. Minnesota Climatology Working Group. (available at: http://climate.umn.edu/climatechange/climatechangeobservedNu.htm)
[55] Zandlo, 2008. Climate Change and the Minnesota State Climatology Office: Observing the Climate. Minnesota Climatology Working Group. (available at: http://climate.umn.edu/climatechange/climatechangeobservedNu.htm)
[56] Zandlo, 2008. Climate Change and the Minnesota State Climatology Office: Observing the Climate. Minnesota Climatology Working Group. (available at: http://climate.umn.edu/climatechange/climatechangeobservedNu.htm)
[57] Zandlo, 2008. Climate Change and the Minnesota State Climatology Office: Observing the Climate. Minnesota Climatology Working Group. (available at: http://climate.umn.edu/climatechange/climatechangeobservedNu.htm

in 1997, 1998, and 1999.[58] Seasonal temperature trends for summer and winter in Minnesota are shown in Figure 7.

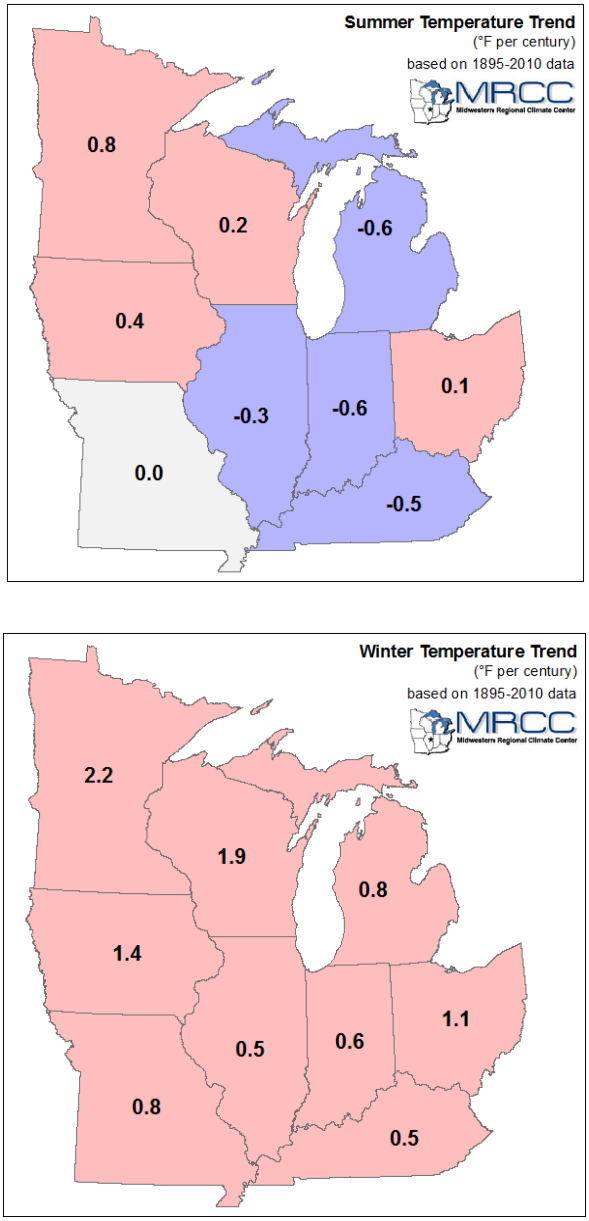



**Figure 7 Temperature trends for winter and summer seasons in Minnesota 1895-2010[59]**

[58] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)

[59] http://mrcc.sws.uiuc.edu/climate_midwest/mwclimate_change.htm# (see Appendix B)

#### 2.1.2.4 Historic trends and projections of GHG emissions

Over the earth's history atmospheric GHG levels have fluctuated due to warming and feedbacks related to the earth's orbital cycles, volcanic events and other natural contributors to GHG variability. Records of these atmospheric $CO_2$ variations over the last several glacial/interglacial cycles are shown in Figure 8 and are discussed in greater detail above. In more recent history, global atmospheric concentrations of three key GHGs ($CO_2$, $N_2O$ and $CH_4$) have been increasing notably as a result of human activities since the turn of the 19th century (see Figure 9)[60].

[60] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)] (Summary for Policymakers)

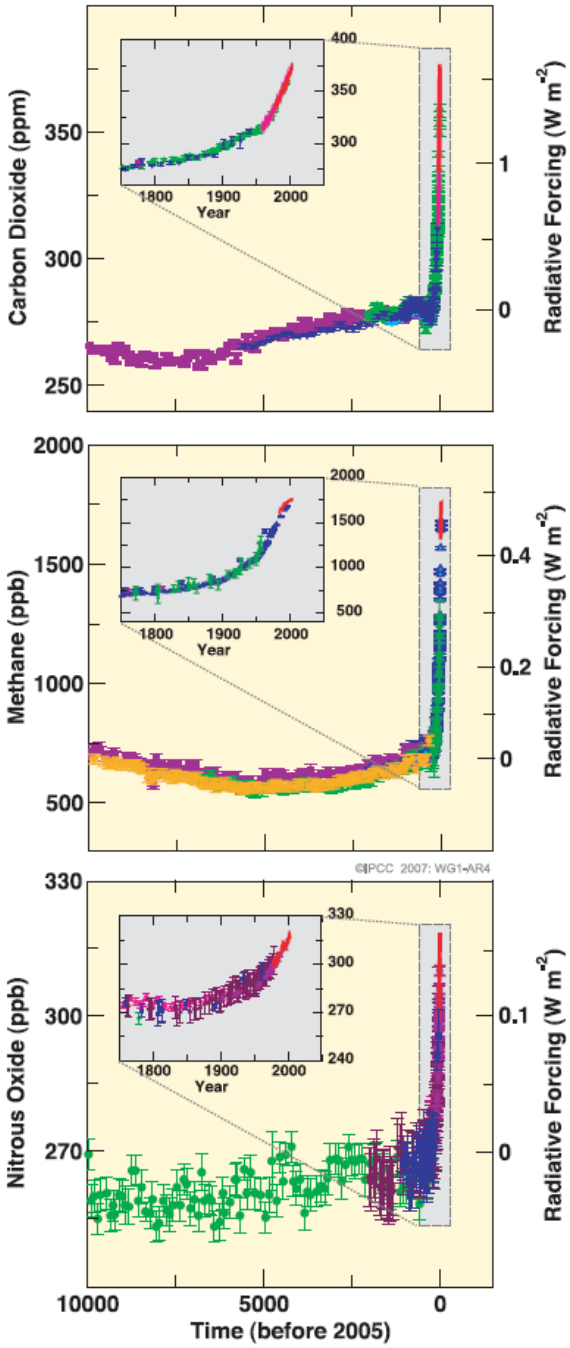



**Figure 8** **Global trends in GHG levels derived from paleo-proxy and instrumental records for the past several thousand years[61].**

[61] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)] (Summary for Policymakers)

At the global scale, anthropogenic GHG emissions result primarily from the burning of fossil fuels with land use and land use changes representing a secondary, but notable, source of anthropogenic GHG emissions. As shown in Figure 9, global anthropogenic emissions of $CO_2$ to the atmosphere have been steadily increasing since the turn of the 19th century[62].

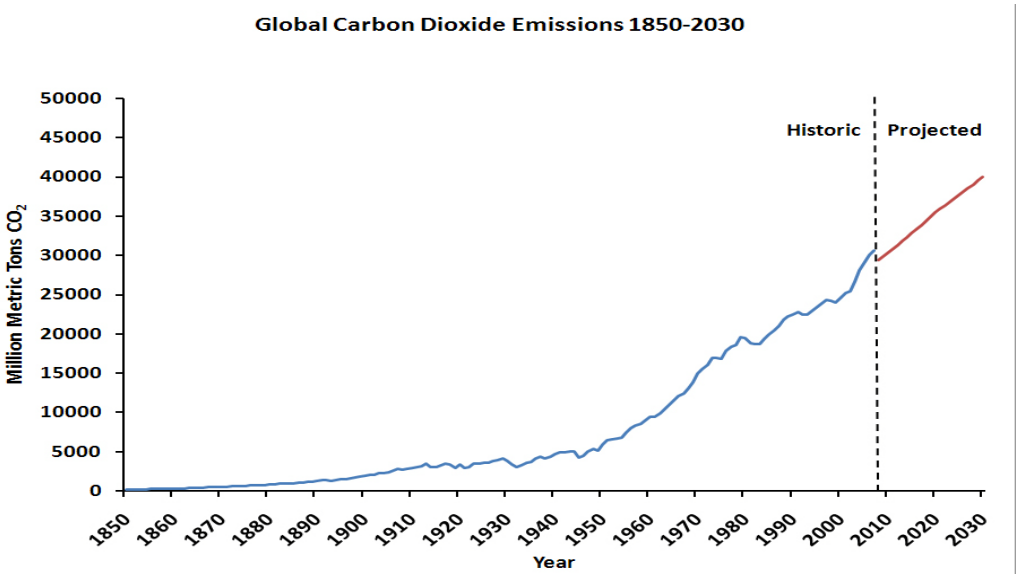



**Figure 9 Global anthropogenic CO2 emissions 1850 through 2010; predicted emissions extended to 203063**

IPCC projections of future GHG emissions on the global scale (see Figure 10) are constructed for various scenarios that depend strongly on human population growth, global economic growth, the success of international efforts to curb growth in GHG emissions, and the development of new and more efficient energy sources. All projected scenarios show a trend toward increasing GHG emissions through the middle of this century[64]. The next IPCC report concerning these projected GHG emission scenarios is expected at the beginning of the year 2013.

[62] http://www.pewclimate.org/facts-and-figures/international/historical (see Appendix B)
[63] http://www.pewclimate.org/facts-and-figures/international/historical (see Appendix B)
[64] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)] (Summary for Policymakers)

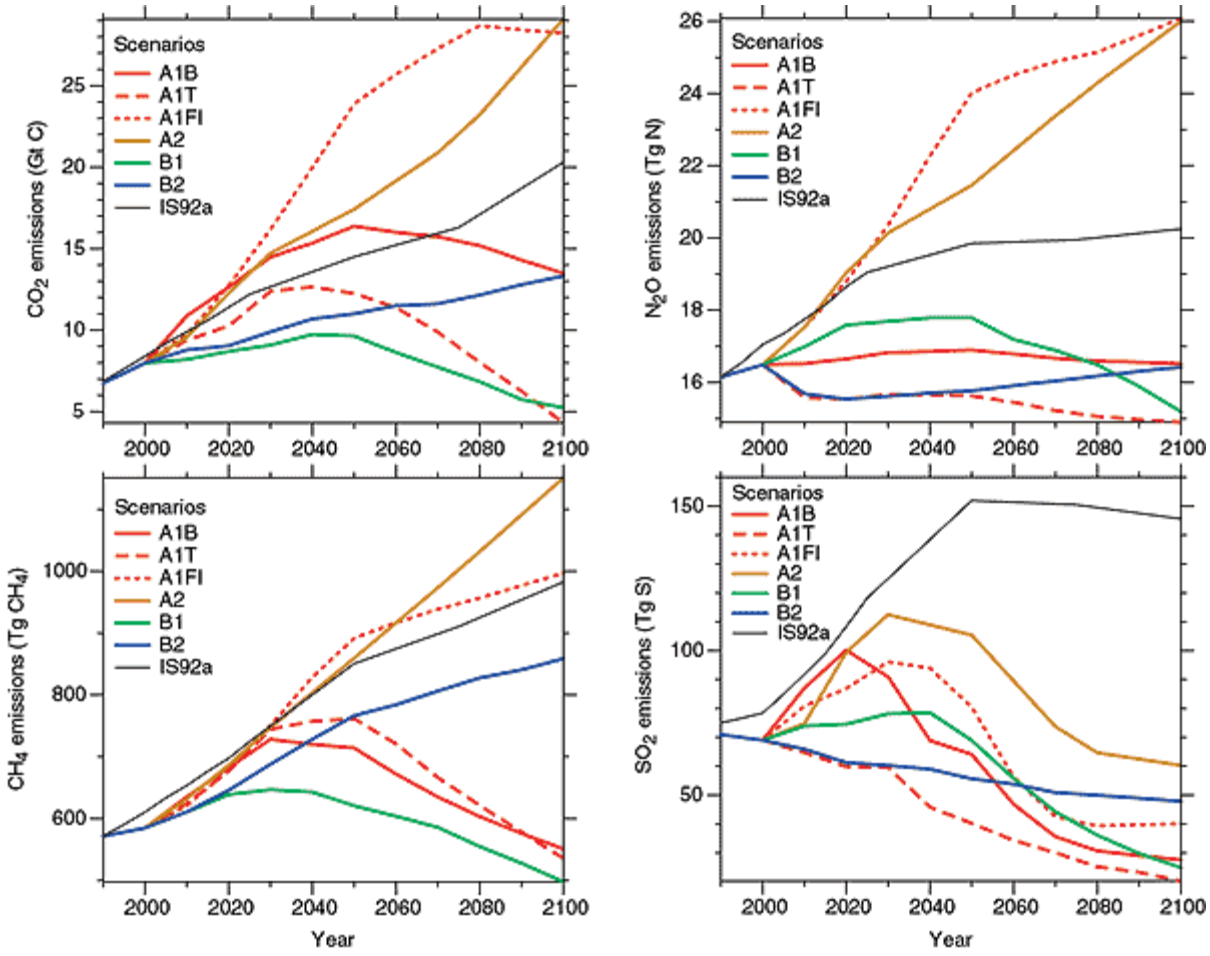



**Figure 10 IPCC SRES Projections65**

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[65] IPCC, 2001: Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton et. al., eds.] (Figure 17). The Six IPCC Special Report on Emissions Scenarios (SRES) illustrative scenarios: A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end-use technologies).
A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.
B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.
B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 and B1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

In 2009, total U.S. GHG emissions were 6,633.2 million metric tons $CO_2$-e, and net emissions were 5,618.2 million metric tons $CO_2$-e, which reflects the influence of sinks (the net $CO_2$ flux from land use, land use change, and forestry). While total U.S. emissions have increased by 7.3 percent from 1990 to 2009, emissions decreased from 2008 to 2009 by 6.1 percent (427.9 million metric tons $CO_2$-e). A decrease in economic output resulting in a decrease in energy consumption across all economic sectors as well as a decrease in the carbon intensity of fuels used to generate electricity (a phenomenon due to fuel switching as the price of coal increased, and the price of natural gas decreased significantly) are the most significant contributory factors in the reported GHG emission decrease. As the largest contributor to U.S. GHG emissions, $CO_2$ from fossil fuel combustion has accounted for approximately 79 percent of global warming potential (GWP) weighted emissions since 1990, from 77 percent of total GWP-weighted emissions in 1990 to 79 percent in 2009. Emissions from this source category grew by 9.9 percent (470.6 million metric tons $CO_2$-e) from 1990 to 2009 and were responsible for most of the increase in national emissions during this period. From 2008 to 2009, these emissions decreased by 6.4 percent (356.9 million metric tons $CO_2$-e). Overall, from 1990 to 2009, total emissions of $CO_2$ and $CH_4$ increased by 405.5 million metric tons CO2 $CO_2$-e (8.0 percent) and 11.4 million metric tons $CO_2$-e (1.7 percent), respectively, while N2O emissions decreased by 19.6 million metric tons $CO_2$-e (6.2 percent). Over the same period, aggregate weighted emissions of HFCs, PFCs, and SF6 rose by 54.1 million metric tons $CO_2$-e (58.8 percent)[66]. Historic estimated annual U.S. GHG emissions from anthropogenic are shown in Figure 11.

[66] US EPA, 2011. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2009. Chapter 2: Trends in Greenhouse Gas Emissions. (http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Chapter-2-Trends.pdf)

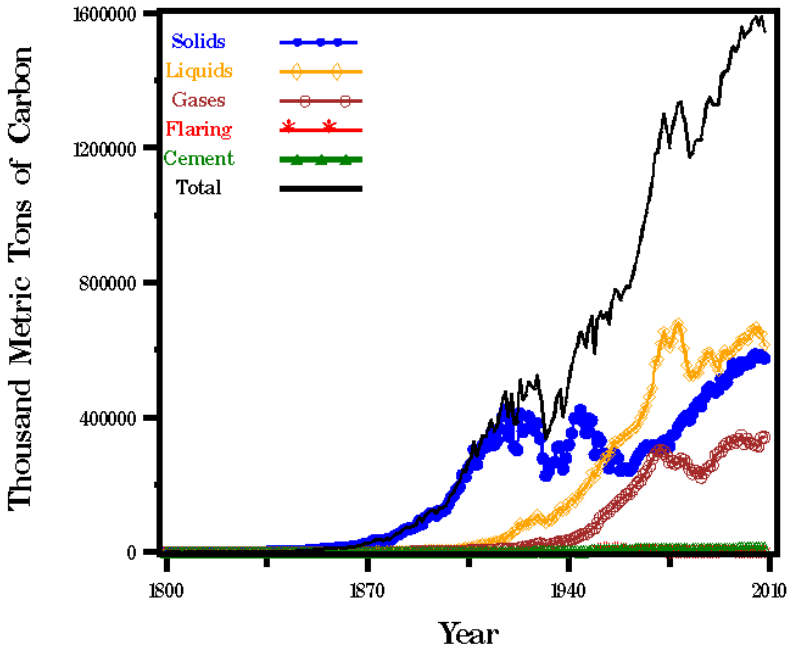



**Figure 11 U.S. Carbon emissions 1800-200467**

Like global GHG emission projections, trends in future U.S. GHG emissions depend critically on future economic growth, population growth, and the success of alternative energy and energy efficiency measures. Through recent legislation, the Federal Government has agreed to and continues to work towards the goal of reducing its GHG pollution by 28 percent by the year 2020. This reduction and reporting of GHG pollution is meant to ensure that the Federal Government leads by example in building a clean energy economy. As the single largest energy consumer in the U.S. economy, the Federal Government spent more than $24.5 billion on electricity and fuel in 2008 alone. Achieving the Federal GHG pollution reduction target will reduce Federal energy use by the equivalent of 646 trillion BTUs[68].Estimates of historic GHG emissions in the state of Minnesota follow the global and national trend of generally increasing emission levels. Minnesota's GHG emissions are estimated to have increased about 20% since 1988.

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[67] Boden, Marland, and Andres, 2011. National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2008. Carbon Dioxide Information Analysis Center Oak Ridge National Laboratory. Oak Ridge, TN. doi 10.3334/CDIAC/00001_V2011. (http://cdiac.ornl.gov/trends/emis/usa.html)

[68] White House Office of the Press Secretary, January 29, 2010. Press Release: "President Obama Sets Greenhouse Gas Emissions Reduction Target for Federal Operations. (http://www.whitehouse.gov/the-press-office/president-obama-sets-greenhouse-gas-emissions-reduction-target-federal-operations)

Trends in historic GHG emissions in Minnesota are tied to the same key economic and energy trends that play a strong role in global and national greenhouse emission trends. Historic emissions data for Minnesota presented in Figure 12 shows rapid growth in Minnesota's emissions over the period 1970 to 1979, coinciding with a period of robust economic expansion in Minnesota. During the period from the early to late 1980's economic troubles combined with de-industrialization, fuel switching and lower carbon energy sources resulted in gross reductions in statewide GHG emissions. Since the late 1980s Minnesota has trended toward rapid growth in GHG emissions.

According to MPCA: "Statewide GHG emissions increased by an estimated 51.5 million $CO_2$-e tons between 1970 and 2008, to a total of 159.5 million $CO_2$-e tons, 48 percent higher than emissions in 1970.

Between the years 1970 and 2008, the most significant growth in estimated statewide GHG emissions occurred in just two sectors: the electric power sector and the transportation sector. Emissions from transportation and electric power generation comprised roughly 41 percent of all Minnesota GHG emissions in 1970, and, by 2008, they accounted for 60 percent, more than doubling in absolute terms[69].

[69] http://www.pca.state.mn.us/index.php/topics/climate-change/climate-change-in-minnesota/greenhouse-gas-emissions-in-minnesota.html (see Appendix B)

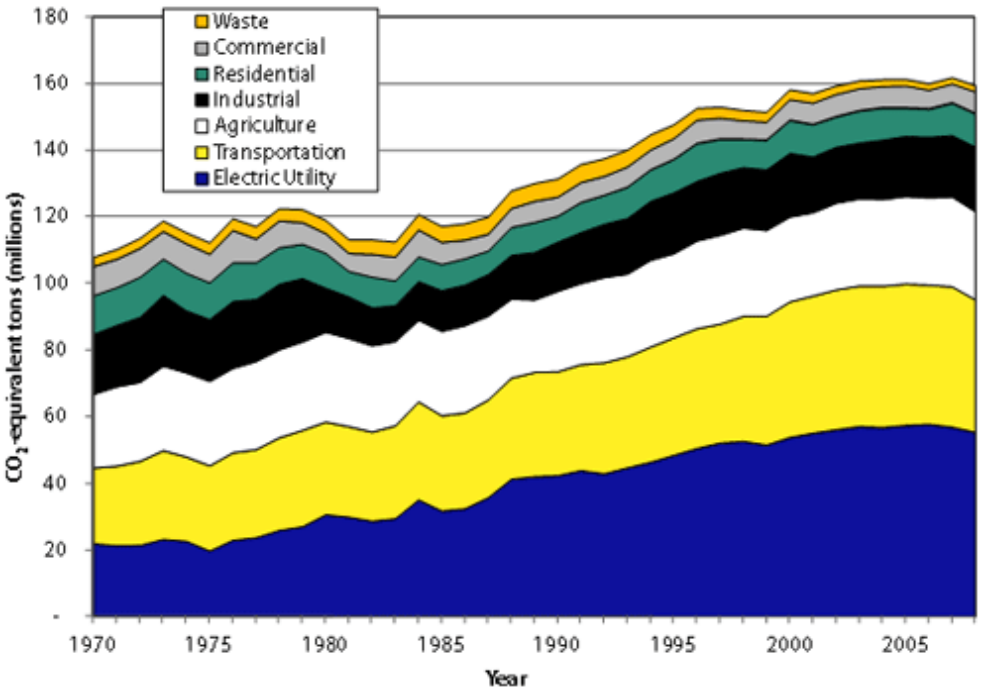



**Figure 12 GHG Emissions in Minnesota: 1970-200870**

Recent state GHG reduction goals, energy efficiency targets and renewable portfolio standards will likely shape future GHG emissions in Minnesota. Minnesota is one of many states that have voluntarily joined The Climate Registry, committing to consistent and systematic monitoring of GHG emissions from state-owned properties and participating agencies. In 2007, Minnesota Governor Tim Pawlenty signed into law legislation that set a renewable energy requirement in Minnesota of 25 percent renewable generation by the year 2025. Additional 2007 legislation (Minnesota's Next Generation Energy Act) also initiates measures addressing global warming and energy efficiency. The Next Generation Energy Act sets new renewable portfolio standards for major electricity generators in the state, establishes new standards for ethanol fuel availability, sets statewide energy efficiency goals and sets per capita and total emission reduction goals for the state[71].According to the most recent data collected on Minnesota's GHG

[70] According to MPCA: "Electric utility and transportation sectors are the primary sources of the long-term increase in greenhouse emissions in Minnesota. In 1960, these two sectors accounted for about 40 percent of all emissions from the state. By 1997, their contribution had risen to 60 percent. Increased use of electricity in homes, businesses and industry is largely responsible for the increase in emissions from the utility sector. Emissions from residences, businesses and industries that produce their own energy have remained relatively flat".

[71] Minnesota Session Laws. 2007, Regular Session. CHAPTER 136--S.F.No. 145

emissions, the MPCA has reduced GHG emissions reported to The Climate Registry in 2010 by 10% from its 2008 baseline[72].

#### 2.1.2.5 Uncertainty in Climate Change Projection

While climate scientists have evidence to draw conclusions about certain aspects of climate change with confidence, other areas, particularly specific climate projections at the regional and local scales are less certain. At this point, scientific debate tends to center around the magnitude and spatial and temporal specifics of climate change projections with agreement among scientists regarding the causes of climate change and "virtual certainty" regarding a global warming trend[73].

According to the Intergovernmental Panel on Climate Change (IPCC), evidence has lead scientist to conclude with 99% certainty that human activities, particularly the burning of fossil fuels, have resulted in increases in the concentrations of GHGs in the Earth's atmosphere since preindustrial times. Similarly, scientists can conclude that because the major GHGs emitted by humans are known to have atmospheric residence times on the order of tens to hundreds of years, atmospheric GHG levels will continue to rise over the next few decades. The body of evidence has lead scientist to conclude with 99% certainty that higher levels of atmospheric GHG tend to warm the planet. Globally, an "unequivocal" warming of 1.0 to 1.7 °F occurred over the period 1905-2005. Warming is observed over the world's oceans and in both the Northern and the Southern hemispheres[74].

In the Fourth Assessment Report of the IPCC an international panel of more than 600 scientists concluded that "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations". The body of evidence from a growing number of scientific studies strongly suggests but cannot indisputably prove that rising levels of anthropogenic GHGs are contributing to climate change. The IPCC defines "very likely" as a greater than 90% chance the result is true. Scientists anticipate that if atmospheric concentrations of GHGs continue to rise, average global temperatures will also continue to rise and precipitation patterns will change.

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[72] Minnesota Department of Commerce and Minnesota Pollution Control Agency, January 2012. Annual Legislative Proposal Report on Greenhouse Gas Emission Reductions to the Minnesota Legislature. (available at: http://www.pca.state.mn.us/index.php/view-document.html?gid=17143)

[73] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].

[74] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].

Important uncertainties remain regarding the magnitude, extent and timeframe of warming. The response of other climate processes including precipitation patterns and storms is also very uncertain. Uncertainty in climate sensitivity and in future natural and anthropogenic forcing results in a broad range of projected climate outcomes. Shortcomings in the ability of models to match certain aspects of the climate system also make climate projections uncertain. As the network of observations, methods for analyzing these observations and techniques for using improved observations to inform climate models have all improved, climate scientists have been able to decrease uncertainty in some areas. In some areas more observations and better models are needed in order to improve confidence in model projections. Improvements are needed in understanding of natural climatic variations, changes in the sun's energy, land-use changes, the warming or cooling effects of pollutant aerosols, and the impacts of changing humidity and cloud cover. Determining the relative contribution to climate change of human activities and natural causes, narrowing the range of projected future greenhouse emissions and climate system responses and improving understanding of rapid or abrupt climate responses will likely also be essential components of improved climate projections.

#### 2.1.2.6 Projected Environmental Effects of Climate Change in Minnesota

Climate change poses risks to Minnesota's current environment as Minnesota is situated in a unique location that makes it particularly vulnerable to the potential effects of climate change. Minnesota's diverse ecosystems encompass three major biomes (prairie, deciduous forest, and northern coniferous forest), and one biome with a relatively smaller spatial extent in Minnesota (Tallgrass Aspen Parkland). The boundaries between these biomes can change abruptly in response to even slightly different climactic conditions. Areas in Minnesota that support the different ecosystems sometimes differ by no more than four degrees (F) in temperature and six inches in precipitation.[75] These boundary areas function as transition zones between two different biomes and are thus more susceptible to changes induced by climate change. Minnesota's position in the northern latitudes also increases its vulnerability, because these areas have seen the greatest seasonal change over the past two decades.[76]

Throughout its geological history, Minnesota has undergone significant climactic changes, and evidence suggests a different and gradually changing landscape over the past 10,000 years. When glaciers still covered part of Minnesota spruce trees were abundant. As the glaciers retreated, these trees were replaced

[75] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)
[76] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)

with pines and oak trees. As summers became warmer, between 8,000 and 5,000 years ago prairie plants appeared in western Minnesota. Slight fluctuations in temperatures throughout the pollen record indicate a shifting back and forth of the prairie-forest border.[77]

At present, the most effective tools for climate change projection are Global Circulation Models (GCM) that effectively simulate the dynamics of the Earth's oceans, atmosphere and climate systems. When forced with similar future scenarios of natural and anthropogenic influences, many GCMs project similar climate change outcomes on a global scale. Climate projections on the regional and local scale are less consistent due to the imprecision involved in extrapolating from global to regional and local scales and the increase in model-simulated variability at these smaller scales[78]. The range of potential future anthropogenic forcing on the climate system adds an additional layer of uncertainty to climate model projections.

In 2004 a landmark study investigating climate trends and future climate changes in the Great Lakes Region was conducted using two widely accepted GCMs forced with a range of potential anthropogenic forcing futures[79]. This GCM output was then downscaled to a region and local level. They typical resolution of a GCM is on the order of 150 kilometers by 150 kilometers. This resolution limits precision and introduces new sources of uncertainty beyond those already present in the GCM output. Therefore, conclusions drawn from this work should be taken in a context of uncertainty. The study projects increasing average annual temperatures throughout the 21st century with some variation across the region and substantial variation by season. Modeled temperature projections from the study for the Midwest region during the summer and winter seasons are shown in Figure 13. The study projects more rapid increases in spring and summer temperatures, with summer temperatures likely exceeding current averages by 3-4 °F within the next 20 to 30 years. "Clear" increases in fall and winter temperatures are

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[77] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)

[78] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].

[79] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America. (http://ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf) relies on the results of the U.S. Department of Energy/U.S. National Center for Atmospheric Research GCM (Parallel Climate Model (PCM)) and the HadCM3 model developed by the U.S. Meteorological Office's Hadley Centre for Climate Modeling. When compared to the full range of current climate models the sensitivity (degree of warming projected in response to increases in atmospheric greenhouse gases) of the HadCM3 is moderate and the PCM's sensitivity is low) Anthropogenic forcing futures used in the model simulations span the range of business as usual projections detailed in the IPCC Special Report on Emission Scenarios (see footnote 62), thereby considering scenarios of high emissions associated with rapid economic growth and continued dependence on fossil fuels as well as lower emissions associated with a move toward more efficient technologies and sustainable economies.

apparent in model projections by the middle of the 21st century. Model results show potential winter temperature increases relative to current averages ranging from 6-14°F (averaged over the period 2070-2099) for the full range of emission scenarios evaluated. Summer temperatures show a broader range of potential temperature increases with average increases (2070-2099) in the range of 5-16 °F for the full range of emission scenarios evaluated. Fall and spring temperatures are projected to warm less than winter and summer temperatures.

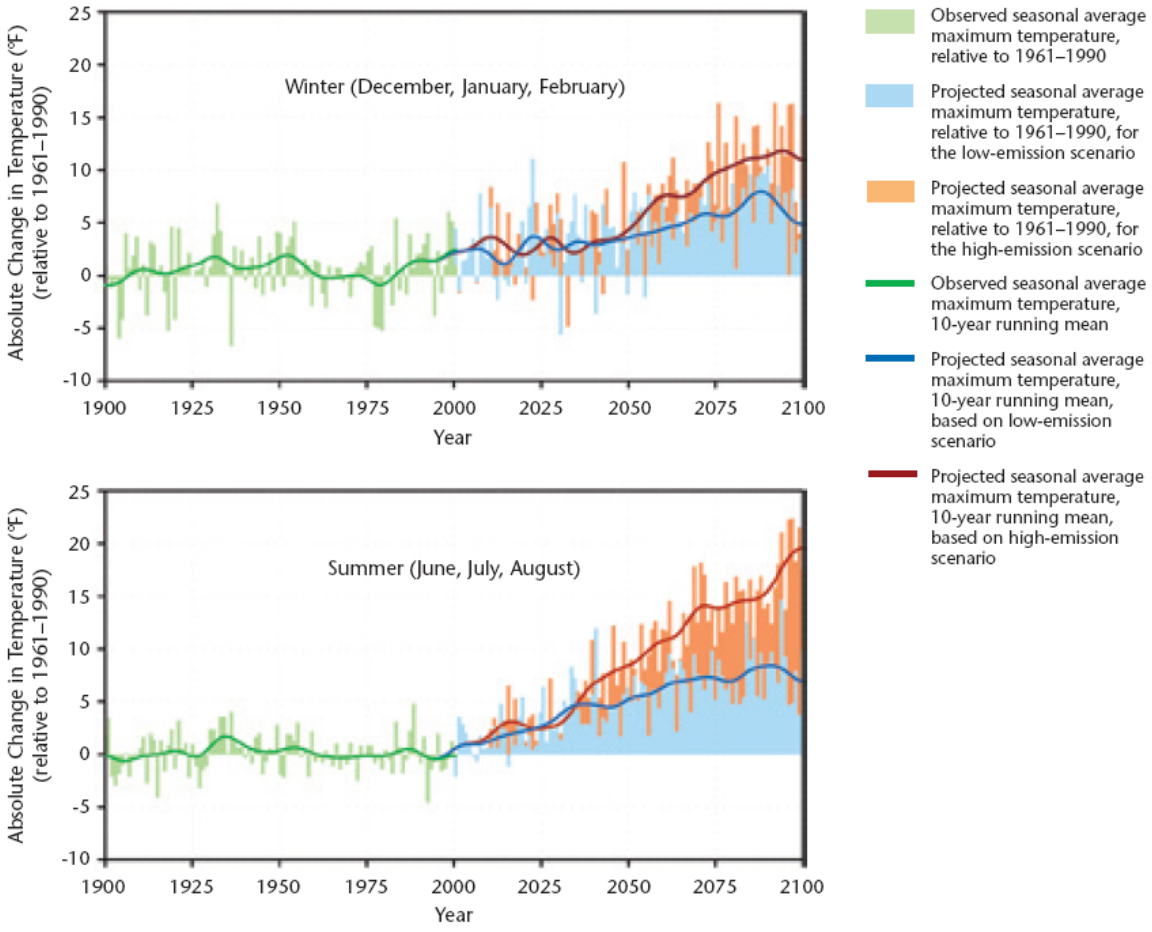



**Figure 13 Great Lakes Region observed and projected average surface temperature[80]**

Variation in temperature increases is likely to be observed across the region with areas centered near the great lakes showing smaller temperature increases (Figure 14). Summer warming is likely to most strongly impact the southwestern portions of the region including Southern Minnesota. Winter warming is will likely have the strongest impact on the region's northern latitudes.

[80] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America.

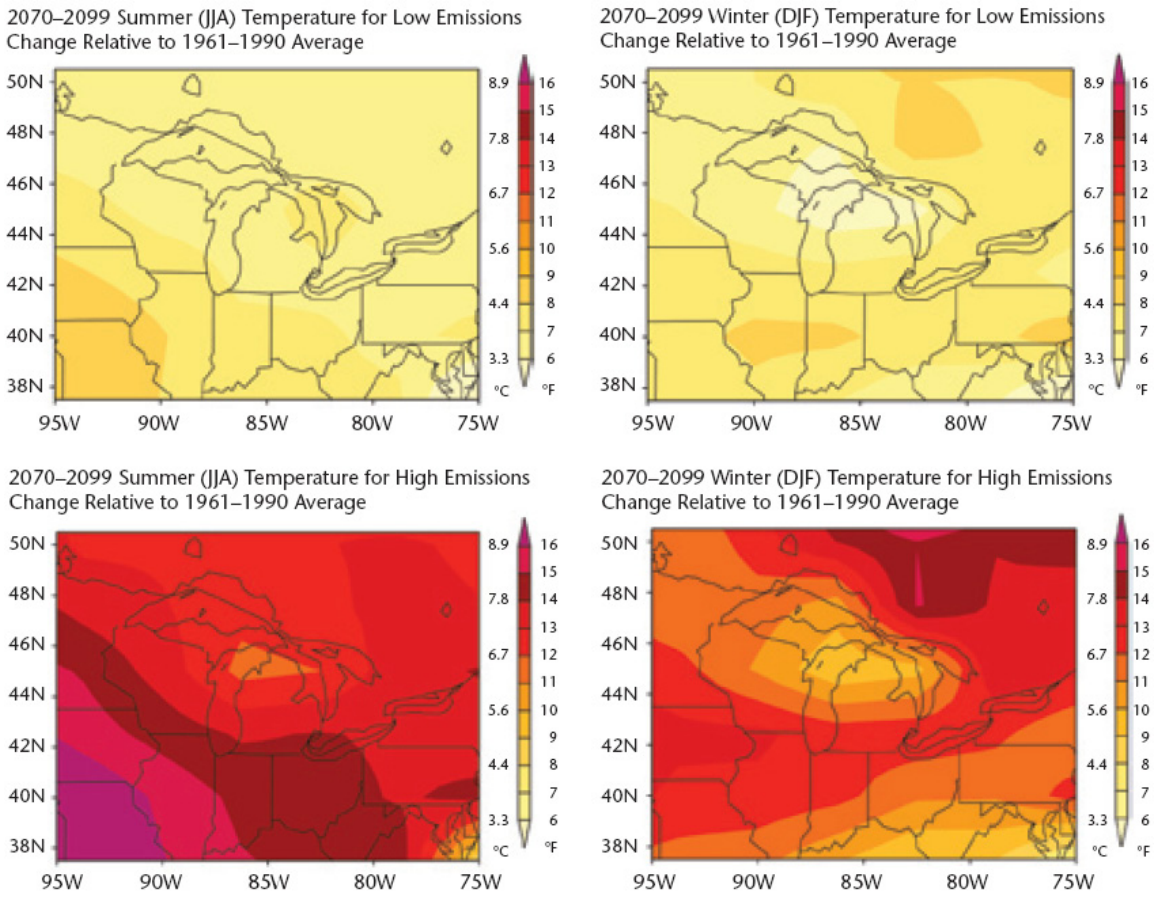



**Figure 14 Projected summer and winter temperature changes 2070-209981**

Models project that average annual surface temperature in Minnesota will increase 6 to 10°F in the winter and 7 to 16°F in the summer by the end of the 21st century relative to the 1961-1990 baseline depending on the range of future anthropogenic GHG emissions.[82] Heat waves that are more frequent, more severe, and longer lasting are projected[83]. With this increase in temperature combined with the precipitation changes described below throughout the state, a generally wetter and more humid climate is expected for the state at least in the short term. Predictions for the long term climate of Minnesota are less certain, and include the possibility of a drier or what is referred to as a Great Plains climate, much like that found in

[81] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America.
[82] Kling et. al., 2003. Minnesota Findings from Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America. (available at: http://ucsusa.org/assets/documents/global_warming/ucssummarymnfinal.pdf)
[83] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009

Nebraska or a warmer, humid climate like that of Ohio.[84] Climate and vegetation zones are predicted to shift northward about 60 miles for each 1.8°F increase in temperature, indicating the potential for a complete change in the composition of Minnesota's climate affecting vegetation and wildlife.[85]

#### *2.1.2.6.1 Precipitation*

Like regional temperature projections, model projections of future precipitation changes are uncertain, particularly at the regional and local scales. Most models results indicate that precipitation in the upper Midwest region is projected to increase over the course of the 21st century with some degree of seasonal variability[86].

Under both low and high future emission scenarios analyzed for the Great Lakes Region using GCMs, precipitation is projected to rise by 10-20% above current averages by the end of the century[87]. Model projections indicate that this increase in average precipitation may be accompanied by seasonal changes as well as changes in the frequency of 24 hour and multi-day heavy precipitation events. This pattern is expected to lead to more frequent flooding, increasing infrastructure damage, and impacts on human health. Overall, winters are projected to become wetter and summers are projected to become drier across the region[88]. Winter and spring precipitation is likely to increase, especially in higher latitudes and downwind or (of?) the great lakes. Summer precipitation may decrease by as much as 50%. Projected seasonal precipitation changes are shown in Figure 15[89].

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[84] Minnesota Pollution Control Agency, 2007. "Global Climate Change. Air Quality #1.13 May 2007.
[85] Minnesota Pollution Control Agency, 2007. "Global Climate Change. Air Quality #1.13 May 2007.
[86] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]. (Chapter 11)
[87] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America. see also footnote 133
[88] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009
[89] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America., see also footnote 133

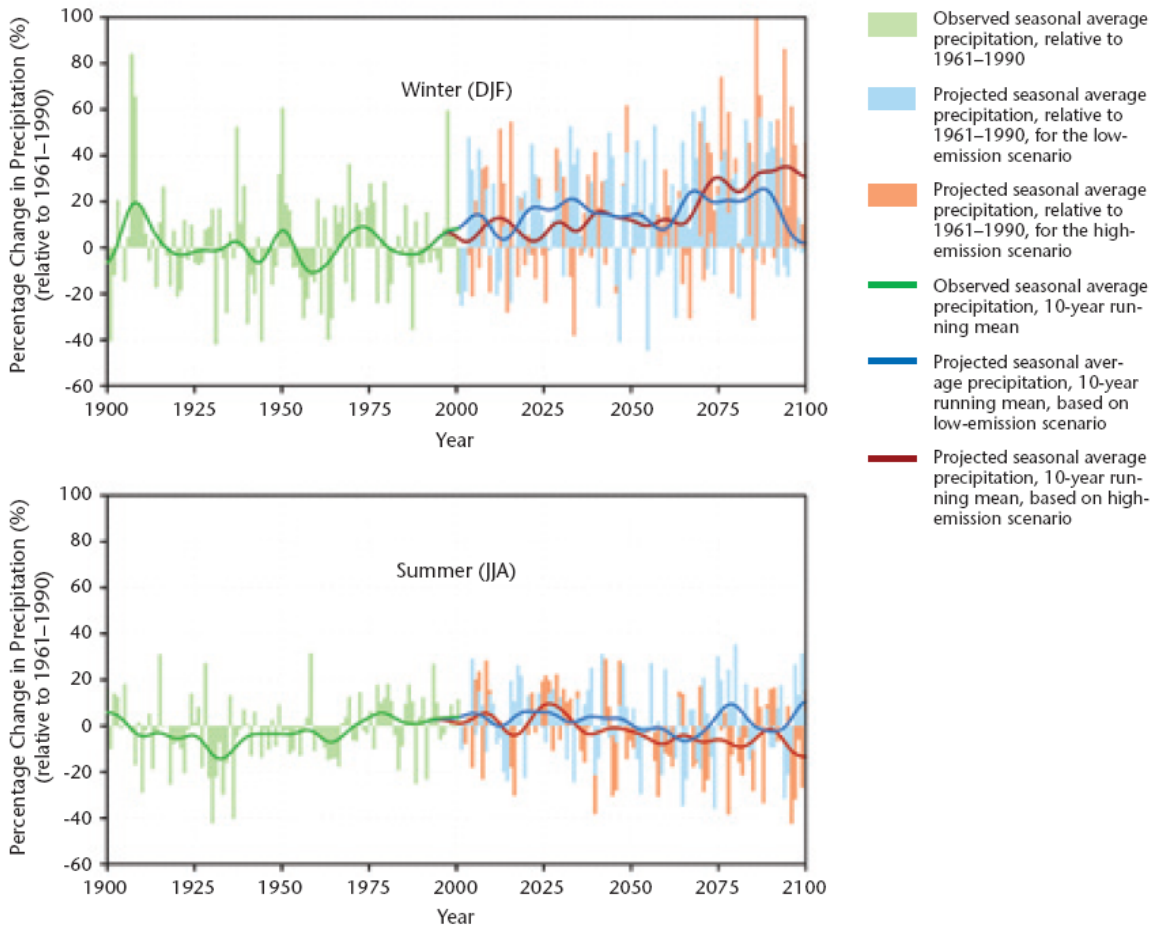



**Figure 15 Observed and projected daily average precipitation for summer and winter seasons in the Great Lakes Region[90]**

Winter, summer, and fall in Minnesota are expected to see an increase in precipitation of approximately 15% as climate change continues. Summer rainfalls of greater magnitude and frequency are projected to increase in keeping with this trend of general increase. Figure 16 shows projected changes in the frequency of heavy rainfall events for the Great Lakes Region[91]. It is possible that increased precipitation will also change patterns of severe weather events; however, these projected effects are uncertain.[92]

[90] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America.
[91] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America., see also footnote 133
[92] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America.

Some studies indicate that the magnitude of snowfall events and duration of snow may decrease in Minnesota as a consequence of climate change.[93]

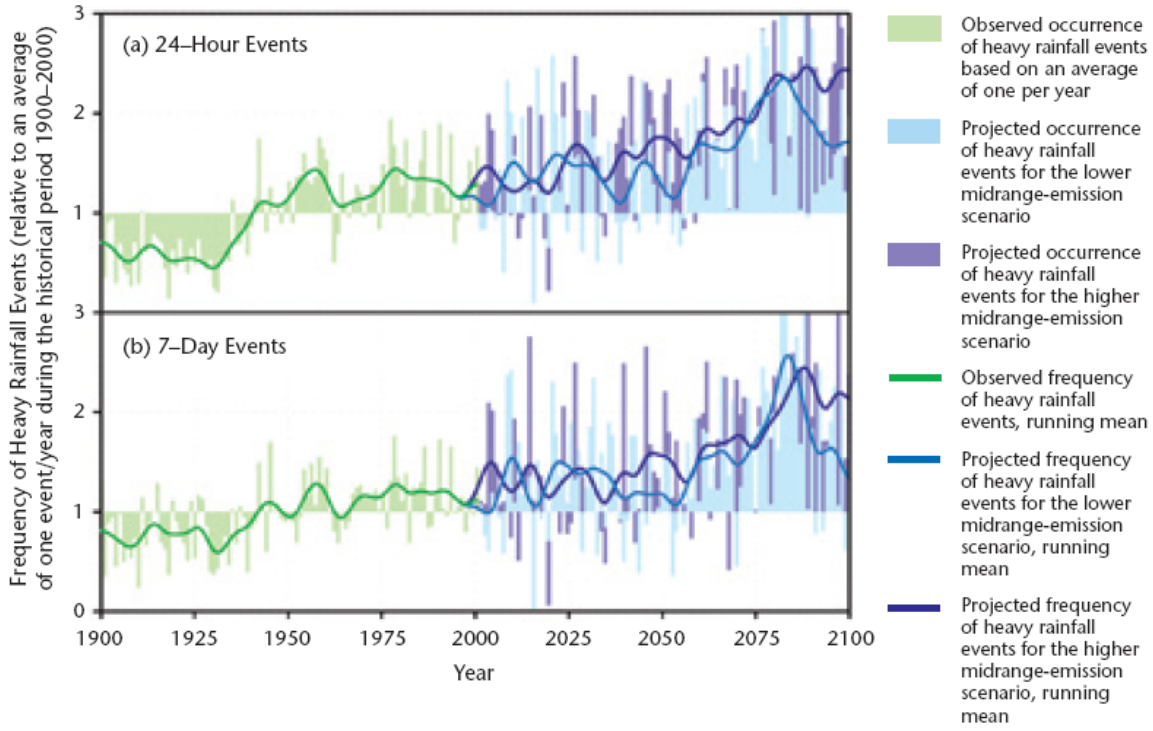



**Figure 16 Projected change in frequency of heavy rainfall events in the Great Lakes Region94**

#### *2.1.2.6.2 Water Resources*

Water resources are particularly sensitive to even slight changes in climatic conditions. As projected climate conditions in Minnesota are uncertain, the effect of this climate change on lakes and streams is also very uncertain

Increased carbon dioxide in the atmosphere can result in an increase in the amount of evaporation which is predicted to give way to significant decreases in lake, river, and stream levels of up to 12 inches[95]. Such decreases in surface water levels would likely place increased pressures on Minnesota's aquifers and other groundwater supplies. It is not clear whether increased precipitation would offset this loss, or

[93] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]. Chapter 11.
[94] Kling et. al., 2003. The study Confronting Climate Change in the Great Lakes Region. A report of the Union of Concerned Scientists and the Ecological Society of America.
[95] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)

whether moisture would be transported by the atmosphere, eventually falling as precipitation in other regions.[96] Shorter winters will result in decreased ice cover on lakes and streams and early ice breakup in the spring. Earlier ice-out may allow even higher levels of evapotranspiration, while earlier ice and snow melt may result in reduced summer flows.

Surface water temperatures may increase with increased air temperatures. Certain numerical modeling studies in which atmospheric carbon dioxide concentrations are doubled suggest a 3 to 4 °F increase in lake and stream temperatures[97]. However, a recent analysis of stream temperatures in the Pacific Continental United States indicates that western stream temperatures are not necessarily rising at the same rate as air temperatures. In fact, while some streams examined in the study show a warming trend, others showed a cooling trend, and still others showed no change at all. Snowmelt, interaction with groundwater, water flow and discharge rates, solar radiation, wind, and humidity have been identified as potential factors influencing these stream water temperature trends[98].

Warmer surface water temperatures, lower water levels and the side effects of increased evapotranspiration may have important implications for Minnesota's future water quality. While flood damage may be reduced by lower lake levels, shorelines may be more vulnerable to damage from erosion. Persistent high or low levels may reduce the diversity of plants and animals that live in, or depend on shoreline habitats. High water levels can result in flooding of near shore infrastructure[99]. Warmer and less oxygenated water may cause problems for aquatic ecosystems and lead to increased algal blooms. Reduced fresh water inflow into lakes, particularly Lake Superior, may threaten water quality.

#### *2.1.2.6.3 Forests*

Despite variation in projections of Minnesota's future environment under a regime of climate change, projections agree that forested areas of the state will undergo significant changes. The processes that typically accelerate these types of ecosystem changes such as fire and introduction of invasive species may be further exacerbated by climate change, and may catalyze changes initiated by climate change. If Minnesota's climate becomes much drier as it gets warmer, it is likely that forests will be replaced by

[96] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)
[97] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)
[98] 1.Ivan Arismendi, Sherri Johnson, Jason Dunham, Roy Haggerty, David Hockman-Wert. The paradox of cooling streams in a warming world: Regional climate trends do not parallel variable local trends in stream temperature in the Pacific continental United States. Geophysical Research Letters, 2012; DOI: 10.1029/2012GL051448
[99] J Wingfield, 2009. Lake Level Fluctuations: Causes and Implications. International Upper Great Lakes Study (IUGLS) Fact Sheet No. 4.

prairie ecosystems.[100] In this scenario, Minnesota's forested area could decrease by 50 to 70% (Figure 17). Drought and heat may naturally create more wildfires, further reducing the extent of Minnesota's forests.

Other climate projections anticipate that Minnesota will become wetter and forests will undergo a transition from conifers to hardwood trees that are more adapted to the wet conditions.[101] Pine, birch, and maple forests will be replaced with forest comprised of oak, elm, and ash. The transition will be manifested in the short term as oak, elm and ash gradually integrate into maturing Minnesota forests, and will leave behind a more dense, but less diverse mix of vegetation in the long run.[102]

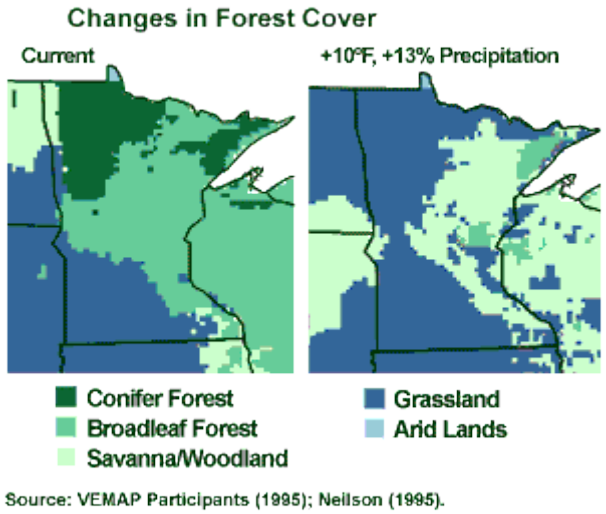



**Figure 17 Potential climate change impacts on Minnesota's forests**

#### *2.1.2.6.4 Other Ecosystems*

Aquatic ecosystems may be particularly vulnerable to climate change in Minnesota. Shifts in ecosystem diversity and dominant species types would likely result if there are changes in surface water temperatures. Coldwater species can be expected to decline as cool and warm water species expand their range into warmer Northern Minnesota waters. Warmer temperatures, leading to more extreme summer stratification, and lower oxygen levels may contribute an additional threat to Minnesota's aquatic ecosystems.

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[100] Minnesota Pollution Control Agency, 2003. Minnesota Climate Change Action Plan. (http://www.pca.state.mn.us/publications/reports/mnclimate-action-plan.pdf)
[101] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)
[102] Weflen, 2001. "The Crossroads of Climate Change". Minnesota Conservation Volunteer. Minnesota Department of Natural Resources (also available at http://www.dnr.state.mn.us/volunteer/janfeb01/warming.html)

Minnesota's wetland and bog ecosystems may also face challenges in a changing climate. Changes in precipitation, variations in the duration of wet and dry periods, and increases in the frequency of extreme precipitation may lead to changes in wetland type and distribution including wetland losses in some areas and wetland gains in other areas. Changing weather patterns may lead to higher levels of erosions and changes in flood pulses resulting in habitat disturbance and displacement of certain waterfowl, amphibians and other wetland fauna. Increased evaporation is also likely to result in accelerated $CO_2$ and methane release from wetland and peatland areas.

#### *2.1.2.6.5 Agriculture*

Changes in Minnesota's climate could have serious implications for agriculture in the state. Increasing temperatures and the resulting increased rates of evaporation decrease soil moisture and ultimately demand irrigation. This need for water may exacerbate the strain already placed on water supplies by warming, and lead to further deterioration of water quality.[103] Minnesota agriculture centers around corn, soybeans, and wheat. Projections indicate that wheat and soybeans could thrive in the warmer environment, and farm production may increase.[104] However, while the longer growing season provides the potential for increased crop yields, increases in heat waves, floods droughts, insects, and weeds will present increasing challenges to managing crops and livestock[105].

#### *2.1.2.6.6 Human Health*

Changes in Minnesota's climate and increased temperatures may cause increased likelihood of heat related illness and deaths. Warming temperatures also increase the likelihood of insect-borne illnesses, by creating more potential habitats for insects such as mosquitoes.[106] Another health-related issue arises from the fact that climate change can affect air quality. Warmer climate is projected in some studies to increase the natural emissions of VOCs, accelerate ozone formation, and increase the frequency and duration of stagnant air masses that allow pollution to accumulate, which will exacerbate health symptoms. If present-day levels of ozone-producing emissions are maintained, rising temperatures also imply declining air quality in urban areas such as those in California which already experience some of the worst air

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[103] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009

[104] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009

[105] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009

[106] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009

quality in the nation.[107]. In Addition, the last several years have witnessed an explosion in publication on the air quality impacts of climate change (see for example: http://pubs.acs.org/doi/abs/10.1021/es803650w, http://www.atmos-chem.phys.org/9/1111/2009/acp-9-1111-2009.html, http://www.atmos-chem-phys.net/8/871/2008/acp-8-871-2008.html, http://pubs.giss.nasa.gov/docs/2008/2008_Wu_etal_2.pdf, http://pubs.giss.nasa.gov/docs/2008/2008_Wu_etal_1.pdf, http://pubs.giss.nasa.gov/docs/2009/2009_Dawson_etal.pdf, http://pubs.giss.nasa.gov/docs/2008/2008_Dawson_etal.pdf, http://pubs.giss.nasa.gov/docs/2008/2008_Racherla_Adams.pdf, http://pubs.giss.nasa.gov/docs/2008/2008_Menon_etal_2.pdf, http://pubs.giss.nasa.gov/docs/2006/2006_Unger_etal_2.pdf, http://www.fypower.org/pdf/Stanford_CO2_Jacobson.pdf).

## 2.2. Proposed Project and Climate Change

The Project could have an effect on various resources near the Project site that may also be affected by climate change. This section includes a qualitative description of the Project's potential impacts on climate. The description is qualitative because there are no analytical or modeling tools to evaluate the incremental impact of the proposed Project's discrete GHG emissions on the global and regional climate. In addition, there are no analytical and modeling tools to evaluate any cascading impacts—that is, cumulative effects—from the proposed Project's GHG emissions on natural ecosystems and human economic systems in Minnesota or the Upper Midwest region.

This section assesses the interaction between climate change and the Project over the operating lifetime of the project, which is approximately 20 years. As noted earlier in the report, while subject to notable uncertainties, models projections suggest that the temperature may increase by 3 – 4 degrees F during the lifetime of the Project (including 20 year operating life and 60 year closure period). Models for precipitation indicate that precipitation may increase 10 – 20 percent by the end of the century, generally in the winter. As discussed in Section 2.1.2, model predictions at the spatial and temporal resolution relevant to the Project are subject to a great deal of uncertainty and the discussion below should be considered in the context of this uncertainty.

[107] US GCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009

Details regarding the GHG emissions for the Project are discussed in Section 3.1 and in Appendix A. Based on this information, the Project is estimated to emit a total of 697,342 metric tons of $CO_2$-equivalent emissions per year, including both direct and indirect emissions. These emissions estimates reflect several measures already incorporated into the facility design to reduce GHG emissions. Estimated emissions from the Project will constitute 0.0014 percent of the total annual global GHG emissions estimated in 2004.[108] There may be additional emissions and lost sequestration capacity due to ground cover disturbance. An estimate of these effects is provided in Section 3.1.2 of this report.

Given the limitations of climate models in addressing the impacts of GHG emissions at the Project level on global, national, regional, and local climate, the impacts of Project GHG emissions cannot be accurately or meaningfully estimated. Project emissions represent a very small fraction of annual global GHG emissions. At present, projections of climate change impacts typically rely on Global Circulation Models (GCM) that attempt to simulate the dynamics of the earth's oceans, atmosphere, and climate systems. When forced with similar future scenarios of natural and anthropogenic influences, many of the GCMs can generate consistent projections of climate change at the global scale with global scale anthropogenic forcing. However, climate projections on the regional and local scale are less consistent because of the imprecision involved in extrapolating from global to regional and local scales, as well as the increase in model-simulated variability at these smaller scales.[109] The broad range of potential future global scale anthropogenic emission scenarios adds another layer of uncertainty to climate model projections. When compared to the internal variability in the suite of models used to project climate change impacts, the uncertainties associated with future forcing scenarios, and the limitations in model spatial and temporal resolution, Project emissions are not significant enough to allow a meaningful analysis of Project-related climate change impacts on a given environmental receptor.

Because there are no models to predict the exact impacts of GHG emissions from the Project, the following section provides a qualitative assessment of how the Project may affect the climate and how changes in climate may affect the Project. In addition to the information presented in this report, the potential effects of climate change on water quality modeling will be assessed as described in the Water Modeling Data Package Volume 1 – Mine Site, Section 5.9, and the Water Modeling Data Package

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[108] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]
[109] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)]. Chapter 11.

Volume 2 – Plant site, Section 5.8. Beyond this, the affects of climate change are not currently being considered in any other Project impact analyses

### 2.2.1. Wetlands

The wetlands at the Project site are predominantly composed of coniferous bog, open bog, coniferous and hardwood swamp, and alder thicket wetlands. The impact climate change will have on wetlands in and near the Project site is uncertain. Climate changes that could affect wetlands include changes in precipitation along with changes in temperature. Precipitation is projected to increase with the increase in temperature across the state and there could be the potential for increased frequency and magnitude of rainfalls. In addition, warmer temperatures could lead to increased evapotranspiration.

It is possible that an increase in precipitation and more frequent and stronger storms combined with increased evapotranspiration could cause greater fluctuations in the water levels in the wetlands. The effects could be evident both seasonally and immediately after large storm events. Forested, bog, and shrub wetlands could see a larger increase in evapotranspiration than other wetland types. However, increased evapotranspiration could be offset by increased precipitation with minimal change in water level fluctuation. Furthermore, the coniferous bog and swamp environments that are prevalent near the Project site may be comparatively resilient to changing climates, as the forest canopy and a thick layer of sphagnum moss may act as a buffer against changes in temperature and evapotranspiration. In open water wetlands, fluctuations of water levels could change the competitive balance among the plants and invertebrates found in some wetland types. The majority of the wetlands present at the Project site, however, are associated with saturated soils and limited inundation. Invertebrates are generally less abundant in saturated wetlands than within wetlands containing standing water. Given the relatively limited presence of invertebrates and the buffer provided by the coniferous forest canopy and protective layer of sphagnum moss, it is unlikely that there would be a significant effect on invertebrates.

The increasing water temperature could impact wetland vegetation at the site. However, if coniferous forest continues to dominate the site, the shading of the forest canopy may minimize the potential for increased water temperatures. Over the period covered by the Project, it is difficult to determine what, if any, changes in species may occur. The only species that would likely have time to replace existing native northern species during the period of the Project would be invasive species. These species spread quickly under favorable conditions, both naturally and with the help of humans carrying seed from other places. Invasive species could potentially out-compete the natives and lead to a decrease in biodiversity over the lifetime of the Project.

The most current and accurate estimates of total wetland impacts expected to result from the Project are discussed in the NorthMet Project Wetland Data Package. Certain potential Project activities and influences on wetlands could be additive or even offset by climate change. Partial drainage of wetlands could be offset by increased precipitation or balanced by a potential increase in evapotranspiration. This balance, however, is dependent upon the climate change impacts on water availability, as increases in evapotranspiration are dependent upon water availability. In addition, climate change impacts on species diversity and invasive species could be accentuated by Project activities that result in wetland fragmentation. Fragmentation increases total wetland perimeter area and may enhance the potential for invasive species introduction.

GHG emissions due to the direct removal of organic matter from peatlands, and the reduction of carbon sequestration capacity due to the direct or indirect disturbance of wetland plant communities are assessed quantitatively in Section 3.1.2 as part of the overall carbon cycle impacts.

### 2.2.2. Water Resources

Potential regional climate changes may have an effect on the degree or type of impact from the Project on local and regional water resources, including the Partridge River, Colby Lake, and the Embarrass River. Potential climate changes predicted for the region include increased summer and winter air temperatures, increased average annual precipitation, changes in the frequency and intensity of storm events, decreased snow and ice cover, increased surface water temperatures, greater potential for flooding and erosion, increased evaporation, and reduction in coniferous forest. Currently available climate change models are unable to accurately quantify the effects of these changes on water resources at the spatial and temporal scales that are relevant to the Project. In the absence of the appropriate information to characterize the actual impacts on water resources driven by climate change, a preliminary qualitative assessment is provided below.

Increased air temperatures may result in wetter winters and either wetter or drier summers. Warmer temperatures in winter may reduce the duration of winter low flows in the Partridge or Embarrass Rivers, increase winter flows from additional melting, and reduce the magnitude and timing of spring snowmelt events. Higher winter flows would be less affected by chemical loads that might leak from stockpile liners or overflow from flooded mine pits, resulting in lower chemical concentrations than predicted in watercourses and water bodies during periods of critically low flows. Drier summers may increase the frequency of critically low flows in the summer months. Increased water temperatures could affect mercury methylation, although temperature is only one of several factors; fluctuations in the water table resulting from increased precipitation and evaporation may also affect mercury methylation.

Changes in precipitation could have multiple and potentially offsetting effects on regional hydrology and Project impacts. An increase in average annual precipitation would result in greater dilution of water chemistry effects on the Partridge River, Embarrass River, and Colby Lake. Conversely, average liner yields and liner leakage from stockpiles could increase. Greater average precipitation would accelerate the filling and improve the water quality of the West Pit. Hydrologic impacts may include higher average water levels in Colby Lake and reduced water level fluctuations in Whitewater Reservoir, as a higher level in Colby Lake will require less frequent pumping between Colby Lake and Whitewater Reservoir. The morphology of the upper reaches of the Partridge River may not be affected by increased streamflow; that section of the Partridge River has experienced high flows from past dewatering at the Northshore Mining facility. Increased average precipitation may also change the hydrologic regime of wetlands in and around the Mine Site, although this may be offset by increased evaporation.

Wetter summers (i.e., increased total precipitation, larger rainfall events) may have multiple impacts on water resources in Northern Minnesota. Larger rainfall events would likely produce more runoff from individual precipitation events (more precipitation in excess of interception and infiltration capacity). Higher event runoff could lead to higher peak streamflows, or at least higher high flows (peak flows in the Partridge River are periodically associated with snowmelt, as opposed to storm events). Greater cumulative precipitation or increased frequency of storms would likely lead to higher average streamflows. Extreme low flows typically occur in winter months, so impacts may be less apparent. More frequent/greater summer precipitation could lead to increased soil moisture, resulting in higher evapotranspiration and possibly increased groundwater recharge, ultimately observed as higher summer baseflow in streams. With respect to Project impacts, wetter summers could result in greater annual water storage in the West Pit and therefore higher discharge flows after the wild rice sensitive period. This could increase the geomorphic impacts of the Project on the receiving water bodies.

Increased frequency and magnitude of precipitation may result in potential overflows of process water systems to off-site waterbodies. Increased potential for greater head on stockpile liners from increased precipitation may also result in an increase in liner yield and leakage. Additional storm runoff could require additional capacity for wastewater treatment, larger culverts, ditches, sedimentation ponds, and process water sumps. Larger process water sumps and pond sizes could result in additional leakage to groundwater. Larger storm events may increase the risk of flood water entering the pits, requiring a shutdown of operations until flood waters are removed from work areas.

Climate change may include increased evaporation due to higher temperatures caused indirectly by additional carbon dioxide in the atmosphere. Greater evaporation may require additional modification of

the Flotation Tailings Basin interior to maintain a pond in closure. In addition, the East and West Pits may take longer to flood. A decrease in the amount of liner yields may occur because of increased evaporation from the stockpile surfaces (both active and reclaimed), resulting in decreased liner leakage rates to groundwater. Other impacts could include changes in soil moisture, which may affect water chemistry of seepage at the Flotation Tailings Basin.

The Project site is located at the boundary of deciduous and coniferous forest ecosystems. The boundaries between these biomes can change abruptly in response to climatic factors. Climate change resulting in the transition of coniferous forests to deciduous forest or drier, prairie ecosystems may affect the success of coniferous reclamation cover of the Category 1 Waste Rock Stockpile.

### 2.2.3. Air Quality

A wetter and warmer climate and increased variability in weather patterns that may result from GHG induced climate change could potentially change the air quality impacts from the Project.

With a wetter and warmer climate the relative humidity could be higher, which could affect visibility directly as well as contribute to visibility impacts from enhanced secondary sulfate and nitrate formation. Visibility impairment in Minnesota's federal Class I areas (Voyageurs National Park and the Boundary Waters Canoe Area Wilderness) is greatly affected by sulfate and nitrate particles in the atmosphere. These particles are created when sulfur dioxide and nitrogen oxides react in the atmosphere to form ammonium sulfate and ammonium nitrate. $NO_x$ will be emitted by combustion sources associated with the Project, including space heaters and mining vehicles. Sulfur dioxide will only be emitted in small amounts because of PolyMet's choice of processing technology and fuels. The sulfate and nitrate particles readily absorb water and grow rapidly. They grow to a size that is "disproportionately responsible for visibility impairment as compared with other particles that do not uptake water molecules."[110]

Changes or increased variability in weather patterns could potentially result in a different dispersion pattern of pollutants emitted from the Project. Different pollution dispersion patterns could affect the location and magnitude of ambient air quality impacts from criteria pollutants and the modeled visibility impacts. These changes could either increase or decrease the visibility impacts of the project on Class I areas. At this time there is no information available to predict possible changes in local wind patterns, so there is no method for predicting potential changes to visibility impacts.

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[110] Malm, William C. 1999. Introduction to Visibility. Prepared for the Cooperative Institute for Research in the Atmosphere.

Fugitive emissions from mining activities can affect local (Class II) modeled ambient air concentrations. Wetter conditions may lead to reductions in Project fugitive dust emissions and a reduction in impacts at the Project boundary.

The effect of any potential future changes in climate on the wet deposition of sulfates and nitrates in the Project area is uncertain. Wet deposition is influenced by precipitation amount and frequency (i.e., how often the material is washed out of the atmosphere), and the amount of $SO_2$ and $NO_x$ (precursors to sulfate and nitrate aerosol, respectively) emitted to the atmosphere. As described earlier in this report, current predictions are that Minnesota's climate will become warmer and wetter. If the atmospheric concentration of sulfate and nitrate aerosols declines, at higher precipitation rates the amount of wet deposition that occurs in Minnesota will decline and if (at higher precipitation rate) the concentration of sulfate and nitrate aerosols increases, deposition will increase.

Monitoring data available from the NADP indicate that sulfate and nitrate wet deposition have declined in Minnesota. Sulfate wet deposition has declined since the mid-1980s. Declines in nitrate wet deposition are more recent, occurring since the late 1990s.[111] Based on foreseeable future regulations of $SO_2$ and $NO_x$ emissions at the state and federal level, it is unlikely that wet sulfate and nitrate deposition would increase significantly in the future. In the absence of changes in precipitation amount or frequency, the most likely future scenario is that deposition stays the same, with a possible slight reduction.

The actual buffering capacity of Minnesota's ecosystems should also be considered in assessing potential future impacts. As reported by Eilers and Bernert[112] (1997), most lake systems in Minnesota have more buffering capacity against acid deposition than previously thought. Minnesota's lake systems are well-buffered against current and foreseeable levels of acid deposition[113]. It is likely that the inherent buffering capacity of Minnesota's ecosystems would help protect any future increases in acid deposition from climate change. The probability of which deposition scenario will actually occur is not known.

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[111] Barr Engineering. 2009. *Cumulative Impacts Analysis - Minnesota Iron Range Industrial Development Projects - Assessment of Potential Ecosystem Acidification Cumulative Impacts in Northeast Minnesota*. Prepared for U. S. Steel

[112] Eilers, J.M. and J.A. Bernert. 1997. *Temporal trends and spatial patterns in acid-base chemistry for selected Minnesota lakes.* Report to the Minnesota Pollution Control Agency.

[113] Eilers and Bernert (1997) citation (Item 1. P. ix). On P.87 of Eilers and Bernert: "The high concentrations of base cations and organic anions provides considerable buffering and neutralization capacity (Appendix F). Only under the most extreme conditions would it be possible to acidify any of these lakes from atmospheric sources." Note, in Eilers and Bernert and the NADP Monitoring data, sulfate and nitrate deposition were/are identified to be declining. Therefore, the "foreseeable levels of acid deposition" are expected to be lower than current levels, which are notably lower than in the early 1980s. Given that lakes are not showing effects from past deposition that was higher and current deposition, they should not see effects in the future with lower deposition of sulfate and nitrate.

When compared with similar metal mineral processing facilities, the emissions of $NO_x$ and $SO_2$ from Project operations are estimated to be low. This is because the hydrometallurgical process proposed for the Project does not require supplemental fuel during normal operation and sulfur in the concentrate is leached out as acid in the autoclave before being precipitated in a stable form (gypsum) as opposed to being released to the air. Fuel is only used in stationary sources during startup of the autoclaves and for ancillary purposes, such as heating and backup power. Diesel fuel will also be used to power the haul trucks and some of the other large mining vehicles. The end result is that fuel usage will be lower for the Project than for metallic mineral processing facilities using techniques that require supplemental fuel combustion. Based on fuel use and an assessment of ecosystem acidification performed using current meteorological data, the Project is expected to have minimal contribution to ecosystem acidification with or without potential changes in climate.

### 2.2.4. Threatened, Endangered, and Special Concern Wildlife and Plants

Threatened and special concern wildlife, as well as their habitat and Minnesota listed plants, could potentially be impacted by climate change. However, it is not clear that any changes would occur over the 20 year lifetime of the Project.

The three wildlife species of interest for the Project are the gray wolf, Canada lynx, and bald eagle. The gray wolf and the bald eagle have a large range that covers many climate zones and are unlikely to be affected from an increase in temperature over the lifetime of the Project. Within the study area, local populations of Bald Eagles may or may not be affected, depending on changes in fish habitat. For the Canada lynx, northern Minnesota is the most southerly part of its range. Lynx critical habitat is primarily boreal forest. If climate change causes northward migration of the southern extent of boreal forest, lynx may migrate north as well and the numbers of lynx in Minnesota may decline. However, it is not clear that the temperature could change enough over the course of the next 20 years to cause this change.

No federal threatened or endangered plants were found onsite during the botanical survey performed for the proposed project. However, several Minnesota listed species were found, including Sparganium glomeratum, Botrychium pallidum, Botrychium rugulosum, Eleocharis nitida, Caltha natans, and Botrychium ascendens. It is impossible to determine exactly what will happen to any given species as a result of climate change. Given that northern Minnesota is at the southern end of the range for the Sparganium glomeratum, it is possible that this plant could be affected by a warmer, wetter climate.

The Iron Range represents most, or a significant portion of, the ranges of several of listed plant species in Minnesota, including B. ascendens, B. pallidum, and B. rugulosum. Outside of Minnesota, the species

ranges are generally at higher latitudes and altitudes (B. ascendens and B. pallidum) or are found throughout the Great Lakes region (B. rugulosum). In many cases, the species occur in the Iron Range in early successional habitats resulting from mine disturbance and reclamation. The Iron Range likely presents a combination of habitat types, disturbance regimes, and climate that are conducive to these species. The distributional ranges suggest that climate change may reduce the abundance of these species in the state by altering biotic and abiotic factors to create more southerly conditions. In general, plant species closely associated with boreal forest communities could potentially see their southern range limit migrate northward with climate change. In general, the three species of Botrychium found on the site prefer mesic to dry areas, not wet areas. If climate changes cause the habitat to become wetter, the change could drive the Botrychium from its current locations. However, areas that are currently too dry to sustain the Botrychium could become hospitable, provided that other factors do not overwhelm the influence of added moisture.

### 2.2.5. Cover Types and Carbon Cycle Impacts

The Project will result in impacts to wetlands, forests, and other cover types that will affect carbon storage and sequestration in these ecosystems. However, reclamation and mitigation activities associated with the Project will offset carbon losses caused by Project activities. The magnitude of potential offset depends on many factors, including the types of impacted and restored cover types that are involved and the timescales over which restoration and re-sequestration occur. Given the uncertainty in sequestration capacities and rates in the particular ecosystems that the Project will affect and the lack of appropriate carbon storage and sequestration models, the net effect of Project activities and reclamation/mitigation activities on terrestrial carbon cycle processes is difficult to assess with precision. However, a quantitative assessment of potential terrestrial carbon cycle impacts from the direct or indirect disturbance of ground cover plant communities is provided in Section 3.1.2. An evaluation of the effect of the reclamation effort on the terrestrial carbon cycle is provided in Section 3.1.3.

#### 2.2.5.1 Background

A February 2008 report to the MDNR detailing research conducted at the University of Minnesota indicates that the state's wetland and forest resources are significant reservoirs of sequestered carbon.

Peatlands (including bogs, fens, marshes, and other wetlands) represent the single largest terrestrial carbon stock in the state of Minnesota. The University of Minnesota research summarized in the February 2008 report demonstrates that the 5.73 million acres of existing organic soils in "peatlands" in Minnesota contain an estimated 4,250 million metric tons of carbon (Anderson et al, 2008). This is the equivalent of approximately 745 metric tons of stored carbon per acre, based on the MDNR peatland

inventory, the U.S. Department of Agriculture National Resources Conservation Service State Soil Geographic database and National Soil Information System database and, 1990 Land Management Information Center land cover data. By comparison, the University of Minnesota research estimates that in 2006, Minnesota's 16.21 million acres of forest contained 1,650 million metric tons of carbon or approximately 99 metric tons of carbon per acre.

Undisturbed peatland areas contain large, thick deposits of organic materials that have accumulated over long periods in saturated conditions where decomposition is minimal. Drainage and disturbance of these wetland areas introduce the accumulated organic material to oxygen, which results in comparatively rapid decomposition and a rapid release of $CO_2$ to the atmosphere. Wetland restoration, on the other hand, has the potential to sequester carbon from the atmosphere. This sequestration process occurs much more slowly than the carbon release associated with wetland disturbance but may ultimately result in total carbon accumulation that is comparable to an undisturbed wetland of a similar type. Peatlands in Minnesota have been accumulating carbon for on the order of 5,000 years and peatlands can continue to accrue carbon for millennia. Because carbon accumulation in wetlands occurs gradually and over long periods, a restored wetland must be preserved over very long timescales to offset carbon released from disturbance.

Other recently published University of Minnesota studies indicate that under certain conditions, wetland restoration may provide one of the best terrestrial sequestration options in Minnesota (in areas with enough hydric soils) (Lennon and Nater, 2006). In many areas of Minnesota, particularly in the "Prairie Pothole Region" of western Minnesota, wetlands restoration reestablishes conditions close to what prevailed prior to disturbance. This can lead to decreased rates of organic matter oxidation and potential increases in carbon sequestration. For example, restoring local hydrology and natural vegetation in previously drained wetland areas in the Prairie Pothole Region can sequester approximately 4.53 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ (1.2 ±1.9 MT C $acre^{-1}$ $yr^{-1}$) in the upper 15 cm of soil[114]. Other wetland areas have a more modest potential for carbon sequestration ranging from 0.4 to 1.1 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ (0.1 to 0.3 MT C $acre^{-1}$ $yr^{-1}$).

However, while wetlands do sequester carbon in biomass, the anaerobic decomposition that occurs in wetlands and peatlands results in the release of carbon as methane. Current research indicates that, with a few exceptions (e.g., forested upland peat and coastal wetlands), wetlands with permanently pooled water

[114] Lennon and Nater, 2006. Biophysical Aspects of Terrestrial Carbon Sequestration in Minnesota. *Regents of the University of Minnesota.* Direct requests to the Water Resources Center, 612-624-9282.

probably result in small positive net forcing rates, based on the consideration of carbon equivalent fluxes of both $CO_2$ and $CH_4$.[115] Flooded soils can be ideal environments for $CH_4$ production because of their high levels of organic substrates, oxygen-depleted conditions, and moisture. The level of $CH_4$ emissions varies with soil conditions as well as climate. Some recent research has suggested that the opposite may be true: that in shallow lake systems, the balance between carbon withdrawals from the atmosphere (in the form of $CO_2$) and $CH_4$ emission may favor $CO_2$ withdrawal, implying a negative net forcing rate.[116] However, the applicability of this information to flooded wetland areas depends on the extent to which the shallow lake systems studied have carbon cycle dynamics similar to specific flooded wetland systems, an issue that is outside the scope of this report.

Fundamentally, the uncertainty surrounding wetlands' effects on the direction of the $CO_2$ and $CH_4$ fluxes, and the consequent net forcing, makes the long-term assessment of wetland degradation or removal highly uncertain from a climate change perspective. Despite this uncertainty, a quantitative analysis of the effect of wetlands impacts on the carbon cycle has been included in this report, ignoring the contribution of methane emission to net forcing as a conservative assumption.

As indicated in the February 2008 University of Minnesota study, undisturbed forest areas sequester large amounts of carbon in aboveground woody and leafy biomass as well as in below ground carbon stores. Forested areas accumulate carbon over comparatively short periods (an order of magnitude shorter than wetlands), with rapid accumulation in younger ecosystems that ultimately reaches a steady state as ecosystems reach maturity. Total accumulated carbon and sequestration rates depend on ecosystem type. In terms of total biomass production, red and white pine stands show the best carbon sequestration potential, with a steady and relatively rapid accumulation of carbon over a period of 90-120 years. Over these timescales afforested systems are effective at sequestering above-ground carbon in biomass,

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[115] IPCC fourth assessment, Report Ch. 4.4.6: "Decomposition under anaerobic conditions produces methane - a greenhouse gas. Wetlands are the largest natural source of methane to the atmosphere, emitting roughly 0.11 Gt $CH_4$ $yr^{-1}$ of the total of 0.50-0.54 Gt $CH_4$ $yr^{-1}$ (Fung et al., 1991). Using a Global Warming Potential (GWP) of 21 for $CH_4$, emissions of ~1.7 g $CH_4$ $m^{-2}$ $yr^{-1}$ will offset the CO2 sink equivalent to a 0.1 Mg C $ha^{-1}$ $yr^{-1}$ accumulation of organic matter. The range of $CH_4$ emissions from freshwater wetlands ranges from 7 to 40 g $CH_4$ $m^{-2}$ $yr^{-1}$; carbon accumulation rates range from small losses up to 0.35 t C $ha^{-1}$ $yr^{-1}$ storage (Gorham, 1995; Tolonen and Turunen, 1996; Bergkamp and Orlando, 1999). Most freshwater wetlands therefore are small net GHG sources to the atmosphere. Two exceptions are forested upland peats, which may actually consume small amounts of methane (Moosavi and Crill, 1997) and coastal wetlands, which do not produce significant amounts of methane (e.g., Magenheimer et al., 1996)."

[116] The information in the Kenning PhD defense abstract regarding whether the high productivity of shallow lakes enables them to be $CO_2$ and/or $CH_4$ sinks indicates that both phytoplankton- to macrophyte-rich shallow lakes are annual $CO_2$ sinks and $CH_4$ sources during the growing season. The thesis abstract also indicates that the shallow lakes studied "appear to result in a net overall reduction in greenhouse gas warming because their uptake of $CO_2$ is 571-2845 times faster than their release of methane, even considering that methane is 25 × stronger as a greenhouse gas."

exhibiting carbon sequestration rates as high as 7.65 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ in Minnesota. Carbon sequestration rates for hybrid poplar biomass production are large as well, ranging in Minnesota from 5.05 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ in low-productivity stands to over 6.83 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ in high-productivity stands. However, most hybrid poplar biomass production sites reach peak production after 7 to 10 years (Anderson et. al, 2008).

#### 2.2.5.2 Project Impacts on Cover Types

Project impacts on cover types at the Mine Site, Flotation Tailings Basin, Hydrometallurgical Residue Facility, and railroad/Dunka Road areas will range from removal of existing cover types to changes in existing land cover. The Mine Site consists almost entirely of native vegetation. The primary cover types at the Mine Site are mixed pine-hardwood forest on the uplands and black spruce swamp/bog in wetlands. Aspen, birch, jack pine, and mixed hardwoods comprise the remaining forest on the site. Impacts to vegetative cover types and species occur through clearing, filling, and other construction activities. Wetland impacts occur primarily through excavation, filling, and other activities that result in wetland loss or loss of wetland functions.

The most current and accurate estimates of total wetland impacts expected to result from the Project are discussed in the NorthMet Project Wetland Data Package. Wetland impacts are expected to occur primarily in the Mine Site area. Coniferous bog (Eggers and Reed Wetland Classification) is the most common type of wetland community that would be impacted. The majority of wetlands that will be impacted by the Project are given an overall wetland quality rating of "high" and are categorized as natural in origin. Carbon cycle impacts from wetland disturbances depend on a number of factors, including the amount of carbon stored in a given wetland environment, and the extent to which Project impacts will result in decreases in the rate of carbon sequestration in new biomass or even a release of stored carbon. Wetland carbon storage is known to vary by wetland type, because some wetland types are known to sequester carbon at much higher rates than others. Because wetlands tend to sequester carbon very slowly over long periods, the period over which a given wetland has been established and actively sequestering carbon also strongly impacts potential carbon releases. Appendix A has a breakdown of wetland carbon storage capacity and sequestration rates gathered from the current scientific literature.

There are a number of weaknesses in the current data surrounding wetland carbon storage capacity, sequestration rates, and emission rate upon disturbance. Studies detailing the carbon storage capacity of wetland types of a particular age are rare. The February 2008 University of Minnesota study, for example, lumps peatlands, bogs, fens, and marshlands of all ages together to arrive at an average carbon storage level of 745 metric tons of carbon per acre. The lack of specificity with regard to stand age, the length of

time the wetland has been accumulating carbon, and other site characteristics makes the quantitative assessment of the total carbon storage and potential GHG fluxes that are likely to be associated with these wetland impacts imprecise. The total carbon release and the rate at which it will be released depend on several factors. First, the rate of release is highly dependent on the properties of the organic material. Variations in the age and recalcitrance of accumulated organic material will strongly influence the rate at which the carbon in stored in these materials will be broken down and returned to the atmosphere. Second, the fate of the material can strongly influence the rate and extent of carbon release. Organic materials that are buried, minimally disturbed, and used in other wetland restoration activities or stockpiled will have a greater tendency to continue to sequester stored carbon from the atmosphere because the introduction of oxygen in these settings is limited.

Despite the high degree of uncertainty in parameters that define the wetland carbon cycle, estimates of the total above-ground wetland carbon stock assumed lost due to Project activities, the total carbon stored in excavated peat and annual carbon emissions from its stockpiling, potential carbon flux associated with the use of stockpiled peat in reclamation activities, the loss of or reduction in carbon sequestration capacity of wetlands, and the annual emissions from indirectly impacted wetlands due to lowered water levels were derived and are reported in Section 3.1.2. Further descriptions of the calculations used to derive these estimates can be found in Appendix A.

Total Project impacts on non-wetland cover types are expected to affect approximately 2,100 acres, including mixed forest, deciduous forest, grassland, and shrubland. Forest clearing and disturbance may result in the loss of carbon sequestered in belowground biomass, in aboveground leafy biomass, and in aboveground woody biomass. The timescale of carbon lost from forest biomass depends on the end use of this material. Clearing and burning will result in a relatively rapid release of carbon to the atmosphere whereas manufacture of long-lived forest products such as lumber will delay the release. Because carbon accumulation in forest and grassland ecosystems occurs relatively quickly, afforestation, reforestation, and grassland restoration may offset forest disturbance over relatively short timescales.

As in the wetlands case, estimates of the total above-ground forest carbon stock assumed lost to Project activities , and the loss of carbon sequestration capacity in upland forests were derived and are reported in Section 3.1.2. Further descriptions of the calculations used to derive these estimates can be found in Appendix A.

#### 2.2.5.3 Planned Restoration Activities

Compensatory mitigation will be undertaken for reasonably foreseeable impacts to wetlands. The primary goal of the planned wetland mitigation is to restore high quality wetland communities of the same type, quality, function, and value as those impacted by the Project. Given site limitations and technical feasibility, it is impracticable to replace all impacted wetland types with an equivalent area of in-kind wetlands. A more detailed discussion of the most recent and most accurate wetland mitigation plans can be found in the NorthMet Project Wetland Management Plan.

A qualitative comparison between total carbon released to the atmosphere as a result of Project wetland impacts and the total carbon that may be re-sequestered in mitigated wetland is not possible for two reasons.

First, the ability of restored wetlands to offset potential carbon cycle effects caused by Project wetland impacts depends on a variety of factors including the similarity of impacted and restored wetland types as well as the total acreage of each wetland type. Carbon sequestration varies considerably from one wetland type to another, with some wetland types acting as a net source of carbon and others acting as a strong sink for carbon. As noted in the 2008 University of Minnesota study, there is a dearth of measured data concerning carbon sequestration rates in restored wetlands. The study cites a potential carbon sequestration rate of 0.7 (±0.4) metric tons $CO_2$ per acre per year for peatland restoration and a potential sequestration rate of 4.5 (±6.9) metric tons $CO_2$ per acre per year for prairie pothole restoration. Studies investigating the carbon sequestration potential of wetlands at a level of detail that would make a precise comparison of the Project wetland impacts and planned mitigation possible are not available. However, studies do indicate that wetland areas with high water tables and limited drainage can tend to favor carbon accumulation as a result of anaerobic conditions. Wetland ecosystems with woody vegetation present can also tend to increase ecosystem carbon sequestration from carbon accumulation in aboveground biomass. The presence of recalcitrant mosses and other plant materials may result in higher carbon storage potential for certain wetland ecosystems.

Second, the long timescales over which wetland carbon sequestration takes place make it difficult to effectively compare potential carbon cycle effects of wetland impacts against the potential carbon cycle effects of mitigation. As discussed in Section 2.2.5.2, the timescale over which wetland impacts may result in release of carbon cannot be precisely determined given present scientific knowledge of these carbon cycle dynamics. However, wetlands tend to accumulate carbon at a relatively slow rate and some wetland/peatland areas can continue to accrue carbon for millennia. Reclamation and re-vegetation of non-wetland areas at the Mine Site and Plant Site will involve the placement of cover material suitable for

vegetation over the former footprints, grading and sloping activities as needed and planting. It is anticipated that this cover material will be a soil mix that will include peat that was excavated and stockpiled during the development of the mine. The most accurate and up-to-date details regarding the requirements and sequencing of reclamation activities can be found in the NorthMet Project Reclamation Plan. As with wetland restoration, the net terrestrial carbon cycle effects of non-wetland Project impacts and restoration activities depends on the similarity of ecosystem types. As discussed above, total accumulated carbon and sequestration rates depend on ecosystem type and maturity. However, an effort has been made in this report to assess the carbon flux associated with reclamation activities, because peat extracted during mine development will comprise a fraction of the soil mixture used for cover in reclamation activities and the fate of the peat carbon stock in the Project area has been identified as an area of interest and concern during the development of the scope for this report. Further evaluation of this potential carbon flux is provided below.

## 3.1. Carbon Footprint for Proposed Project

### 3.1.1. Direct and Indirect Industrial Emission Impacts

The estimated maximum carbon footprint of the Project is based on the Project as currently proposed running at maximum capacity. The expected GHG emissions from the Project are calculated using The Climate Registry General Reporting Protocol and the MPCA General Guidance for Carbon Footprint Development in Environmental Review. As these documents suggest, GHG emissions are broken down into direct and indirect emissions. Emissions are calculated using default emission factors for specific fuels from the two documents. The carbon footprint is summarized in Table 2 and Table 3. Figure 1 shows the location and layout of the Plant Site and Mine Site. Refer to Appendix A, NorthMet Project Greenhouse Gas Emission Inventory and Energy and Efficiency Analysis, for more information on development of the carbon footprints. Detailed descriptions of emission sources at the Mine Site and Plant Site areas are also provided in Appendix A.

**Table 2 Project GHG Emission Summary**

| Source | Maximum Potential Direct Emissions [1] ($CO_2$-e, m.t./yr) [2] | Maximum Potential Indirect Emissions ($CO_2$-e, m.t./yr) | Maximum Potential Total Emissions [3] ($CO_2$-e, m.t./yr) |
|---|---|---|---|
| Mines Site Point Source Emissions (generators, heaters) | 1600 | | |
| Mine Site Mobile Source Emissions(mining equipment and vehicles, ore hauling by rail) | 38,086 | | |
| Plant Site Point Source Emissions (ore crushing, concentrating, metal recovery, support equipment) | 138,641 | | |
| Plant Site Mobile Source Emissions (, ongoing construction and support vehicles) | 8,014 | | |
| Subtotal | 186,342 | 511,000 **[4]** | 697,342 |

**Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year**

[1] Direct emissions: Emissions from sources that are owned or controlled by the reporting entity, including stationary combustion emissions, mobile combustion emissions, process emissions, and fugitive emissions.

Potential direct emissions of GHGs for the Project use generally accepted emission factors and calculation methods of the World Resources Institute Greenhouse Gas Protocol Standard, International Panel on Climate Change (IPCC), and the MPCA General Guidance for Carbon Footprint Development in Environmental Review.

[2] $CO_2$-equivalents: The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing emissions of different GHGs. For the purposes of emissions reporting, GHGs are the six gases identified in the Kyoto Protocol: carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$).

Global warming potential (100 year): The ratio of radiative forcing (degree of warming to the atmosphere) over a timescale of 100 years that would result from the emission of one unit of a given GHG compared to one unit of $CO_2$. Factors used in estimating $CO_2$-equivalent emissions: $CO_2$ = 1; $N_2O$ = 298, $CH_4$ = 25.

As used in this analysis, emissions of $N_2O$ have 298 times more impact than does $CO_2$.

[3] Total project emissions (direct + indirect) are derived by summing estimated direct project emissions of 186,342 m.t./yr with the estimate of 511,000 m.t./yr indirect emissions (186,342 + 511,000 = 697,342 metric tons).

[4] Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by a manufacturing company represent the manufacturer's indirect emissions. Electrical demand for the Project is estimated to be approximately 59.3 megawatts. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. See Appendix A for calculation details.

**Table 3 Total Potential GHG Emissions Estimated over the lifetime of the project for the NorthMet Project Proposed to be Located near Hoyt Lakes, Minnesota**

| Source | Maximum Total Potential Direct Emissions ($CO_2$-e, m.t.) | Maximum Total Potential Indirect Emissions ($CO_2$-e, m.t.) | Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t.) |
|---|---|---|---|
| Mine Site [1] (mining equipment and vehicles, ore hauling, support equipment) | 793,734 | | |
| Plant Site [1] (ore crushing, concentrating, metal recovery, ongoing construction and support vehicles) | 2,933,103 | | |
| Construction Phase Emissions [2] | 92,885 | | |
| Reclamation (Closure) Phase Emissions [3] | 438,988 | | |
| Subtotal | 4,258,710 | 10,220,000 **[4]** | 14,478,710 |
| Terrestrial carbon loss (aboveground wetland carbon stock, aboveground forest carbon stock, 20 years of emissions from stockpiled peat, emissions from peat used in reclamation) | 199,591 | | 199,591 |

**Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year.**

[1] Based on maximum annual emissions occurring for 20 year proposed operating life of Project

[2] Includes Phase 1 (flotation concentrate production only) and Phase 2 (Hydrometallurgical Plant) Construction

[3] Based on 20 year closure period for Plant Site and 60 year closure period for Mine Site.

[4] Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated

and subsequently used by a manufacturing company represent the manufacturer's indirect emissions. Electrical load for the Project is estimated to be approximately 59.5 megawatts. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. See Attachment B for calculation details. Based on maximum annual emissions occurring for 20 year proposed operating life of Project

### 3.1.2. Terrestrial Carbon Cycle Impacts

In addition to the emissions of GHGs directly from the Project or indirectly as a result of electricity usage, other activities have the potential to release carbon into the atmosphere. Wetlands represent the single largest terrestrial carbon stock in the state of Minnesota. Undisturbed forest areas sequester large amounts of carbon in aboveground woody and leafy biomass as well as below ground carbon stores. The amount of stored carbon that may be released from these ecosystems as the result of Project activities is difficult to quantify. Based on Barr's understanding and the understanding reached in other adequate EIS work of the carbon cycle in wetlands and the potential impacts of the proposed project, it is likely that wetland carbon cycle impacts will include decreases in carbon sequestration capacity and a loss of some accumulated carbon, both from aboveground biomass and excavated peat. Additionally, some carbon losses from forest soils might occur. While some of the carbon released from terrestrial ecosystems as a result of Project activities will be restored over longer timescales as the site is reclaimed the analysis that follows is focused on potential releases of carbon and it is assumed that the eventual re-storage of this carbon represents a potential "better-case" scenario than the quantitative analysis indicates.

Despite possible uncertainties surrounding the extent and timing of Project activities on terrestrial carbon cycle processes, an effort has been made to quantitatively define the wetland carbon cycle impacts of the Project. Quantitative estimates for six wetland carbon cycle impact categories have been calculated and are reported in Table 4:

1. Total carbon stored in the above-ground vegetation of wetlands lost to Project activities [treated as a one-time emission]
2. Total carbon stored in excavated peat and annual emissions from its stockpiling
3. Possible carbon flux from peat used in reclamation activities
4. Annual emission rate for indirectly impacted wetlands due to potential water level drop
5. Loss of annual carbon sequestration capacity due to the disturbance of wetland plant communities discounting methane emissions from wetlands as a conservative assumption.
6. Reduction in annual carbon sequestration capacity in indirectly impacted wetlands

The total above-ground carbon stock lost to Project activities represents a theoretical cap on the amount of carbon that can eventually be released from the above-ground vegetation. All vegetation in directly

impacted areas has been assumed lost in this analysis. The only ongoing annual emission rates calculated are those resulting from peat excavation and stockpiling, potential carbon flux associated with the use of excavated peat in reclamation activities, and indirect hydrologic impacts to wetlands. The loss of carbon sequestration capacity differs from emission rates in that it represents a loss of absorptive capacity rather than an actual emission. However, its net effect on $CO_2$ levels is essentially the same. Detailed descriptions of the calculations used to derive these estimates can be found in Appendix A.

**Table 4 Wetlands Carbon Cycle Impacts Summary**

| **Source** | **Pollutant** | **Carbon Stock** ($CO_2$-e m.t.) | **Estimate Type [1]** |
|---|---|---|---|
| Total carbon stored in excavated peatlands [2] | $CO_2$ | 1,309,000 | Central tendency |
| **Source** | **Pollutant** | **Single Emission** ($CO_2$-e m.t.) | **Estimate Type [1]** |
| Total aboveground carbon stock directly impacted by Project [3] | $CO_2$ | 65,495 | High estimate |
| **Source** | **Pollutant** | **Emission Rate** ($CO_2$-e m.t./yr) | **Estimate Type [1]** |
| Stockpiled peatlands carbon emissions | $CO_2$ | 1,176 | Central tendency |
| Wetland sequestration capacity loss from direct impacts | $CO_2$ | 1,168 | Central tendency |
| Emissions from indirectly impacted wetlands [5] | $CO_2$ | 7.41/acre | High estimate |
| Wetland sequestration capacity reduction from indirect impacts [6] | $CO_2$ | 3.34/acre | Unknown |

**Units = $CO_2$-e, m.t. = GHG emissions as $CO_2$-equivalents, in metric tons**

[1] High estimate: high degree of confidence that estimate is above actual value; Central tendency: best estimate of actual value based on available literature; Unknown: low level of confidence in relationship to actual value

[2] Based on site studies of peat in overburden.

[3] Assumes treatment of all aboveground carbon stored in impacted wetlands as a one-time carbon dioxide emission

[4] See Appendix A for full derivation

[5] Assumes carbon emission rate[117] of 500 g/m2/yr, which coincides with rates from drained and relatively undisturbed peat (See Appendix A for full derivation). Indirect wetland impacts calculated on a per acre basis as total indirect wetland impact areas were not determined at the time this report was prepared.

[6] The wetland capacity reduction in indirectly impacted wetlands is based on a reduction from 0.7 metric tons/ha/yr (sequestration rate for peatlands) to 0.33 metric tons/ha/yr (sequestration rate for mineral wetlands). Indirect wetland impacts calculated on a per acre basis as total indirect wetland impact areas were not determined at the time this report was prepared.

The aboveground wetland carbon stock that is directly impacted by the Project represents a theoretical cap on the amount of carbon dioxide stored in aboveground wetland vegetation that could hypothetically be emitted. This estimate should not be taken to mean that all wetland carbon will be emitted over a short timescale as $CO_2$.

Two estimates of potential annual $CO_2$ emissions from excavated and stockpiled peatlands have been provided: a high estimate based on data from fairly dry, harvested peat and stockpiles; and a lower estimate based on data from drained but relatively undisturbed peat. Additionally the loss of carbon sequestration capacity from directly impacted wetlands has been estimated, by matching estimates of sequestration capacity found in the scientific literature to acreages of indirectly and directly impacted wetlands determined during the wetland delineation study.[118] Methane emissions from wetlands were discounted in the calculation of net changes due to direct and indirect wetland impacts. Additional details, including the sources of sequestration rates and acreages, can be found in Appendix A.

An effort has also made to quantitatively define the forest carbon cycle impacts of the Project. Details of these calculations and the underlying assumptions can also be found in Appendix A. Table 5 below summarizes potential forest carbon cycle impacts from the Project.

[117] Grønlund, A., A. Hauge, A. Hovde, and D.P. Rasse. 2008. Carbon loss estimates from cultivated peat soils in Norway: a comparison of three methods. Nutrient Cycling in Agroecosystems. 81(2):157-167.
[118] Barr Engineering Company. November 19, 2008. Updated Table 5-1.1-A. Original report - RS-14 Wetland Delineation and Functional Assessment, Draft-02, November 20, 2006. Minneapolis, MN.

**Table 5 Forest Carbon Cycle Impacts Summary**

| **Source** | **Pollutant** | **Single Emission** ($CO_2$-e m.t.) | **Estimate Type [1]** |
|---|---|---|---|
| Total aboveground carbon stock directly impacted by Project [2] | $CO_2$ | 102,052 | High estimate |
| **Source** | **Pollutant** | **Emission Rate** ($CO_2$-e m.t./yr) | **Estimate Type [1]** |
| Upland forest sequestration capacity loss from direct impacts | $CO_2$ | 1,814 | Central tendency |

**Units = $CO_2$-e, m.t. = GHG emissions as $CO_2$-equivalents, in metric tons**

[1] Theoretical max: maximum value possible given physical variables; High estimate: high degree of confidence that estimate is above actual value; Central tendency: best estimate of actual value; Unknown: low level of confidence in relationship to actual value

[2] Assumes treatment of all aboveground carbon stored in impacted forest as a one-time carbon dioxide emission

The aboveground forest carbon stock loss due to direct Project impacts is a theoretical maximum of the amount of carbon dioxide stored in the impacted forest vegetation. This estimate should not be taken to mean that all aboveground forest carbon will necessarily be emitted over a short timescale as $CO_2$. The net carbon cycle impact is highly dependent on the end-use of the cleared vegetation. The loss of carbon sequestration capacity from the directly impacted upland forest has been estimated. The loss of forest sequestration capacity was calculated by matching estimates of sequestration capacity found in the scientific literature to acreages of impacted forests determined during wildlife habitat surveys.[119] Additional details, including the sources of sequestration rates and acreages, can be found in Appendix A.

A summary of the carbon cycle results annualized over the Project life cycle is presented below in Table 6.

[119] ENSR. March 22, 2004. Winter 2000 Wildlife Survey for the Proposed NorthMet Mine Site, St. Louis County, Minnesota. ENSR Document Number 5461-001-300. Golden, CO; ENSR. July 2004. NorthMet Mine Summer Fish and Wildlife Study. ENSR Document Number 05461-002-400. Redmond, WA.

**Table 6 Terrestrial Carbon Cycle Annual Impacts Summary**

| Source | Pollutant | Emission Rate ($CO_2$-e m.t./yr) | Estimate Type [1] |
|---|---|---|---|
| Annualized aboveground carbon loss from wetlands [2] | $CO_2$ | 3,275 | High estimate |
| Annualized aboveground carbon loss from forests [2] | $CO_2$ | 5,103 | High estimate |
| Stockpiled peatlands carbon emissions (high) | $CO_2$ | 1,176 | Central Tendency |
| Wetland sequestration capacity loss from direct impacts | $CO_2$ | 1,168 | Central tendency |
| Forest sequestration capacity loss from direct impacts | $CO_2$ | 1,814 | Central tendency |
| Wetland sequestration capacity reduction from indirect impacts [3] | $CO_2$ | [3] | Unknown |
| Emissions from indirectly impacted wetlands [3] | $CO_2$ | [3] | High estimate |
| *Total emissions (with high stockpiled peatland estimate)* | *$CO_2$* | *12,535* | *High estimate* |

**Units = $CO_2$-e, m.t. = GHG emissions as $CO_2$-equivalents, in metric tons**

[1] Theoretical max: maximum value possible given physical variables; High estimate: high degree of confidence that estimate is above actual value; Central tendency: best estimate of actual value; Unknown: low level of confidence in relationship to actual value

[2] Annualized results are generated by dividing the assumed one-time aboveground carbon emissions by the 20-year Project life

[3] Indirect wetland impacts on a per acre basis only as indirect wetland impact areas were not finalized prior to drafting of this report. Sequestration capacity loss = 3.34 metric tons $CO_2$/acre/year. Annual carbon loss = 7.41metric tons $CO_2$-e./acre/yr

## 3.2. Alternatives Analysis: Hydrometallurgical vs. Pyrometallurgical Processing

Two main alternatives are available for processing a sulfide ore: 1) hydrometallurgical processing – as proposed for the Project and 2) pyrometallurgical processing – commonly referred to as smelting. A comparison was made between these processing options to evaluate the effect of the chosen processing method on the GHG emissions for the Project as well as overall environmental impacts. While the June 2009 NorthMet Project Climate Change Evaluation report included a quantitative comparison between the carbon intensity of the NorthMet process and carbon intensities for smelting process at facilities in Sweden and Finland, changes in the proposed NorthMet process since June 2009 have made a direct quantitative comparison problematic. However, Bateman Engineering (2005) estimated that the hydrometallurgical process has approximately 50% less energy demand than a copper smelting process.

Less energy demand is one indicator of potentially lower GHG emissions and possibly a lower carbon intensity.

## 3.3. Conclusions

The potential annual direct and indirect GHG emissions from the Project are estimated as follows (as metric tons $CO_2$-e): direct = 186,342 indirect = 511,000, total = 697,342.

A hydrometallurgical process uses approximately 50% less energy than a smelting process (Bateman Engineering, 2005). Energy usage is generally an indicator of GHG emissions, but this is not conclusive evidence that the hydrometallurgical process proposed for the Project has lower GHG emissions than a smelting operation because the majority of the GHG emissions from the metal recovery component of NorthMet's process come from neutralization, not energy use.

The calculation of terrestrial carbon cycle impacts from the Project is an imprecise undertaking; however, a number of conclusions can be drawn. The first is that the total impacts normalized over the 20-year lifespan of the Project are fairly small compared to the impacts from fuel use and the industrial process components of Project emissions. The second is that, despite the large amount of carbon contained in the excavated peat and conservative assumptions used in their calculation, annual $CO_2$ emissions from stockpiled peat represent less than 0.5% of the emissions from fuel use and nonfuel industrial processes for the Project. This is not to say that higher emission rates for these specific carbon cycle impact categories are not possible but that they are unlikely given the conservative assumptions embedded in this analysis.

## 4.1. Project GHG reduction measures

As part of the Project, PolyMet has considered and is taking measures to reduce GHG emissions and decrease the carbon intensity of production by improving both energy and production efficiency. As noted in Section 3.2 of this report, PolyMet's choice to implement a hydrometallurgical process rather than a pyrometallurgical process results in an expected reduction in energy usage. This may or may not reduce project GHG emissions below levels that are typical at existing pyrometallurgical facilities. In addition, PolyMet is reducing GHG emissions by choosing equipment which runs on low $CO_2$ emitting fuel options and implementing process designs which maximize energy efficiency.

When new motors are required, PolyMet will purchase premium efficiency motors rather than standard motors. Motor efficiencies will vary depending on motor size and load. Small (1 hp) motors will have an estimated of maximum efficiency of 85%, larger motors (250 hp) will have an estimated maximum efficiency of 96%. A portion of the overall electrical load will come from new, larger motors, so this will help maximize overall efficiency. In addition, gravity transport of process slurries will be used where possible, instead of pumps. PolyMet also intends to configure the Process Plant such that the overall power factor for the facility is as close to one as practical. This will help minimize the current and therefore power losses on the power line servicing the facility.

The primary production excavators and one of the two blast hole drills will be electric rather than diesel powered, eliminating a direct source of GHG emissions. Instead of employing used conventional locomotives, PolyMet will purchase new Gen-Set locomotives, which are more efficient and use less fuel. Also, space heating in the Process Plant is a major contributor to total direct GHG emissions. To reduce GHG emissions, PolyMet will employ natural gas fired space heaters. Estimated maximum $CO_2$-equivalent ($CO_2$-e) emissions from natural gas are less than other fuels, which will reduce direct and indirect GHG emissions.

In addition to selecting a low emitting fuel for space heating, the exhaust from the emission controls utilizing cartridge type filtration for the Coarse Crusher, Drive House #1, Fine Crusher and Concentrator Buildings will be recycled back into the buildings, where practical, and reduce the amount of ambient make up air drawn into the building. Any emission control system exhaust recycled back into a building will pass through a supplemental HEPA filter. Two potential suppliers of HEPA filters have been contacted. Both indicate that these filters are capable of achieving 99.97% efficiency on 0.3 micron particles. The recycling back into the building is seasonally dependent for some collectors, while others

will discharge back into the building year round. The recycling of emission control exhaust will reduce the space heating requirements at the Plant Site as it allows for reuse of air that has already been heated, rather than only passing it through the system one time. This will reduce fuel usage and therefore GHG emissions.

Estimated heating fuel usage, and therefore greenhouse gas emissions, have been further reduced by the proposed installation of additional insulation in the existing 1950's vintage Coarse Crusher, Drive House #1, Fine Crusher and Concentrator Buildings at the Process Plant.

A more detailed description of energy efficiency and actions designed to reduce GHG emissions is found in Appendix A, NorthMet Project Greenhouse Gas Emission Inventory & Energy and Efficiency Analysis. Information on methods of reducing GHG emissions that were considered, but found to be infeasible, is also in Appendix A.

## 4.2. Alternative GHG reduction measures

A number of other GHG reduction options have been evaluated as methods for minimizing the carbon footprint of the Project. Two options include biological sequestration strategies and carbon offsets. While biological sequestration options have been explored, more scientific research is needed to resolve uncertainty surrounding the viability, quality, and sequestration rate of certain biological offset methods. The option of purchasing carbon credits poses several potential issues, given the limited extent of current carbon markets and trading opportunities, as well as uncertainty regarding the structure of potential future carbon regulations.

### 4.2.1. Biological carbon sequestration

The primary source of published data on biological sequestration options and economics in the Project area are two recent University of Minnesota studies prepared for the Minnesota Terrestrial Carbon Sequestration Project.[120] These studies and personal communication with the authors indicate that the two most promising biological sequestration methods in Minnesota appear to be (1) changed management of existing forest land or (2) growing high-productivity trees such as poplar on areas not previously forested (afforestation). This research also indicates that several other approaches show some promise for

[120] Lennon, Megan J, and Edward A. Nater, 2006 *Biophysical Aspects of Terrestrial Carbon Sequestration in Minnesota*, University of Minnesota White Paper available at http://wrc.umn.edu/outreach/carbon/; Polasky, Stephen, and Yang Liu, 2006, *The Supply of Terrestrial Carbon Sequestration in Minnesota*, available at http://wrc.umn.edu/outreach/carbon/

biological carbon sequestration, including the conversion of row-crop acreage to grasslands or pasture, the use of cover crops in row-crop agriculture, wetland restoration, and agroforestry.

Some of the biological sequestration options appear to be based on more solid experimental evidence than others. Better documented methods include agroforestry, afforestation, and grassland establishment programs, such as the Conservation Reserve Program (CRP). The data backing other options is sparse. For example, recent data indicate that the use of a winter cover crop such as rye has less potential to sequester carbon than indicated by earlier studies.[121]

#### 4.2.1.1 Afforestation

In Minnesota, marginal farmlands are likely to offer the most promise for afforestation projects. In terms of total biomass production, red and white pine stands show the best carbon sequestration potential, with a steady and relatively rapid accumulation of carbon over a period of 90-120 years. Over these timescales afforested systems are effective at sequestering above-ground carbon in biomass, exhibiting carbon sequestration rates as high 7.65 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ in Minnesota. However, this sequestration potential is limited once the system reaches its steady state.

#### 4.2.1.2 Wetland Sequestration

Recently published University of Minnesota studies indicate that under certain conditions, wetland restoration may provide one of the best terrestrial sequestration options in Minnesota (in areas with enough hydric soils).[122] In many areas of Minnesota, particularly in the "Prairie Pothole Region" of Northern Minnesota, restoring wetlands re-establishes the original hydrologic conditions, which may lead to decreased rates of organic matter oxidation and potential increases in carbon sequestration. Restoring local hydrology and natural vegetation in previously drained wetland areas can sequester approximately 4.53 MT $CO_2$ $acre^{-1}$ $yr^{-1}$ in the upper 15 cm of soil. However, while wetlands do sequester carbon in biomass, the anaerobic decomposition that occurs in wetlands and peatlands results in the release of carbon as methane. Current research indicates that wetlands with permanently pooled water are net carbon sources as a result of methane production. If wetland restoration is considered as a carbon sequestration strategy, a focus on restoration efforts on Type 1 and 2 ephemeral wetlands is recommended, as they show the strongest potential for generating a net carbon sink.

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[121] Nater, 2007, personal communication.
[122] Lennon, Megan J, and Edward A. Nater, 2006 *Biophysical Aspects of Terrestrial Carbon Sequestration in Minnesota*, University of Minnesota White Paper available at http://wrc.umn.edu/outreach/carbon/

#### 4.2.1.3 Perennial Grassland

Extensive loss of prairie and grassland areas has occurred since the time Minnesota was originally settled, making restoration of former prairie areas to perennial grassland a good potential avenue for carbon offset. Increases in soil organic carbon resulting from the establishment of perennial grassland is attributed to decreased physical disturbance from tilling (lower aeration and organic matter decomposition rates) and increased above- and below-ground biomass inputs.

The greatest sequestration result is seen in the conversion of land currently in cultivation of row crops to grassland. This type of conversion has been estimated to produce sequestration rates between 1.48 and 4.45 MT $CO_2$ $acre^{-1}$ $yr^{-1}$. On the other hand, the rate of carbon sequestration resulting from conversion of marginal pasture or croplands to grassland in Minnesota is estimated at 1.04 MT $CO_2$ $acre^{-1}$ $yr^{-1}$. Although more research is needed, current studies indicate that perennial grassland systems may reach a steady state between 50 and 148 years, after which carbon sequestration benefits are negligible.

### 4.2.2. Carbon offset credits

Under this option, PolyMet could purchase verified, retired offsets every year instead of implementing and owning a sequestration project. However, there are a wide variety of brokers and quality of offsets available. CO2 offset "quality" has been a recurring problem in this so-far voluntary market. There is a danger that purchased offsets will neither be formally recognized by any future state or federal regulatory program, nor recognized as legitimate by local environmental groups.

## 4.3. Conclusions

Biological carbon sequestration may hold potential in the future, particularly as the science advances regarding wetland and forest sequestration options. As part of the proposed Project, PolyMet will undertake various mitigation activities which may offer an opportunity to create environments with high carbon sequestration rates. As the science in this area advances there will likely be more clearly defined opportunities for biological carbon sequestration in the region of Minnesota where the Project is located.

The option of purchasing carbon credits from verified brokers has many potential pitfalls given the voluntary nature of carbon markets and the ongoing debate surrounding the quality of certain types of carbon credits. With rapidly developing carbon dioxide and GHG goals and policies in the Midwest, it is difficult to assess whether the small voluntary markets currently in place may be integrated into new markets if cap and trade policies are established, or if these existing markets are abandoned and replaced.

PolyMet has taken several process design and equipment measures to reduce GHG emissions as discussed above.

# Appendices

# Appendix A

## Greenhouse Gas Emission Inventory and Alternatives Report

# *Greenhouse Gas Emission Inventory and Energy and Efficiency Analysis*

## *NorthMet Project*

***Prepared for***
***PolyMet Mining Inc.***

***June 2012***


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# Greenhouse Gas Emission Inventory and Energy and Efficiency Analysis

**June 2012**

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Attachment E Aboveground Carbon Stock and Sequestration Capacity Loss Calculations

# 1.0 Introduction and Summary

Greenhouse gas (GHG) emissions from PolyMet Mining Inc.'s NorthMet Project (Project) will be evaluated during the environmental review process. This document presents a calculation of expected GHG emissions from the Project based on a memorandum from James Warner, Minnesota Pollution Control Agency (MPCA), dated July 16, 2008. The memorandum mandates that all new projects requiring an Air Emission Risk Analysis (AERA) or Part 70 permit also include a calculation of the expected GHG emissions from the project using The Climate Registry (TCR) General Reporting Protocol (GRP) (March 2008). On February 18, 2010 the Whitehouse Council on Environmental Quality (CEQ) published draft guidance on the consideration of the effects of climate change and GHG emissions under the National Environmental Policy Act (NEPA). This draft guidance was also considered in the development of the project GHG emission inventory and in the energy and efficiency analysis.

For the purposes of this report, GHGs are the six gases identified in the Kyoto Protocol: carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Carbon dioxide is the most prevalent GHG, so emissions are generally expressed in units of carbon dioxide equivalents ($CO_2$-e). For the Project, emissions of $CO_2$, $N_2O$, and $CH_4$ are estimated on a $CO_2$-equivalent basis using generally accepted emission factors and following generally accepted calculation methods, primarily from the MPCA guidance, the TCR GRP, or the Environmental Protection Agency's (EPA's) mandatory reporting rule (MRR) (Code of Federal Regulations (CFR) Title 40 Part 98). Information from the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (2006) is used when the MPCA guidance, TCR GRP, and/or 40 CFR Part 98 do not provide needed guidance. The Project will not emit HFCs, PFCs, or $SF_6$.

Global warming potentials used for estimation of CO2-equivalents for the Project are taken from 40 CFR Part 98. The global warming potentials are listed in Table 1.

**Table 1 GHG CO2-equivalence Values Used in Calculations**

| GHG (Chemical Formula) | $CO_2$-equivalence or global warming potential (100 year) |
|---|---|
| $CO_2$ | 1 |
| $CH_4$ | 21 |
| $N_2O$ | 310 |

Major components of the Project include mining, ore crushing/grinding and concentrating, and metal recovery. During metal recovery, the nickel-rich fraction of the flotation concentrate is routed to a pressurized autoclave. Energy is produced during sulfide oxidation within the autoclaves and is used as the primary heat source for the hydrometallurgical process. The hydrometallurgical process eliminates several steps typically associated with pyrometallurgical processing and the related energy demand and $SO_2$ emissions. Overall, hydrometallurgical processing such as PolyMet's planned operation is estimated to reduce energy demand and by 50% as compared with a pyrometallurgical process (Bateman 2005).

PolyMet has taken several other measures to reduce GHG emissions related to process design and equipment used. Energy efficient equipment will be purchased when available. For example, the Project will employ premium efficiency motors and Gen-Set locomotives. In addition, most emissions units used will run on the lowest $CO_2$ emitting fuel option for the type of equipment. The facility will also initially produce flotation concentrate for sale from all of the ore processed, which would reduce the Project's direct and indirect GHG emissions from those estimated in this report during the limited times operating in that mode.

Using MPCA guidance and TCR GRP, the maximum total potential direct and indirect GHG emissions from the Project were calculated. Direct emissions are GHG's generated by processes at the Plant Site and Mine Site. The potential maximum direct GHG emissions from the Project, from mining through metal recovery at the Process Plant, are estimated to be approximately 186,342 metric tons per year. $CO_2$ emissions account for 99.1% of the estimated GHG emissions at the Mine Site and 99.6% of the estimated GHG emissions for the Plant Site. Direct GHG emissions potentially associated with the Project are less than 0.12% of estimated 2005 statewide emissions, approximately 0.003% of estimated 2007 U.S. emissions (US DOE 2008), and approximately 0.00038% of estimated global GHG emissions of more than 49 billion metric tons per year (IPCC 2007). Potential indirect GHG emissions related to power production for the Project are estimated at 511,000 metric tons per year. As shown in Table 4, the total potential Project emissions (direct + indirect) are also a fraction of the estimated statewide, national, and global GHG emissions.

In addition to the direct and indirect industrial $CO_2$ emissions, quantitative estimates for five carbon cycle impacts were calculated:

1) Total carbon stored in the above-ground vegetation of wetlands and forests lost to Project activities [treated as a one-time emission] = 167,546 metric tons of $CO_2$
2) Annual emissions from the stockpiling of excavated peat = 1,176 metric tons of $CO_2$ per year

3) Possible carbon loss from peat used in reclamation activities = 8,524 metric tons of $CO_2$
4) Annual emissions from indirectly impacted wetlands = 7.41 metric tons of $CO_2$ per acre per year
5) The loss of annual carbon sequestration capacity due to the disturbance of wetland and forest plant communities = 2,982 metric tons of $CO_2$ per year
6) The reduction in annual carbon sequestration capacity in indirectly impacted wetlands = 3.34 metric tons per year

Apart from the one-time aboveground carbon loss estimate, these impacts are minimal compared to the direct and indirect industrial emissions: Additionally, the aboveground carbon lost (a) will not take place as an actual one-time $CO_2$ emission event but will be a staged development of the Project; and (b) is a likely overestimate given the value of long-lived forest products that will be potentially available for harvest. Temporal issues surrounding the project-specific impacts, such as the change in $CO_2$ emission rate from stockpiled peatlands after closure, are discussed in Section 10.

GHG emissions may vary from facility to facility as a result of a number of factors that make direct comparisons difficult. Calculating a "carbon intensity" for GHG emissions is a way to directly compare facilities. Typically, an estimate of carbon intensity is derived by dividing GHG emissions by a unit of production. Generally, a lower carbon intensity indicates a more efficient process with regard to GHG emissions and the lower the carbon intensity the fewer GHGs emitted per unit of material processed. While the June 2009 NorthMet Project Climate Change Evaluation report included a quantitative comparison between the carbon intensity of the Project and carbon intensities for smelting process at facilities in Sweden and Finland, changes in the proposed NorthMet process since June 2009 have made a direct quantitative comparison problematic.

However, studies suggest that a hydrometallurgical process uses approximately 50% less energy than a smelting process (Bateman Engineering, 2005). The majority of the GHG emissions from the metal recovery component of the Project come from neutralization, not energy use.

# 2.0 GHG Emission Estimation Methodology

Potential emissions from the Project are estimated on a $CO_2$-equivalents basis using several available methods and emission factors, including:

- World Resources Institute Greenhouse Gas Protocol Standard;
- The Climate Registry's May 2008 General Reporting Protocol (GRP);
- MPCA's General Guidance for Carbon Footprint Development in Environmental Review;
- International Panel on Climate Change (IPCC); and
- U.S. Environmental Protection Agency (EPA).

Attachment A provides the details of the emission calculations.

Indirect emissions related to generating electric power for the Project are also estimated. These calculations use emission rates for the principal Minnesota electric utility providers found in the MPCA General Guidance for Carbon Footprint Development in Environmental Review. Indirect emission calculations are provided in Attachment B.

## 2.1 Mine Site

The Mine Site is located approximately 8 miles to the east of the Plant Site, approximately 6 miles south of the city of Babbitt, Minnesota. The sources of GHG emissions related to Mine Site activities are as follows[1]:

- Wastewater Treatment Facility Backup Generator
- Wastewater Treatment Facility Propane Fired Space Heaters
- Mining Related Equipment
    - Generator to Move Large Electric Mine Equipment
    - Mining Vehicles, including excavators, haul trucks, dozers, and graders.
        - PolyMet owned vehicle emissions and potential Contractor vehicle emissions are aggregated together for these calculations.
    - Locomotives (hauling ore from the Mine Site to the Plant Site)

[1] The wastewater treatment process for the Project is not included as a source of greenhouse gas emissions. It is not expected to be a source because the process water will contain little or no organic carbon.

Emissions from the generator and space heaters are calculated using maximum capacities and emission factors from the MPCA General Guidance for Carbon Footprint Development in Environmental Review. Emissions from the mining vehicles are calculated using maximum annual fuel consumption numbers over the anticipated mine life and emission factors for worst case fuel scenarios from The Climate Registry's GRP. Total direct $CO_2$-equivalent emissions from the mine site are estimated to be 39,687 metric tons per year.

## 2.2 Plant Site

As described in the March, 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement and the NorthMet Project Description Version 3 Submitted September 13, 2011, the Project will use froth flotation to produce a copper rich and nickel rich flotation concentrate from the sulfide ore. A pressure oxidation hydrometallurgical process will be used to recover metals from the nickel-rich flotation concentrate. The process injects oxygen into a pressure vessel (autoclave) where the bulk sulfide concentrate is submerged in an acidic solution. The sulfide minerals are oxidized and the metals are taken into solution. The metals are recovered from the metal-rich solution. Final products are copper concentrate, a nickel-cobalt hydroxide, and a platinum group metals (PGM)/gold concentrate. Worldwide, pressure oxidation is a proven technology for base metal extraction. PolyMet's major change to this technology is the addition of a small amount of chloride to facilitate the dissolution and enable the recovery of gold and PGM (AuPGM).

The Plant Site has the following sources of GHGs:

- Autoclave Startup Boiler
- Oxygen Plant Adsorber Regeneration Heater
- Space Heaters
- Backup Generators and Fire Pumps
- Autoclave
- Solution Neutralization and Iron and Aluminum Precipitation Tanks
- Vehicle traffic, including heavy haul trucks going to the Area 1 Shop for maintenance, construction trucks at the Tailings Basin and light trucks
- Locomotive used to move railcars in the switchyard

Emissions for the Autoclave Startup Boiler, the Oxygen Plant Adsorber Regeneration Heater, the Space Heaters, the Backup Generators and Fire Pumps, are calculated using the maximum capacities of each unit and appropriate emission factors for combustion taken from either the MPCA guidance document or

The Climate Registry's GRP. The $CO_2$ emissions from the Autoclave and Iron and Aluminum Precipitation Tanks are calculated from information on the weight fraction $CO_2$ in the gaseous phase taken from the MetSim process flow simulation model transmitted by Bateman via a spreadsheet, and vent flow rates. The $CO_2$ weight fractions are determined based on material balance and knowledge of process chemistry. Emissions from vehicle traffic are based on vehicle miles traveled using emission factors for worst case fuel scenarios from The Climate Registry's GRP. Total direct $CO_2$-equivalent emissions from the Process Plant are estimated to be 146,655 metric tons per year.

## 2.3 Construction and Closure Emissions

Construction emissions have been calculated for both the Mine Site and the Plant Site based on the same information as used for the operating emissions, with the exception of tailpipe emissions from vehicles used for Process Plant construction. The Process Plant construction emissions were estimated using the Urbemis2007 program version 9.2.4 available from www.urbemiss.com. Emissions were estimated based on the footprint of new buildings to be constructed and estimated intensity of emissions from upgrading existing buildings. Construction emissions include Plant Site point and mobile sources, Mine Site point and mobile sources as well as other miscellaneous construction sources. All construction emissions were calculated for Year 0 of the Project and include emissions from equipment used for new building construction as well as paving and grading. Closure emissions have been estimated for a potential closure period of 20 years for the Plant Site and 60 years for the Mine Site and include emissions for mobile equipment as well as point sources at both the Mine Site and Plant Site. The primary emission generating activities during the closure period will be related to waste water treatment.

## 2.4 Sale of Flotation Concentrate

The emission calculations used in this analysis assume that all nickel-rich flotation concentrate will be processed through the Hydrometallurgical Plant. This assumption yields a maximum GHG emissions scenario for the Project. However, the facility may not always process 100 percent of the nickel-rich flotation concentrate in the Hydrometallurgical Plant. For example, the facility may produce flotation concentrate for sale from all of the ore processed at certain periods, such as during construction of the Hydrometallurgical Plant, when the Autoclave is down for maintenance, or when PolyMet could sell reserved power at very high rates. GHG emissions from the Project will be lower when producing flotation concentrate for sale, rather than processing nickel-rich concentrate in the Hydrometallurgical Plant. As a result, Appendix A may overstate the Project's GHG emissions under actual conditions.

# 3.0 Summary of Project GHG Emission Estimates

Project-related GHG emissions on a $CO_2$-equivelent basis are summarized below and in Table 2 and Table 3.

- Maximum direct GHG emissions from the Project operation are estimated at 186,342 metric tons per year. Of these direct emissions, 21% are from the Mine Site operations and 79% are from Plant Site operations. Additional calculation details are provided in Attachment A. For the Mine Site, $CO_2$ emissions account for approximately 99.1% of the estimated GHG emissions, with $N_2O$ accounting for approximately 0.8% of the estimated emissions. For the Plant Site, $CO_2$ emissions account for approximately 99.6% of the estimated GHG emissions.
- Potential indirect GHG emissions from power production for the Project are estimated at approximately 511,000 metric tons per year. This calculation is based on Project power needs of approximately 59.5 megawatts, which is planned to be provided by Minnesota Power. An emission factor of 2159.5 pounds $CO_2$ per megawatt hour for all electricity provided by Minnesota Power is used in the calculation. Additional calculation details are provided in Appendix B.
- Total potential construction emissions are estimated as 92,885 metric tons. Closure GHG emissions are estimated as 438,988 metric tons based on a 60 year closure period for the Mine Site and a 20 year closure period for the Plant Site. Further details on these emissions are provided in Tables A-3 and A-3 in Attachment A.
- Total potential Project GHG emissions, e.g., after construction, but before plant closure, are an estimated 697,342 metric tons per year (Table 2). Approximately 30% of the total GHG emissions are from direct emissions and 70% are from indirect emissions.

The estimated GHG emissions from the project, both direct emissions and total (direct + indirect), are small in comparison to statewide (Minnesota), national, and global GHG emission estimates. Table 4 shows that the Project's direct GHG emissions will be approximately 0.12% of statewide emissions estimated from available MPCA data (2003), approximately 0.003% of national emissions estimated by the EPA (2007), and approximately 0.00038% of global emissions. Also shown in Table 4, when indirect emissions are accounted for, the potential total GHG emissions for the Project (direct + indirect) are still small and only a fraction of the estimated statewide, national, and global emissions.

**Table 2 Summary of Maximum Potential Annual GHG Emissions Estimated for the Project***

| Source | Maximum Potential Direct Emissions [1] ($CO_2$-e, m.t./yr) [2] | Maximum Potential Indirect Emissions ($CO_2$-e, m.t./yr) | Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t./yr) |
|---|---|---|---|
| Mine Site (mining equipment and vehicles, ore hauling) | 39,687 | | |
| Plant Site (ore crushing, concentrating, metal recovery) | 146,655 | | |
| Subtotal | 186,342 | 511,000 **[4]** | 697,342 |

**Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year.**

* Terrestrial carbon cycle impacts have not been added to this table due to critical differences in the origin and temporal component for terrestrial emissions. See terrestrial carbon calculations and discussions in subsequent sections

[1] Direct emissions: Emissions from sources that are owned or controlled by the reporting entity, including stationary combustion emissions, mobile combustion emissions, process emissions, and fugitive emissions.

Potential direct emissions of GHGs for the Project are estimated using generally accepted emission factors and calculation methods of the World Resources Institute Greenhouse Gas Protocol Standard, International Panel on Climate Change (IPCC), and the MPCA General Guidance for Carbon Footprint Development in Environmental Review.

[2] $CO_2$-equivalents: The quantity of a given GHG emission is multiplied by its total global warming potential. This is the standard unit for comparing emissions of different GHGs. For the purposes of emissions reporting, GHGs are the six gases identified in the Kyoto Protocol: carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$).

Global warming potential (100 year): The ratio of radiative forcing (degree of warming to the atmosphere) over a 100 year timescale that would result from the emission of one unit of a given GHG compared to one unit of $CO_2$. Factors used in estimating $CO_2$-equivalent emissions: $CO_2 = 1$; $N_2O = 310$, $CH_4 = 21$.

As used in this analysis, emissions of $N_2O$ have 310 times more impact than do $CO_2$ emissions over 100 years.

[3] Total Project emissions (direct + indirect) are derived by summing estimated direct Project emissions with the estimate of indirect emissions.

[4] Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by a manufacturing company represent the manufacturer's indirect emissions. Electrical load for the Project is estimated to be approximately 59.5 megawatts. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. See Attachment B for calculation details.

**Table 3 Total Potential GHG Emissions Estimated over the lifetime of the Project**

| Source | Maximum Total Potential Direct Emissions ($CO_2$-e, m.t.) | Maximum Total Potential Indirect Emissions ($CO_2$-e, m.t.) | Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t./yr) |
|---|---|---|---|
| Mine Site [1] (mining equipment and vehicles, ore hauling) | 793,734 | | |
| Plant Site [1] (ore crushing, concentrating, metal recovery) | 2,933,103 | | |
| Construction Phase Emissions [2] | 92,885 | | |
| Reclamation (Closure) Phase Emissions [3] | 438,988 | | |
| Subtotal | 4,258,710 | 10,220,000 **[4]** | 14,478,710 |
| Terrestrial carbon loss (aboveground wetland carbon stock, aboveground forest carbon stock, 20 years of emissions from stockpiled peat, emissions from peat used in reclamation) | 199,591 | | 199,591 |

**Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year.**

[1] Based on maximum annual emissions occurring for 20 year proposed operating life of Project

[2] Includes Phase 1 (flotation concentrate production only) and Phase 2 (Hydrometallurgical Plant) Construction

[3] Based on 20 year closure period for Plant Site and 60 year closure period for Mine Site.

[4] Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by a manufacturing company represent the manufacturer's indirect emissions. Electrical load for the Project is estimated to be approximately 59.5 megawatts. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. See Attachment B for calculation details. Based on maximum annual emissions occurring for 20 year proposed operating life of Project

**Table 4 Estimated Statewide, National, and Global GHG Emissions Compared to the Potential Emissions from the Project**

| Source Category | Estimated GHG Emissions ($CO_2$-e, m.t./yr) | NorthMet Project Direct GHG Emissions as a Percent of Total | NorthMet Project Total (direct + indirect) GHG Emissions as a Percent of Total |
|---|---|---|---|
| NorthMet Project [1] | | | |
| Direct Emissions | 186,342 | | |
| Indirect Emissions | 511,000 | | |
| TOTAL | 697,342 | | |
| | | | |
| Minnesota (year 2008) [2] | 159,400,000 | 0.12 | 0.44 |
| United States (year 2007) [3] | 7,282,400,000 | 0.003 | 0.01 |
| Global (year 2004) [4] | 49,000,000,000 | 0.00038 | 0.0014 |

**Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year**

[1] Potential direct emissions of GHGs for the Project are estimated using generally accepted emission factors and calculation methods of the World Resources Institute Greenhouse Gas Protocol Standard, International Panel on Climate Change (IPCC), and the MPCA General Guidance for Carbon Footprint Development in Environmental Review. See Attachment A for calculation details.

Indirect emissions: Electrical load for the Project is estimated to be approximately 59.5 megawatts. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. See Attachment B for calculation details.

[2] http://www.pca.state.mn.us/index.php/topics/climate-change/climate-change-in-minnesota/greenhouse-gas-emissions-in-minnesota.html.

[3] Energy Information Administration, Official Energy Statistics from the US Government. Emissions of Greenhouse Gases Report. Released December 3, 2008. http://www.eia.doe.gov/oiaf/1605/ggrpt/

[4] IPCC 2007, Fourth Assessment Report, Working Group 1 Climate Change 2007: Synthesis Report

Estimated GHG emissions for the Project are a fraction of statewide emissions. In turn, Minnesota's estimated statewide GHG emissions are small on a national and global basis. Minnesota's emissions are approximately 2% of the estimated U.S. emissions and 0.3% of global emissions. These comparisons further emphasize that the potential GHG emissions from the Project are small**.**

# 4.0 NorthMet's Hydrometallurgical Process vs. Smelting Facilities

Major components of the Project include mining, ore crushing/grinding and concentrating, and metal recovery. During metal recovery, the nickel-rich flotation concentrate is routed to a pressurized autoclave. Energy is produced during sulfide oxidation within the autoclaves and is used as the primary energy source for the hydrometallurgical process. The hydrometallurgical process eliminates several steps typically associated with pyrometallurgical processing and the related energy demand.

The traditional method to recover copper and nickel involves smelting, where the concentrate is subjected to high temperatures for the recovery of copper and nickel products. As described by the United States Geological Survey (USGS 2004), *"... Technically, smelting means to melt and fuse. With regard to copper smelting, it means to melt and fuse copper-bearing materials, which include concentrates, dust (circulating load), fluxes (slagmaking materials), and revert (circulating load) in a furnace. Heat is required for the melting and fusing and can be generated by several means, such as electric current, fuel combustion, or mineral oxidation. ..."*. The hydrometallurgical process proposed for the Project will produce copper concentrate as well as gold and platinum group metals (AuPGM) and nickel/cobalt hydroxide concentrate products.

While the June 2009 NorthMet Project Climate Change Evaluation report included a quantitative comparison between the carbon intensity of the Project and carbon intensities for smelting process at facilities in Sweden and Finland, changes in the Project since June 2009 have made a direct quantitative comparison problematic. However, Bateman Engineering (2005) estimated that the hydrometallurgical process has approximately 50% less energy demand than a copper smelting process. Less energy demand is one indicator of potentially lower GHG emissions and possibly lower carbon intensity.

# 5.0 Electrical Efficiency

## 5.1 Process Plant

PolyMet is taking several steps in the design of the Process Plant to increase electrical efficiency. These steps include designing the facility to operate with a power factor as close to one as practical, and the specification of high efficiency motors for the new motors to be installed. Additional details are provided below.

### 5.1.1 Power Factor

The power loss on a power line serving a facility is a function ($I^2R$) of the resistance of the line (R) and the current in the line (I). The current in the line is the current required to serve all of the loads at the facility. There are three types of load – resistive load (load required to spin a motor, light a light or heat a heater), inductive load (load required to set up magnetic fields that allow equipment like motors and transformers to function) and capacitive load (load required because of electric fields developed by transmission lines and other equipment). The relationship (KW/KVA) between resistive load (KW) and total (resistive + inductive + capacitive) load (KVA) is called Power Factor. The inductive and capacitive loads are in opposite directions, so, if they are equal at a facility, the current on the power line serving the facility will be only that required to serve the resistive load and the Power Factor will be one.

A large industrial facility can have a significant inductive load component due to the many electric motors used. This results in a current in the power line serving the facility that is higher than that required to serve the resistive load only. In PolyMet's case, the existing Cliffs Erie Plant has synchronous motors (special motors that can be adjusted to have resistive plus inductive or resistive plus capacitive loads) driving the rod and ball mills and power factor correction capacitors at the main power substation. This means that the overall Power Factor of the facility can be adjusted to be near to one, which results in the minimum current (and therefore power loss) on the power line serving the Process Plant. PolyMet intends to set up the synchronous motors and power factor correction capacitors such that the overall facility Power Factor is a close to one as practical.

Quantification of the emission reduction from achieving a Power Factor close to one requires several assumptions. To estimate the low end of the potential emission reduction, it was assumed that all power was coming from the nearest power plant, Laskin Energy Center, which is about 5.7 miles away. The estimated reduction in average electrical load is 16,500 Watts, with an estimated annual reduction in indirect $CO_2$ emissions of about 140 metric tons.

### 5.1.2 Efficiency of Electrical Equipment

A review of the equipment that corresponds to 50% of the total electrical load at the process plant was conducted. The total connected electrical load for the process plant is estimated as 42.4 MW[2]. The 96 pieces of new electrical equipment planned for the Process Plant that were evaluated have a total electrical load of 21.3MW, which is greater than 50% of the total load for the Process Plant.

Almost all of this equipment utilizes electric motors.

Two pieces of equipment that do not have electric motors are on the list of equipment evaluated: the Power and Light Distribution Board in the Oxygen Plant and the Caustic Tank Heater. These units have no moving parts and are inherently efficient.

The remaining 94 pieces of equipment evaluated will have new electric motors. This equipment includes 26 agitators, 43 pumps, 10 fans and blowers, six HVAC units, four compressors, the Limestone Crusher, the Lime Slaker, the Primary Limestone Mill, the caustic tank heater and the make-up air heater.

All motors purchased new by PolyMet will be high efficiency. The efficiency of each specific motor will vary greatly depending on size and load. Table 5 provides the expected low end range of efficiencies based on motor size and load.

**Table 5 Low End Range of Motor Efficiency by Size and Load**

| | Loading | | |
|---|---|---|---|
| Motor Size | 50% | 75% | 100% |
| 1 HP | 81.5% | 84.0% | 85.5% |
| 250 HP | 94.1% | 95.6% | 95.8% |
| 1000 HP | 93.6% | 94.4% | 94.1% |

The design of the Process Plant will size the new electric motors such that the operating load is 75 – 100% of the motor capacity. This will allow for efficient operation of the motors. This design will account for the fact that motors are not available in every conceivable size.

The smallest motors included in the 96 pieces of equipment evaluated are 75 hp. There are seven motors of this size on the list, 68 at about 100 hp or less, 16 between 100 and 150 hp, two between 150 and

[2] Note: the total connected load is the sum of the power required for all primary equipment at its expected electrical load. The estimated average hourly power draw, which takes into account the anticipated run time for each piece of equipment was used to estimate indirect greenhouse gas emissions in Section 9.0.

250 hp, two between 250 and 500 hp, and eight greater than 1000 hp. The larger motors make up a significant portion of the total electrical load, so this will result in a higher overall efficiency. For example, the air compressor in the oxygen plant has an electrical load of 5.3 MW or about 12% of the total load for the Process Plant.

The electrical demand reduction at the Plant Site from using premium efficiency motors where new motors will be purchased is estimated as 213 kW. This corresponds to an annual electrical usage savings of 1,864 MWh, which is equivalent to a reduction about 1800 metric tons of $CO_2$ emissions per year.

## 5.2 Mine Site

Electrical efficiency is also being incorporated into the design of the Mine Site. The total connected load at the Mine Site is much lower than the Plant Site at 5.7MW[3]. Almost half of the load comes from the electric powered excavators and blast hole drill rigs used in the mining operation. The remaining load is from pumps, heaters, the Waste Water Treatment Facility, the Rail Transfer Hopper and other miscellaneous equipment.

High efficiency electric motors will be specified for all equipment at the Mine Site. In addition, high efficiency transformers and lighting will be installed. The Waste Water Treatment Plant will have electric heaters. The building insulation will be designed to minimize heat loss and therefore power consumption.

The annual emission reduction at the Mine Site from using premium efficiency motors where new motors will be purchased is estimated as about 19 metric tons of $CO_2$ per year.

## 5.3 Gravity Feed

The existing and proposed facilities will make use of gravity flows where practical to help maximize the efficiency of the proposed operation. Use of gravity flows in the concentrator avoids the need to install two additional 500 horsepower pumps. The annual savings in electricity usage is estimated at about 5,500 MWh which results in an estimated reduction in greenhouse gas emissions of 5400 metric tons of carbon dioxide per year.

[3] The average actual power draw is estimated as 2.6 MW. This value was used in the indirect greenhouse gas emission calculation.

# 6.0 Infeasible GHG Emission Reduction Methods

This report in general focuses on the GHG emissions for the Project and elements of the Project that help minimize GHG emissions. There are other potential ways to reduce GHG emissions that have not been incorporated into the Project design because they are considered infeasible. Examples of these options are provided below along with the rationale for why they are infeasible in the context of the Project. Estimates of potential reductions in GHG emissions from these rejected alternatives are included where the data is available to calculate them.

## 6.1 Electric Drive Mine Haul Trucks

Trucks with either mechanical drive trains or diesel electric drives can be used to haul material at a mine site. Some diesel electric drive trucks offer the possibility of trolley assist, which enables the haul truck to receive electrical power from conductors located above the haulroad. The trolley concept is similar to the system in use for some light rail transit systems where the locomotive is powered by an overhead power source running the length of the tracks. The trolley assist systems used in mining are located on long, permanent or semi-permanent haulroad ramps where the haul truck would be hauling a load up grade. When the haul truck approaches the ramp it engages the overhead trolley power lines increasing the power available to the electric wheel motors, enabling the truck to maintain faster speeds when traveling up the grade. While the truck is traveling under trolley assist the diesel engine may be idling which reduces diesel fuel consumption and therefore direct GHG emissions. The decision to install a trolley assist system is based on the development plans of the mine, the layout of mine road system and economics. The savings associated with reduced fuel consumption and the production benefits of faster haul truck speeds on haulroad ramps must be greater than the installation costs as well as the ongoing maintenance and relocation costs of the trolley assist overhead lines, the increased maintenance costs of the haulroad under the trolley assist conductors and the maintenance costs of the pantograph and electrical systems on the haul trucks. The cost differential between diesel fuel and electric power must also be included in the economic analysis. There are also operating and production cost considerations, such as proactively disassembling the overhead system to prevent damage from blasting as well as the occasional, unexpected delay due to blast damage.

The Project Mine Plan results in the pits reaching their full surficial footprint relatively quickly and then deepening the pits. Mining will proceed downward as well as parallel to the surface. This will result in haulroads that are both regularly being increased in length and being developed into ramps for deepening the pits. As the pit matures some of the haulroads may be considered semi-permanent or permanent and

the economics of installing a trolley assist on those stretches will have to be analyzed taking into account the factors previously mentioned.

Therefore, while trolley assist electric drive trucks do provide a reduction in diesel fuel consumption and a reduction in direct greenhouse gas emissions the decision to install a trolley assist system is economically driven based on many factors.

Given that changing nature of the mine haul roads in the early years of the mine life, the use of trolley assist would not be practical at this point in the operation. After the mine pits have been developed to the point where there are permanent or semi-permanent haul roads in the pits, PolyMet can reconsider if the haul road configuration and economics would be favorable.

## 6.2 Electric Locomotives

If electric locomotives are used, this eliminates diesel fuel combustion in the locomotives and a source of direct GHG emissions. Electric locomotives require trolley electric power delivery. PolyMet does not own the track between the Mine Site and the Plant Site (PolyMet has trackage rights), and it would not be possible to install trolley system on track owned by others. The diesel Gen-Set locomotives that will be specified for the Project are among the most efficient diesel locomotives available. The use of electric ore haul locomotives could reduce direct $CO_2$ emissions by 4,400 metric tons of $CO_2$ equivalents per year.

## 6.3 Newer Mill Technology

Newer mill technology featuring larger mills would reduce power consumption. Installation of larger mills would require revision of structures and very expensive replacement of existing equipment.

If larger mills were installed, they would be semi-autogenous grinding mills or SAG mills. This type of mill would also eliminate the need for the fine crushing stage and require associated changes to the material handling equipment. The cost to retrofit the existing Crushing/Concentrating Plant with SAG mills would approach the cost of building new facilities due to the extensive modification that would be required to the existing buildings. The total estimated cost is about $100 million (+/- 50%).

To put this into perspective, this cost can compared to the estimated startup capital cost for the entire Project. The initial capital cost required prior to first production and sales for the Project is $312 million. Replacing the existing mills with larger SAG mills would increase the initial capital cost by almost one-third, which would have a significant adverse affect on project economics.

In addition to the high capital cost, the SAG mill design would likely use more power than the existing multi-stage crushing/rod mill/ball mill design.

Based on the above, replacement of the existing mills will larger SAG mills and making associated modification to the crushing and material handling equipment would adversely affect the project economics and not provide a clear reduction in power usage or indirect greenhouse gas emissions. All new motors will be high efficiency and gravity flows will be used where possible to help maximize the efficiency of the proposed facility. The reuse of existing equipment also eliminates the carbon footprint associated with the manufacture and transportation of new equipment.

## 6.4 Flotation

The Project includes flotation equipment to separate the metal bearing minerals (concentrate) from the waste material (tailings). There is no other technology commercially available to perform this operation. New flotation equipment specific to sulfide ores will be installed by PolyMet with high efficiency motors. This will help make the flotation process as efficient as possible.

## 6.5 Smelting

Smelting is a potential alternative to the hydrometallurgical process proposed for the Project. However, the hydrometallurgical process is expected to provide better metal recoveries for the NorthMet ore and result in lower environmental impacts due to much lower $SO_x$ emissions. In the smelting process, sulfur in the concentrate is emitted to the air in oxide form, while in the hydrometallurgical process, sulfur ends up in the leach solution exiting the autoclave prior to being converted to a stable solid gypsum form. More details on the comparison between smelting and hydrometallurgy are presented in Section 4.0 of this report.

## 6.6 Waste Heat

The use of waste heat from the autoclaves to heat the Hydrometallurgical Plant buildings was considered to reduce fuel usage for space heating. This option would have resulted in a potential reduction of 19962 metric tons of $CO_2$ equivalents per year, but it is no longer being considered due to concerns over possible changes to the Project water balance. This option is discussed further in Section 7.1.1.

The recovery of heat from the Autoclave exhaust would involve a heat exchanger in the gas stream. The autoclave exhaust is at a relatively low temperature and contains mostly water. Therefore, the recovery of heat would condense water out of the exhaust stream. A overall design objective for the Project is to keep the Hydrometallurgical Plant (closed system – lined residue facility) and beneficiation (closed system –

unlined tailings facility – excess water treated and discharged) water separate because of the very different natures of the water. Adding condensed water from the autoclave exhaust to the Hydrometallurgical Plant water would adversely affect the Hydrometallurgical Plant water balance (i.e. there would be a surplus of water). Also exchanging heat from the relatively low temperature vent stream is unlikely to be very efficient. Detailed design for the heating system in the Hydrometallurgical Plant has not been completed to date, but heat radiated from the hydrometallurgical process would reduce the heating demand, so some heat would be recovered even without installation of a dedicated heat exchanger.

The combination of uncertain benefits and negative effects on the Hydrometallurgical Plant water balance make the recovery of waste heat from the Autoclave exhaust technically infeasible.

# 7.0 Direct Emissions from Fuel Combustion

## 7.1 Space Heater Emissions

### 7.1.1 Process Plant Space Heating

Emissions from natural gas fired space heaters in the Process Plant account for a majority of the fuel combustion emissions. These emission units contribute approximately 34% of the total direct GHG emissions. Options for space heating are ranked in Table 6 below in order of estimated maximum annual emissions.

**Table 6 Process Plant Space Heating Source Ranking**

| Rank | Source | Estimated Max Emissions [1] (m.t. $CO_2$ –e / yr) | Feasible? | NorthMet Selection |
|---|---|---|---|---|
| 1 | Autoclave Waste Heat Recovery & Natural Gas Heaters | 52,289 | No | No |
| 2 | Natural Gas Heaters | 63,819 | Yes | Yes |
| 3 | Propane Heaters | 162,355 | Yes | No |
| 4 | Electric Heaters | 313,184 | Yes | No |

1. Please see Appendix D, Table D-1 for calculation details.

The Project's options for space heating include natural gas or propane fueled heaters, as well as electric heaters. Another potential option is to recover waste heat from the autoclave exhaust for building heat in the Hydrometallurgical Plant. Of these options, only autoclave waste heat recovery affords an opportunity for space heating-related emissions reductions. Waste heat recovery (and subsequent use in building space heating) could result in an approximately 18% reduction in the amount of the natural gas required for heating. However, this option could negatively affect the Project water balance (see Section 6.6. for details). PolyMet has chosen to use natural gas fired space heaters, which will emit significantly fewer GHGs than using propane or electricity for heating

In addition to selecting a low emitting fuel for space heating, the Project design will recycle, where practical, the exhaust from the emission controls utilizing cartridge type filtration for the Coarse Crusher, Drive House #1, Fine Crusher and Concentrator Buildings thereby reducing the amount of unheated ambient make up air drawn into the building. Any emission control system exhaust recycled back into a building will pass through a supplemental HEPA filter. Two potential suppliers of HEPA filters have

been contacted. Both indicate that these filters are capable of achieving 99.97% efficiency on 0.3 micron particles. The recycling back into the building is seasonally dependent for some collectors, while others will discharge back into the building year round. The recycling of emission control exhaust will reduce the space heating requirements at the Plant Site as it allows for reuse of air that has already been heated, rather than only passing it through the system one time. This will reduce fuel usage and therefore GHG emissions. The estimated reduction in potential fuel usage is 197.2 MMcf/yr which results in reduced potential GHG emissions of 11,052 metric tons of $CO_2$ equivalents per year.

The installation of additional insulation in the existing 1950's vintage Coarse Crusher, Drive House #1, Fine Crusher and Concentrator Buildings at the Process Plant has also been incorporated into the Project design. This will result in a reduction in potential natural gas usage of 298.7 MMcf/yr, which results in reduced potential GHG emissions of 16,736 metric tons of $CO_2$ equivalents per year.

### 7.1.2 Area 1 Shop & Area 2 Shop Space Heating

Options for space heating are shown in Table 7 below for the Area 1 Shop and Area 2 Shop, truck maintenance and railroad maintenance shops, respectively. Area 2 will also be used as the Mine Site operations headquarters and personnel staging area.

**Table 7 Area 1 Shop & Area 2 Shop Space Heating Source Ranking**

| Rank | Source | Estimated Max Emissions [1] (m.t. $CO_2$ –e / yr) | Feasible? | NorthMet Selection |
|---|---|---|---|---|
| 1 | Natural Gas Heaters | 8,416 | No | No |
| 2 | Propane Heaters | 10,486 | Yes | Yes |
| 3 | Electric Heaters | 47,720 | Yes | No |

1. Please see Appendix D, Table D-3 for calculation details.

Space heating in the Area 1 Shop and Area 2 Shop will be provided by propane fired space heaters. Natural gas is not available to heat the Area 1 Shop and Area 1 Shop locations. The natural gas line extends only to the main plant site, and the Area 1 and Area 2 shops are not in that location. Because the heaters in the shop account for only a small amount of the Project's total GHG emission totals, PolyMet believes that running a natural gas line to the shops is not worth the environmental and safety risks, and is not cost-effective.

## 7.2 Emissions from Diesel Powered Sources

GHG emissions from mobile sources, generators, and fire pumps involved with the Project are calculated assuming that the equipment will be diesel powered. Other fuel options are ranked in Table 8 in order of GHG emission factors.

**Table 8 Options for Mobile Sources, Generators, and Fire Pumps**

| Rank | Fuel | $CO_2$ Emission Factor[4] (kg $CO_2$ / MMBtu) | Feasible? | NorthMet Selection |
|---|---|---|---|---|
| 1 | Biodiesel[1] | 0 | No | No |
| 2 | Compressed Natural Gas[2] | 52.58 | No | No |
| 3 | Diesel[3] | 73.18 | Yes | Yes |

1. Based on Factor from Table 13.1 of The Climate Registry GRP, using National Biodiesel Board heating value of 118,296 Btu/gal for B100. (http://www.biodiesel.org/pdf_files/fuelfactsheets/BTU_Content_Final_Oct2005.pdf), biogenic $CO_2$ emissions from biodiesel combustion would be 79.97 kg CO2/MMBtu

Note that $CO_2$ emissions from biodiesel combustion are considered "biogenic" and reported separately.

2. Factor from Table 13.1 of The Climate Registry GRP, converted using 1,027 Btu/scf from Table 12.2.

3. "Distillate Fuel Oil No. 1 and 2" Factor from Table 13.1 of TCR GRP.

4. Please see Appendix D, Table D-2 for calculation details.

Though the biodiesel emission factor is the largest, emissions from biodiesel combustion are considered biogenic, meaning that the source of carbon was recently contained in living organic matter. The Climate Registry GRP guidance requires that $CO_2$ emissions from biodiesel combustion be tracked and reported separately. Because biodiesel is typically produced from soybeans, which during their growth consume $CO_2$ from the atmosphere and are renewable, Table 8 above ranks biodiesel first (that is, the option with fewest GHG emissions).

However, biodiesel fueled trucks and equipment are not feasible for the Project because availability of the fuel is limited and because of operational issues with biodiesel at low temperatures.

Compressed natural gas (CNG) trucks are also infeasible because their availability is limited and because they are not cost-effective. Natural gas fired trucks would also have higher $NO_x$ emissions, which would potentially increase visibility impacts.

Therefore, diesel fueled equipment is proposed for the Project's mobile sources, generators, and fire pumps.

EPA's National Clean Diesel Campaign (NCDC) promotes clean air strategies by working with manufacturers, fleet operators, air quality professionals, environmental and community organizations, and state and local officials to reduce diesel emissions. EPA recommends a wide range of emission reduction strategies for diesel vehicles, vessels, locomotives, or equipment.[4] Clean diesel technologies relevant to GHG emission reduction are primarily centered around improved fuel economy or idle reduction strategies. PolyMet will work throughout the life of the Project to achieve maximum fuel economy and reduce idling time.

### 7.2.1 Light Truck Traffic

It should be noted that the light truck traffic associated with the Project will most likely include gasoline fueled vehicles as well as diesel fueled vehicles. However, PolyMet is uncertain of how many light truck vehicles will utilize which fuel. As shown in Table 9 below, gasoline and diesel emission factors are very similar. To be conservative, emissions are calculated with a diesel emission factor.

**Table 9 Fuels Comparison for Light Truck Traffic**

| Fuel | $CO_2$ Emission Factor[2] (kg $CO_2$ / MMBtu) |
|---|---|
| Gasoline[1] | 70.44 |
| Diesel | 73.18 |
| E85 | 66.70 |

1. Based on Factor from Table 13.1 of The Climate Registry GRP, and heat content of 125.07 MMBtu/Mgal from MPCA General Guidance for Carbon Footprint Development in Environmental Review.
2. Please see Appendix D, Table D-2 for calculation details.

An additional option for gasoline powered vehicles would be to use E85 (i.e. 85% ethanol blended with 15% gasoline). PolyMet is willing to consider use of E85 in the Project light vehicle fleet, but its usage would be contingent on the availability of appropriate fleet vehicles for purchase or lease, relative operating costs and warranty and maintenance issues.

The estimated annual gasoline usage for the project is about 51,000 gallons. Gasoline will be stored in two above ground tanks. It is likely that at least one tank would remain in gasoline service to refuel vehicles that are not capable of burning E85.

The potential effect of using E85 would be a reduction of about 26 metric tons of direct greenhouse gas emissions. Beyond this, of the estimated 421.3 metric tons per year of greenhouse gas emissions from E85 usage, 84% would be classified as biomass emissions (from ethanol combustion) for the purpose of

[4] http://www.epa.gov/cleandiesel/basicinfo.htm

calculating carbon footprint. The carbon neutrality of biomass emissions is contingent on the details of how efficiently the ethanol is produced. Fuels and fertilizer used in corn farming and other fossil fuel usage during ethanol production can result in ethanol having a net carbon footprint.

Regardless of the details of the carbon footprint analysis, projected emissions from gasoline usage only contribute 0.2% of the total direct greenhouse gas emissions for the Project. With a relatively small and uncertain benefit from the use of E85, PolyMet is willing to substitute this fuel where economics and operational performance is similar or superior to gasoline.

### 7.2.2 Electric Mining Equipment

PolyMet plans on using some electric mining equipment instead of diesel where feasible. The two primary excavators are electric and there are also two electric drill rigs which will be used. However, the diesel powered secondary production excavator and one blast hole drill rig will need to operate at times where electric hookups are not yet available in newly developed mining areas.

## 7.3 Locomotive Emissions

There are few feasible options for reducing GHG emissions from PolyMet's Switching Locomotive and Main Line Ore Haulage Locomotives. However, PolyMet has investigated alternate locomotives and has elected to purchase new Gen-Set locomotives instead of used conventional locomotives. The conventional locomotives have a single 2,000Hp to 3,000Hp diesel engine driving a single electric generator that powers electric traction motors. The Gen-Set locomotives have three or four 700Hp to 750Hp diesel engines that meet EPA Tier III off-road standards, driving individual electric generators that power electric traction motors. The Gen-Set diesel engines start and stop automatically as required by loading demands. For example, when at idle, one 700 or 750Hp engine is running, when pulling uphill, loaded, all three or four engines may be running. The Project application involves hauling loaded cars uphill (high loading demand), hauling empty cars downhill (low loading demand) and moving trains one car length at a time for loading at the rail transfer hopper and unloading at the coarse crusher (low loading demand). This variable demand results in improved efficiency and lower fuel usage for the Gen-Set locomotives when compared to conventional locomotives, and lower fuel usage corresponds to reduced emissions of $CO_2$ and other greenhouse gasses. The estimated annual greenhouse gas reduction from using the Gen-Set locomotives for ore hauling is 1,588 metric tons of carbon dioxide equivalents.

# 8.0 Direct Emissions from Sulfuric Acid Neutralization

The largest single sources of direct $CO_2$ emissions at the Process Plant will be the solution neutralization and iron and aluminum precipitation tanks, which will neutralize sulfuric acid in the Hydrometallurgical Plant. The sulfuric acid can be managed by one of four methodologies, described below.

One option would be to not produce sulfuric acid. By design, the Project pressure oxidation process essentially fully oxidizes all sulfur present in the flotation concentrate to sulfate (sulfuric acid) using high temperature, pressure, and oxygen gas. This approach is efficient and is capable of leaching gold and platinum group metals (AuPGM). There are low and medium temperature leaching technologies that do not fully oxidize sulfur to sulfate, but they produce elemental sulfur that would have to be recovered. Further, iron is leached as a sulfate, which requires further processing before being converted into a stable species (such as hematite) and stored in the Hydrometallurgical Residue Facility. These low and medium temperature processes are incapable of leaching AuPGM, which is a significant component of the valuable metals for the Project. Therefore, the low and medium temperature processes do not meet the purpose of the Project.

A second option is to use sulfuric acid to leach another compound that might consume the sulfuric acid in the process. This may or may not emit GHGs, depending upon the compound leached. A common method is to use acid in spent raffinate of pregnant liquor to leach an oxide ore as part of a heap leach operation. The leach liquor is returned to the main process plant for recovery of metals from solution. However, PolyMet is not proposing heap leaching or any other process step that would consume sulfuric acid, so this methodology cannot be applied.

Sulfuric acid could also be recovered and sold. The acid in leach liquors is typically 80-180 g/l. However, the final concentration obtained is not of commercial quality for sulfuric acid, e.g., 98% (w/w). Because a marketable product would not be produced, this methodology cannot be applied.

Finally, the sulfuric acid could be destroyed. It is a common practice to neutralize sulfuric acid using limestone to form stable inert gypsum ($CaSO_4.2H_20$) and carbon dioxide gas ($CO_2$). Hydrated lime may also be used to destroy the sulfuric acid. Unlike limestone, hydrated lime does not generate $CO_2$ on contact with sulfuric acid. However, because hydrated lime is a strong base, it increases pH levels in solution well above those levels that limestone generates. The increased pH would precipitate all metals from solution at once. Precipitating metals from solution separately in separate reaction tanks is critical

to generating the Project's separate metal streams and waste streams. Neutralizing with hydrated lime does not meet the purpose of the Project.

Based on this investigation, neutralization of the sulfuric acid with limestone is the only practicable solution for the Project.

# 9.0 Indirect Emissions from Power Production

Potential indirect $CO_2$ emissions from power production for the Project are estimated to be approximately 511,000 metric tons per year (Table B-1; Attachment B).

The limited available data do not allow for a quantitative comparison of potential indirect emissions related to electric power generation for the Project and European smelting operations. Therefore, it is uncertain whether smelting operations would have lower or higher electrical demand than the Project.

The Project is expected to require 59.5 MW of power, which will be supplied by Minnesota Power. According to the MPCA General Guidance for Carbon Footprint Development in Environmental Review, Minnesota Power has the second highest $CO_2$ emissions per megawatt-hour among Minnesota electrical providers as shown in Table 10.

**Table 10 Minnesota Electrical Provider Ranking**

| Minnesota Electrical Provider Ranking | | | | |
|---|---|---|---|---|
| **Rank** | **Electricity Provider** | **$CO_2$ Emission Factor** (lb $CO_2$ / MWH) | **Connection Feasible?** | **NorthMet Selection** |
| 1 | Xcel Energy | 1,317.17 | No | No |
| 2 | Alliant Energy | 1,782.2 | No | No |
| 3 | Otter Tail Power | 2,099.9 | No | No |
| 4 | Minnesota Power | 2,159.5 | Yes | Yes |
| 5 | Great River Energy | 2,202.2 | No | No |

PolyMet's ability to change electricity suppliers—whether to reduce their indirect carbon emissions or for other reasons—is limited by variety of legal and practical barriers. First, in 1999 and 2000, at about the same time federal regulators were restructuring the wholesale electricity industry, Minnesota regulators and legislature also considered deregulating the *retail* electricity industry. See, e.g., Minnesota Public Utility Restructuring Docket No. E, G-999/CI-99-687. However, that state initiative ended by 2001 with the collapse of Enron and the California energy crisis. As a result, with some limited exceptions, retail customers in Minnesota still must purchase their electricity from their state-designated electricity

provider. Second, as summarized below, none of the exceptions in Minn. Stat. §216B.40 are likely applicable to PolyMet.

## 9.1 Exclusive Electric Service Territories

In order to promote "the orderly development of economical statewide electric service" the 1974 Minnesota legislature granted electric utilities exclusive service rights within designated service areas. Minn. Stat. §216B.37.

## 9.2 Service Territory Exceptions

Under Minn. Stat. §216B.40, a utility must serve every customer within its assigned service area and must not serve any customer located anywhere else. However, Minnesota's service territory statute also carved out the following four exceptions to the general rule:

1) If the other utility consents in writing. Minn. Stat. §216B.40
2) In order to serve one utility's property and facilities, even if the property and facilities were in another utility's assigned service area. Minn. Stat. § 216B.42, subd. 2.
3) In order to serve buildings located within another utility's assigned service area if those buildings (a) were located on homestead property that lay at least in part within the assigned service area of the utility seeking to serve; and (b) were under construction as of April 11,1974. Minn. Stat. §216B.421
4) In order to serve very large customers located outside municipalities and within other utilities' assigned service areas, if the Commission found such service to be in the public interest after notice and hearing and consideration of six statutory factors. Minn. Stat. §216B.42, subd. 1.

## 9.3 §216B.42 Exception

Minn. Stat. §216B.42, subd. 1 provides a list of six factors that the Minnesota Public Utilities Commission is to use to evaluate whether to apply the exception:

Subdivision 1. Large customer outside municipality.

Notwithstanding the establishment of assigned service areas for electric utilities provided for in section 216B.39, customers located outside municipalities and who require electric service with a connected load of 2,000 kilowatts or more shall not be obligated to take electric service from the electric utility having

the assigned service area where the customer is located if, after notice and hearing, the commission so determines after consideration of following factors:

1) the electric service requirements of the load to be served;
2) the availability of an adequate power supply;
3) the development or improvement of the electric system of the utility seeking to provide the electric service, including the economic factors relating thereto;
4) the proximity of adequate facilities from which electric service of the type required may be delivered;
5) the preference of the customer;
6) any and all pertinent factors affecting the ability of the utility to furnish adequate electric service to fulfill customers' requirements.

## 9.4 Municipal Exclusion

At the time that the legislation was passed in 1974, some municipalities were concerned that rural cooperatives would use the law to move into areas already served by municipal electric utilities. Therefore, the law makes it clear that the exception only applies to rural areas located outside municipal boundaries.

## 9.5 Public Utility Commission Application of §216B.42

The §216B.42, Subd. 1 exception has been used only infrequently. However, the few times the Minnesota Public Utilities Commission has addressed the issue, it has consistently denied the request on public policy grounds. See, e.g., *In the Matter of the Exception to the Assigned Service Area Agreement Between Northern States Power Company d/b/a Xcel Energy and Wright-Hennepin Cooperative Electric Association*, Docket No. E-002, 148/SA-01-1123, (August 13,1996) (Order Rejecting Challenge to Exception Agreement); and *In the Matter of Otter Tail Corporation d/b/a Otter Tail Power Company to serve the ethanol plant being developed by Otter Tail Ag Enterprises, LLC*, Docket No. E-119,017/SA-06-665 (Request denied, overturning Administrative Law Judge Recommendation).

In the 2007 *OtterTail* decision, for example, the Public Utilities Commission emphasized that the exclusive service territory rules:

> "have been the quid pro quo for utilities' obligations to build, buy, or lease the capacity necessary to serve all comers. That is why the Legislature considered exclusive service arrangements essential to the development of reliable and adequate electric service

> throughout the state. The centrality of assigned service areas to Minnesota energy policy means not only that Otter Tail has the burden of proof in this case but that proper analysis of its petition must occur within the context of the broad public policy goals articulated in Minn. Stat. § 216B.37."

Also, as summarized in the *OtterTail* decision, the Commission has not historically read § 216B.42, subd. 1 as a statute designed primarily to facilitate customer choice. Instead, the Commission has primarily read the exception as one designed to ensure that new industrial customers in rural areas receive adequate electric service without (a) imposing hardship on small rural utilities, who might be incapable of serving large new loads without unreasonably high levels of new investment or (b) imposing hardship on new industrial customers, who might otherwise face the excessive rates required to support unreasonably high levels of new investment. Neither of these conditions appear to apply to the Project.

## 9.6 Applicability to the NorthMet Project

The §216B.42, Subd. 1 exception does not apply to the Project in this case for two regulatory reasons, as well as two practical reasons. First, Minnesota Power's proposed point of delivery to the Plant Site is located within the City of Hoyt Lakes, and the proposed point of delivery for the Mine Site is in the City of Babbitt. Therefore, the §216B.42, Subd. 1 exception does not apply because the service delivery point is located within the municipalities. Second, even if the points of delivery were located outside of municipalities, the Commission is not likely to grant the exception based on public policy grounds, as described above. Third, the exception is intended primarily to address service territory extensions between neighboring service providers, not to allow a large customer to purchase retail electricity directly from a remote generator or supplier. Fourth, PolyMet already has an existing Electric Services Agreement with Minnesota Power that has been approved by the Commission.

## 9.7 Self-Generation Exception

PolyMet could also decide to construct and operate its own electricity generation facility. However, PolyMet is not in the electricity generation business, and the technical and business complications involved in developing a self-generation option is outside the scope of reasonable alternatives to reducing its carbon emissions at this time. (The potential for self-generation, however, did trigger legislation allowing utilities to negotiate separate rate agreements to defer the construction of such generation facilities. See Minn. Stat. §216B.1621; and *In the Matter of the Application by Koch Refining Company for Certification of the Pine Bend Cogeneration Project*, MPUC Docket, No. IP 2/CN-95-1406.

It is expected that the Minnesota Power emission factor for electricity purchases will be lowered over time as more biofuels and renewable energy sources are used for power production at those facilities. The Next Generation Energy Act of 2007 requires that 25% of the energy used in the State of Minnesota be derived from renewable resources by 2025. Under a consent agreement, EPA is obliged to issue guidance that requires the states to implement performance standards for GHGs for existing power plants under Section 111d of the CAA. Additional reductions of GHG emissions may be developed at individual Minnesota power plants through voluntary actions designed to meet GHG emission reduction goals (15% by 2015, 30% by 2025, 80% by 2050) in the Next Generation Energy Act. Similarly, reductions may come from energy efficiency improvements or new fuels developed through new energy projects or research funded under the Next Generation Energy Act.

As the GHG emissions from power production decline, the potential indirect $CO_2$ emissions for the Project may also decline. It is currently uncertain as to how much an individual facility using power from the Mid-Continent Area Power Pool (MAPP) grid will benefit from GHG emission reductions at specific electric generating facilities. However, the overall effect of the initiatives discussed above is likely to be a reduction in GHG emissions related to power production.

# 10.0 Terrestrial Carbon Cycle Impacts

Terrestrial carbon cycle impacts encompass any carbon emissions or loss of carbon sequestration capacity from disturbed terrestrial ecosystems over time due to Project activity. The present estimates of carbon cycle impacts are highly uncertain and use simplifying assumptions about wetlands and forest, many of which lack site-specificity. In addition, some of the emission sources documented may be longer lived than the Project and may change substantially over time, resulting in temporal uncertainties that complicate the quantification of carbon cycle impacts. Despite these uncertainties, quantitative estimates for six carbon cycle impacts are calculated in this section:

1) Total carbon stored in the above-ground vegetation of wetlands and forests lost to Project activities [treated as a one-time emission]
2) Total carbon stored in excavated peat and annual emissions from its stockpiling
3) Possible carbon flux from peat used in reclamation activities
4) Annual emission rate for indirectly impacted wetlands due to potential water level drop
5) Loss of annual carbon sequestration capacity due to the disturbance of wetland and forest plant communities discounting methane emissions from wetlands as a conservative assumption.
6) Reduction in annual carbon sequestration capacity in indirectly impacted wetlands

## 10.1 Aboveground Carbon Lost from Impacted Forests and Wetlands

Wetlands and especially forests hold substantial proportions of their overall carbon in aboveground vegetation. For areas directly impacted by the Project, this vegetation will likely be buried or removed at some point in time during the preliminary construction period or 20 year period of operations. Despite the likelihood that some substantial proportion of this biomass will be buried or used to produce long-lived products (e.g., lumber) and that the vegetation may be removed in stages over a prolonged period, this assumes that all of this carbon is emitted as a one-time release of $CO_2$. The aboveground wetland and upland forest carbon stock loss due to direct Project impacts is a theoretical maximum of the amount of carbon dioxide stored in this aboveground vegetation. Values for the total amount of carbon stored per unit surface area have been developed from the scientific literature and combined with plant community-specific surface area in order to generate total carbon stock estimates.

The carbon storage values from the literature (see Attachment E for more detailed assumptions and calculations) were multiplied by the corresponding acreage, surface area conversion factors, and carbon-

to-$CO_2$ conversion factors to generate a potential $CO_2$ stock, which is summarized in Table 11. It should be noted that some of the values available were based on wetland and forest types that were not an exact match to those documented at the Project site, but were deemed to be close in terms of age, vegetation, and other characteristics.

In addition to wetland and forest aboveground carbon, we present the central estimate of carbon contained in excavated and stockpiled peatlands. This estimate places the aboveground carbon estimates in the context of the much larger carbon stock contained in the layers of peat. Unlike much of the aboveground biomass, it is known that the majority of this peat will have its exposure to the atmosphere minimized through stockpiling, thereby reducing the rate of oxidation to $CO_2$.

**Table 11 Emissions from Wetlands and Upland Forest Aboveground Carbon**

| **Source** | **Pollutant** | **Emission Rate** ($CO_2$-e m.t./acre/yr) | **Estimate Type [1]** |
|---|---|---|---|
| Emissions from indirectly impacted wetlands [2] | $CO_2$ | 7.41 | High estimate |
| **Source** | **Pollutant** | **Single Emission** ($CO_2$-e m.t.) | **Estimate Type [1]** |
| Total aboveground wetland carbon stock directly impacted by the Project [3] | $CO_2$ | 65,495 | High estimate |
| Total aboveground forest carbon stock directly impacted by the Project [4] | $CO_2$ | 102,052 | High estimate |
| **Source** | **Pollutant** | **Carbon Stock** ($CO_2$-e m.t.) | **Estimate Type [1]** |
| Total carbon stored in excavated peatlands [5] | $CO_2$ | 1,309,000 | Central tendency |

**Units = $CO_2$-e, m.t. = GHG emissions as $CO_2$-equivalents, in metric tons**

[1] Theoretical max: maximum value possible given physical variables; High estimate: high degree of confidence that estimate is above actual value; Central tendency: best estimate of actual value; Unknown: low level of confidence in relationship to actual value

[2] Assumes carbon emission rate[5] of 500 g/$m^2$/yr, which coincides with rates from drained and relatively undisturbed peat

[3] Assumes treatment of all aboveground carbon stored in impacted wetlands as a one-time carbon dioxide emission

[4] Assumes treatment of all aboveground carbon stored in impacted upland forest as a one-time carbon dioxide emission

[5] Based on site studies of peat in overburden.

[5] Grønlund, A., A. Hauge, A. Hovde, and D.P. Rasse. 2008. Carbon loss estimates from cultivated peat soils in Norway: a comparison of three methods. Nutrient Cycling in Agroecosystems. 81(2):157-167.

The aboveground carbon estimates should not be interpreted as a mass of $CO_2$ emitted to the atmosphere over a specific timescale, but rather should represent the upper limit on carbon dioxide that could hypothetically result from the disturbance of aboveground biomass in site wetlands and forests. The probability of all disturbed wetland and forest aboveground carbon being converted to $CO_2$ over a short timescale (e.g., 1 year) is low, given the value of long-lived forest products (e.g., lumber), the recalcitrance of much of the woody forest material, and the fact that the impacts may take place in stages over the course of operations.

The section, "Emission from Stockpiled Wetlands" below, details the calculation of the annual emissions from the peatland stockpiling, which presents more realistic estimates of the annual emissions likely to result from impacted peatlands than the assumption of a one-time loss of all peatland carbon. Due to uncertainty about the treatment of non-stockpiled wetland and upland forest biomass, the same sort of analysis was not done for materials from these ground cover types.

## 10.2 Carbon Sequestration Capacity Loss in Impacted Wetlands and Forests

Carbon sequestration capacity represents the expected flux of $CO_2$ into wetland or forest systems for use in a number of processes, including photosynthesis and chemosynthesis, which incorporate the inorganic carbon into stable organic material. When wetlands and forests are disturbed, this can drastically affect the amount of carbon that they can take up. The analysis that we present assumes that all of the carbon sequestration capacity in directly impacted areas is lost. This is an overestimate of the expected loss of capacity for two reasons: (1) the impacts on wetlands and forest will not all take place instantaneously, and some areas may not be impacted until quite a bit later in the project; and (2) the degree of overall impact is not likely to be a complete loss of biological function and carbon sequestration, especially for lightly impacted wetlands and forests. See Attachment E for more detailed assumptions and calculations.

The carbon sequestration rates were multiplied by the corresponding acreage, surface area conversion factors, and carbon-to-$CO_2$ conversion factors to generate the potential loss of carbon sequestration capacity, which is summarized in Table 12.

**Table 12 Loss or Reduction of Carbon Sequestration Capacity**

| Source | Pollutant | Capacity Loss ($CO_2$-e m.t./yr) | Estimate Type [1] |
|---|---|---|---|
| Wetland sequestration capacity loss from direct impacts | $CO_2$ | 1,168 | Central tendency |
| Wetland sequestration capacity reduction from indirect impacts | $CO_2$ | [2] | Unknown |
| Upland forest sequestration capacity loss from direct impacts | $CO_2$ | 1,814 | Central tendency |

**Units = $CO_2$-e, m.t. = GHG emissions as $CO_2$-equivalents, in metric tons**

[1] Theoretical max: maximum value possible given physical variables; High estimate: high degree of confidence that estimate is above actual value; Central tendency: best estimate of actual value; Unknown: low level of confidence in relationship to actual value

[2] The wetland capacity reduction in indirectly impacted wetlands is based on a reduction from 0.7 metric tons C/ha/yr (sequestration rate for peatlands) to 0.33 metric tons C/ha/yr (sequestration rate for mineral wetlands), 3.34 metric tons $CO_2$/acre/year.

The loss of carbon sequestration capacity is treated here as a separate issue from the potential for post-disturbance carbon emissions, though, mechanistically, emission/sequestration are just opposite directions of carbon flux from a defined ground surface area. Carbon sequestration loss for indirectly impacted wetlands is expressed on a per acre basis as total indirect wetland impact acreages were not finalized at the time of this report was drafted.

## 10.3 Emissions from Stockpiled Wetlands

Emissions from the direct removal and stockpiling of wetland material alone and mixed with other overburden material have been calculated using fundamental information about the surface area of the stockpiles, the carbon content of and oxygen diffusion into representative wetland organic material, and pertinent data from disturbed wetlands emissions studies. Below, an analysis of the potential carbon emissions that may occur upon dredging wetlands and relocating the dredged material to stockpiles during the life of the Project is presented. Dr. David Grigal, Professor Emeritus in Soil Science at the University of Minnesota, provided assistance in estimating the quantity of carbon excavated and carbon dioxide emissions from dewatered and stockpiled peat at the Mine Site. The analysis described in detail is for the peat that will be excavated under the stockpile footprints and at the mine pits. Additional peat will be excavated at the tailings basin and for dike and ditch construction at the Mine Site. These additional quantities are described following the detailed description.

The Project will involve the excavation of peat as part of the mining operation, causing the release of long stored carbon. This peat will be stored in stockpiles for a period of time and then used in site reclamation

upon closure. In order to calculate the potential carbon emissions from this material, two parameters must be estimated: the amount of wetland carbon removed, and the fraction of this disturbed material that is emitted as $CO_2$.

### 10.3.1 Amount of Wetland Carbon Removed due to Mining Activities

In order to calculate the amount of carbon released during such peat removal processes, a reasonable estimate of the total mass of carbon (C) that will be disturbed by the mining operation must be generated. In the June 2009 NorthMet Project Climate Change Evaluation Report, five different estimates of total C removed were generated, ranging from slightly over 200,000 tons to nearly 750,000 tons. The methodologies behind these estimates are described in detail in the June 2009 report. The report concludes that the methodology developed by Barr for estimating the mass of peatland C disturbed by the Project is an appropriate methodology and produces results that are in line with the results of alternate methodologies. For this report, the "Barr" methodology has been used to update the estimate of carbon removed. This methodology is described in further detail below.

#### *10.3.1.1 "Barr" Methodology*

The "Barr" estimate of C removed was based on the results of total estimated peat removal from estimates of peat stripping over a 20-year period (728,450 tons). The quantity of peat excavated to construct stockpile foundation and liner systems and at the mine pits is based on the peat volume values in Table 4-1 of the NorthMet Project Mine Plan (Version 1, November 29, 2011), which lists the total volume of peat excavated as 2,491,000 cubic yards. A density value of 0.25 tons per cubic yard was used to arrive at the total mass per the recommendation of the Project soil scientists with a result of 622,750 tons of peat. An additional 66,400 tons of peat will be excavated at the Tailings Basin and an additional 39,200 tons will be excavated at the Mine Site for miscellaneous purposes as described below. The total peat excavated then equals 728,450 tons. The 728,450 tons was converted to tons of organic matter, and then to tons of C. To convert the peat mass to organic matter, summary data from a comprehensive study of 10 northern Minnesota peatlands, sampled with an average of four detailed cores per peatland, was used (Grigal and Nord, 1983). The peatlands were evenly divided between bogs and fens, and organic material ranged from hemic to fibric. Sampling was done by 25-cm (10-inch) depth increments. Average ash content of all samples to a 200-cm depth (80 inches) was 10.9 percent, so that LOI was 89.1 percent of peat mass. That mass was converted to C using the relationship described above (C = LOI * 0.55). The resulting estimated mass of C removed was 357,000 tons (Fig. 2).

### 10.3.2 Surface Area of Stockpiled Wetland Material

The surface area of the peat stockpiles at the Mine Site was calculated using information from discussions with PolyMet regarding a peat stockpiling plan. A footprint of approximately 22 acres has been allocated for a peat stockpile with a maximum height of 40 feet. The volume and surface area of the stockpile exposed to the air was estimated based on two assumptions: 1) there would be no ramp needed for access; 2) the slopes of the sides of the stockpile would be 3.5:1. The resulting volume of this stockpile is 1,029,493 $yd^3$, and the surface area is 986,501 $ft^2$.

The balance of peat would be used for ongoing reclamation activities during mine operations. As indicated above, the total volume of peat excavated is estimated at about 2.5 million cubic yards, so the volume used for reclamation during operations is about 1.5 million cubic yards.

This estimated stockpile surface area will be larger than the effective surface area over most of the Project timeframe in that it assumes the stockpile is always at its maximum size. During the early years of the project, the surface area would be substantially less. Therefore, calculation of an annual $CO_2$ emission rate based on the above peat surface area will result in a maximum value.

### 10.3.3 Amount of Carbon Released from Stockpiled Wetland Material

In order to estimate the amount of carbon eventually released to the atmosphere due to the removal and stockpiling of wetland material, assumptions must be made about physical characteristics of the stockpiling process. As described in the previous section, the surface area for storage of the removed and stockpiled wetland material is assumed to be approximately 58 acres, including both a stockpile exclusively for peat (22 acres), and for peat intermixed with mineral overburden (with peat at the surface over about 36 acres). This estimate represents a maximum surface area, because the actual surface area at any point in time would be the sum of additions during the stripping operation and removals for site remediation/reclamation, and would often be less than this value.

#### *10.3.3.1 Carbon Emissions from Organic Materials*

The characteristics of the organic material are critically important when considering C emissions. Organic material varies in its recalcitrance, resistance to microbial degradation. Very fresh material, high in nutrients and especially in nitrogen (such as fresh leaves), will be broken down quite quickly, emitting nearly all the C that it contains. However, other organic materials (such as wood) break down slowly. Similarly, organic materials from wetlands (peat) can be considered relatively recalcitrant. They are the residual remaining after a long period of microbial degradation, and as such are the most resistant fraction of the original material.

For example, in peatlands in Itasca County in northern Minnesota, long-term rates of peat accumulation (over the last approximately 9000 years) are uniform at about 0.25 tons/ac/yr (Gorham et al., 2003). This is only about 20% of annual production on such peatlands (Grigal and Bates, in preparation; Reich et al., 2001; Weishampel et al., 2009). This remaining 20% of production is the most recalcitrant material; less resistant material has been broken down by microorganisms with release of $CO_2$. Stockpiles of peat material will therefore not break down (and release C as $CO_2$) as quickly as would stockpiles of fresh organic materials such as lawn clippings and leaf litter.

#### *10.3.3.2 Approaches*

There are at least three approaches to estimating C loss from peat piles from stripping operations. They should provide boundary conditions on rates of such loss:

1) Measured rates of peat loss following drainage for agriculture or forestry,
2) Information on $CO_2$ emissions from stockpiles of peat from peat mining operations, and finally
3) A simple model of rates of oxygen movement (diffusion) into peat, which can be used to evaluate the reasonableness of the reported rates of C emission. Oxygen is required by microorganisms as they oxidize organic materials to $CO_2$.

#### *10.3.3.3 Peat loss following drainage*

There have been many studies of loss of peat mass or elevation following drainage, primarily in northern Europe. Loss of elevation of peat, termed peat subsidence, results from the combined effects of both compaction and C loss as $CO_2$ through activity of microorganisms. Subsidence due to compaction occurs primarily during the first few years following drainage, as soil pores that were originally filled with water collapse. This is largely a phenomenon of surface peat; subsurface peat is more compact because it has already been compressed because of the mass of overlying material. Long-term rates of subsidence, following the initial period of peat compression, generally reflect C loss.

Reported long-term rates of subsidence include 7 mm/yr (Netherlands), 10 to 20 mm/yr (both Russia and Scandinavia), 10 to 14 mm/yr (Poland), and 11 to 22 mm/yr (Germany) (Bradof, 1992). Measured subsidence in drained areas of the Red Lake Peatland, northern Minnesota, averaged 3 to 10 mm/yr since 1916. All these rates are surprisingly similar, and 10 to 20 mm per year seems to be a reasonable average.

That rate can be translated to C loss with an estimate of peat mass per unit depth. Three sources from Minnesota were used to provide that estimate, including the Web Soil Survey sponsored by the Natural

Resources Conservation Service (NRCS) (USDA). Data used were for the Embarrass portion of St. Louis County, which includes the mine site. The second source of data was a comprehensive study of 10 northern Minnesota peatlands, sampled with an average of four detailed cores per peatland (Grigal and Nord, 1983). Finally, detailed data for peat soils was collected from a variety of sources but primarily from the soil characterization database of the Natural Resources Conservation Service (NRCS) (Soil Survey Staff 1997) and from characterization data from the University of Minnesota Department of Soil, Water, and Climate.

The resulting average mass of C per unit peat depth was approximately 1 metric ton (Mg) per hectare per mm, or almost 0.5 tons/acre per mm. Loss of C from soil via $CO_2$ emissions is commonly measured in units of grams of C per square meter per year ($g/m^2/yr$), which is equivalent to 100 Mg C/ha/yr or about 45 tons C/acre/yr. The long-term rate of C loss, based on literature-derived subsidence data cited above, therefore ranges from about 1000 to 2000 $g/m^2/yr$.

A review of the literature from Europe reported average rates of C emissions from drained peatlands ranged from 300 $g/m^2/yr$ for drained grasslands to 550 $g/m^2/yr$ for drained small grains to 1900 g/m2/yr for drained row crops (Kasimir-Klemedtsonn et al., 1997). These data indicate that rates of loss increase with soil manipulation; minimally-manipulated grasslands having relatively low rates of loss.

Finally, a detailed study in Norway used three independent methods to estimate C losses from drained and cultivated peatlands: (1) long-term monitoring of subsidence rates, (2) changes in ash contents, and (3) direct $CO_2$ flux measurements (Grønlund et al., 2008). The three approaches provide independent checks of one-another, and consistency in the estimates would provide some degree of confidence in the results. The three approaches yielded estimates of C emissions of 800, 860, and 600 $g/m^2/yr$, respectively, or an average of 750 $g/m^2/yr$.

In summary, this variety of studies of C loss from peat following drainage set a range of from about 300 to 2000 $g/m^2/yr$, with losses associated with minimal manipulation of the surface of about 500 $g/m^2/yr$.

#### *10.3.3.4 CO2 emissions from peat stockpiles*

In contrast to the abundant data on C loss from drained peatlands, there has been limited work carried out to assess C loss from peat stockpiles. Work has been carried out in Finland, and the stockpiles are associated with temporary storage of mined peat before consumption for fuel (Sarkkola, 2007). Monitoring over the period in which $CO_2$ emissions occur (May through November) indicated losses of 3000 mg $CO_2$ /$m^2$ of stockpile per hr, or 3500 g $C/m^2/yr$ (Ahlholm and Silvola, 1990). This emission rate is per surface area of the stockpile, not of the entire disturbed peatland.

These emission rates are considerably higher than those based on peat drainage (300 to 2000 versus 3500 $g/m^2/yr$). It is important to understand that the stockpiles in these cases are very temporary, are not vegetated, and that dry peat is a preferred fuel. All these factors would logically lead to emission rates that are higher than those of drained but less disturbed peatlands.

#### *10.3.3.5 Oxygen diffusion into peat*

Oxygen is required by microorganisms as they oxidize organic materials to CO2, and a simple model of rates of oxygen movement (diffusion) into peat can be used to provide some idea of the reasonableness of the rates of C loss from peat as reported above. Microbial respiration consumes $O_2$ via the basic reaction

$$[CH_2O] + O_2 \rightarrow CO_2 + H_2O \qquad [1]$$

where $[CH_2O]$ represents the basic unit of an organic molecule, such as organic matter from peat.

The result of the reaction described in Eq. [1] is that one mole of $O_2$ is required and consumed for every mole-equivalent of organic matter that is oxidized and a mole of $CO_2$ is produced. The efflux of that $CO_2$ from soil is the vehicle of C loss. The basic question is to what depth $O_2$ can be supplied to achieve the reported rates of C loss from peat.

To approximate an $O_2$ gradient into the soil, a steady-state approximation of diffusion can be used. That approximation is,

$$F_{surface} = D_e * dC_O/dx \qquad [2]$$

where $F_{surface}$ is the annual flux of $O_2$ from the atmosphere into the soil surface, $D_e$ is the effective diffusion coefficient, and $dC_O/dx$ is the $O_2$ concentration ($C_O$) gradient from the atmosphere to the ultimate "sink" for $O_2$ consumption. This assumes a linear gradient that is maintained by a constant source and sink over a sufficient time for equilibrium to occur. By simplifying the computation, these assumptions allow a multiplicity of approximate solutions to be calculated.

Eq. [2] can be reformulated to calculate

$$dC_O = F_{surface} * dx/D_e \qquad [3]$$

This $dC_O$ is the change in $O_2$ concentration over a specific depth (x) that is required to achieve the appropriate flux rate from the atmosphere into the soil. Because the surface concentration of $O_2$ is approximately 209.5 mL $L^{-1}$ (Machta, 1970), then the $O_2$ concentration at the depth of the $O_2$ sink is

$C_{Osink} = 209.5 \text{ mL } L^{-1} - dC_O$ [4]

A spreadsheet was constructed, using as inputs measured or estimated C flux from soil (in g $C/m^2/yr$), the average temperature during period of C efflux, the actual number of months of efflux (biologically active, frost-free season), the measured or estimated soil pore space (in $cm^3/cm^3$), and the measured or estimated volumetric water content (also in $cm^3/cm^3$). The spreadsheet uses those data to compute the average $O_2$ concentration at any desired sink depth.

Based on the assumptions implicit in the spreadsheet, and using the average summer temperature of Babbitt, Minnesota, the literature-derived rate of C flux from drained and relatively undisturbed peat (500 $g/m^2/yr$) can be achieved at nearly any peat water content. If the peat is very wet, however, at field capacity (volumetric water = 0.8 $cm^3/cm^3$), then $O_2$ would be wholly consumed in the upper eight inches of peat, so that the predicted rate of loss probably would be unlikely to be achieved. When a liberal estimate of the rate of C flux from stockpiles (4000 $g/m^2/yr$) is evaluated, those rates can only be sustained if the peat were dry (less than 0.35 $cm^3/cm^3$ water content). If peat were "moist" (about 0.6 $cm^3/cm^3$ water content), $O_2$ diffusion would be limited to the upper six inches of peat and those rates are not be likely to be sustainable. In other words, as peat water content increases, rates of C emission are likely to go down.

In summary, C loss from stockpiled peat at rates of 3500 $g/m^2/yr$ are only likely to be achieved if the peat is quite dry.

#### *10.3.3.6 Conclusion*

If the area of storage of the excavated peat from the mine site is approximately 22.6 acres (91,649 $m^2$), then the annual emissions of C (using the estimate from stockpiles – 3500 $g/m^2/yr$) would be 321 metric tons of C per year, or 1,176 metric tons of $CO_2$ per year. This is about 0.6 percent of the direct emissions from the Project (210,261 metric tons/year), or about 0.2 percent of total emissions including power generation (721,261 metric tons/year).

Because the stockpiled peat is not likely to be disturbed until used for reclamation, rates will likely be lower than the conservative estimate given above and are likely to approach those for drained peatlands (500 $g/m^2/yr$). In addition, as stated earlier, the actual surface area of stored peat would likely be smaller than 58 acres because of the on-going additions during the stripping operation.

With respect to the global carbon cycle, it is important to understand that another effect of using this local material in reclamation is that its use will reduce or eliminate use of other organic materials. All organic

horticultural amendments, and especially high-organic materials such as "peat moss" that are commonly used for such remediation, originate in wetlands. Mining of those wetlands for horticultural purposes releases $CO_2$ to the atmosphere. Use of peat material from the Project site will consequently minimize emissions from these other sources.

### 10.3.4 Additional Peat Stockpiling at Tailings Basin

Additional peat is expected to be excavated along the pipeline route between the Mine Site and the Tailings Basin and at the tailings basin. This peat will be stockpiled at the tailings basin. The quantity was estimated by assuming that 100% of the peat located in the buttress construction area would be excavated and 25% of the peat in the East Basin Expansion Area would be excavated. The balance would be buried or inundated with water. The estimated excavated volume for the Tailings Basin and the pipeline is 265,615 cubic yards with a mass of 66,400 tons. The carbon content was estimated in the same manner as described above and added to the totals reported.

The surface area of a stockpile 40 feet high with a 3.5:1 slope with the necessary volume was calculated with a result of 5 acres. This was added to the stockpile surface area at the Mine Site of 22.6 acres for a total peat stockpile surface area of 27.6 acres.

### 10.3.5 Additional Peat Excavation at the Mine Site

In addition to the excavation under the stockpile footprints and at the mine pits, excavation will be performed at the Mine Site at the overburden storage area and to construct the dikes and trenches. The total quantity was estimated as 175,476 cubic yards or 39,300 tons. This quantity is assumed to be used in reclamation activities. .

## 10.4 Carbon Flux Associated with Peat Use in Reclamation Activities

The carbon balance resulting from reclamation activities is a function of both rate of carbon loss (decay) from the peat materials added as a soil amendment, and the rate of carbon gain in soil and vegetation occupying the site. For the purposes of this evaluation, the primary concern is with the potential for additional carbon losses from previously stockpiled peat that will become a component in the admixture used for reclamation, however, a look at the carbon flux over time and the balance between carbon loss and carbon gain can aid in assessing the potential for additional loss of peat carbon stores. Below is an analysis of the carbon flux associated with reclamation activities. Dr. David Grigal, Professor Emeritus in Soil Science at the University of Minnesota, provided assistance in estimating the potential flux for various reclamation cover types at the Mine Site.

### 10.4.1 Carbon Loss from Peat Used in Admixture

Olson (1963) described the rate of decomposition of organic materials as a simple negative exponential:

$$Y = \exp(-k*T) \qquad [5]$$

where Y is the decimal fraction of mass remaining, T is time in years, and k is a constant. This expression is similarly used to describe decay of organic material. This simple model, however, appears to overestimate loss in later stages of decomposition, and Wieder and Lang (1982), for example, proposed a double exponential model that they considered to provide the most realistic description of observed decomposition data,

$$Y = A \exp(-k1*T) + (1 - A) \exp(-k2*T) \quad [6]$$

where A is (usually) an easily decomposable fraction with a faster rate of decomposition (-k1) and (1 - A) is a more recalcitrant fraction with a slower rate (-k2). Although eqn. [6] may fit the data better, eqn. [5] is probably adequate for approximation.

Peat, by definition, is residual material remaining after hundreds or thousands of years of decomposition. Gorham (1991) estimated that only about 8 to 9% of net primary production is ultimately stored in the peat; the remaining 90+% of material is lost by decomposition. It is likely that most of the loss occurs in the partially-aerobic acrotelm (peat surface layer), with extremely slow rates of loss in the anaerobic catotelm.

No quantitative data on rates of C loss from peat additions to mineral soils could be located. However, a line of evidence for rates of peat decomposition under aerobic conditions is that of C emissions from drained peatlands, which are discussed in greater detail above.

To use these data to estimate a rate of C loss, it can be assumed that the source of the emissions cited above (700 g/m2/yr) is the upper 24 inches of peat. The mass of peat to that depth is about 900 Mg C/ha based on a density of 0.23 tons/cy (moist). This combination of emissions and mass yields an exponential rate constant (k) of -0.0076 and a half-life of 90 years. This is a reasonable rate of loss for partially-decomposed peat. A rate constant of –0.0005 was used by Grigal et al. (2011) in a simulation model for decay of the 0 to 25 cm (10 inch) layer of peat in a peatland in Minnesota. The rate used here (-0.0076) for peat added to mineral soil is 15 times greater.

### 10.4.2 C Gain in Reclaimed Areas

#### *10.4.2.1 Soil*

The purpose of admixing peat with mineral material is to enhance the restoration of a functioning ecosystem on disturbed areas at the Mine Site; e.g., Category 1 rock stockpile. Leisman (1957) carried out a landmark study of soil and vegetation changes on waste piles on the Mesabi Range. He provided detailed data on soil C, and sampled soils on multiple dumps at 2, 4, and 9 inches. If his sampling is assumed to represent the soil depth to 12 inches (2-inch sample represents 0 to 2 inches, 4-inch sample represents 2 to 6 inches, and 9-inch sample represents 6 to 12 inches), then a function of change in soil C with time can be computed. The result is a linear relationship,

Soil C (Mg/ha) = 2.14 + 0.494 * time (years), r2 = 0.99, n = 5. [7]

The oldest stripping dumps sampled by Leisman were 51 years old, and thus the relationship is assumed to be applicable for about 50 years.

#### *10.4.2.2 Vegetation*

The upland cover types that are likely to develop on disturbed areas at the mine site include: aspen woodland, red pine woodland, and herbaceous ground cover. The estimated carbon balance associated with each of these cover types is described below.

##### *10.4.2.2.1 Aspen Woodland*

In addition to measuring soil properties, Leisman also monitored revegetation. He stated, "The stripping spoil bank succession usually led to a fairly uniform woodland community with Populus tremuloides and P. balsamifera being the conspicuous members of the overstory." He collected data on cover and frequency of vegetation, but unfortunately those data cannot be easily used to calculate C storage.

For estimation of C accretion in aspen stands, empirical yield tables for Minnesota collected as part of the Forest Inventory and Analysis (FIA) program, coordinated by the USDA Forest Service, were used. The yield tables were compiled from data gathered on 8,807 commercial forest land plots established during the 1977 inventory of Minnesota's four Forest Survey Units. The tables provide the average stand basal area by age and site quality class, and the number of observations for each average, for 14 forest types. Traditionally, yield tables used in forestry are based on carefully selected forest stands of uniform age and composition. In contrast, these empirical yield tables are based on a random sample of "real world" forests. The sampled stands contain a variety of species, and the stocking (density) may not be optimal. In fact, Hahn and Raile point out that the stocking of the tabulated aspen stands 51 to 60 years old in the

61- to 70-site index class is only about half of optimum. Because of their source, these tables provide a conservative estimate of rates of C accretion with time.

The data from the tables for all site quality classes for the aspen forest type (from 3496 stands) were fit to a logistic function describing basal area change over time,

BA = a/(1+exp((b * (T - c))), [8]

where BA is stand basal area in $m^2$ ha-1, T is stand age in years, and a, b, and c are constants. The constant a is the maximum BA at infinite time, b is the rate at which the function approaches maximum BA (a), and c can be considered a lag term. To determine the constants, the data for each age class (10-year classes) were weighted by the number of plots in each class. Observed and predicted BA were strongly correlated, with r2 (r^2?) = 0.94. Basal area data were converted to above-ground stand biomass from a database of 409 aspen-birch stands.

Carbon content of all biomass data was assumed to be 48% (Hahn, 1982, Alban and Perala, 1990). The ratio of root mass to above-ground mass for forested types is 0.3 (root mass is 0.3 times above-ground mass) (Perala and Alban, 1994, Whittaker and Marks, 1975, Santantonio et al, 1977), and that ratio was used to compute total vegetation C.

#### *10.4.2.2.2 Red Pine Woodland*

An identical approach was used to compute C accretion of the red pine woodland. The 1977 forest inventory sampled many fewer red pine plots (95) than aspen plots. Basal area data were fit to the logistic function, and observed and predicted BA were correlated with $r^2 = 0.69$. A database of 105 red pine stands was used to convert basal area data to above-ground stand C (Grigal et. al, 2011). As with aspen, the root:shoot ratio of 0.3 was used to compute total vegetation C.

#### *10.4.2.2.3 Herbaceous Cover*

To determine the rate of C accretion under herbaceous cover, biomass data for leaves, roots, and stems from a 35-field chronosequence spanning the first 60 years of secondary succession on a Minnesota sand plain were used (Gleeson and Tilman, 1990). Although the sequence represents secondary succession, Gleeson and Tilman (1990) argue that their work in the "unproductive, nitrogen-depleted sandy soils" of Cedar Creek Natural History Area may have more in common with primary successions than with secondary succession on richer soils.

Their data were collected from 22 formerly farmed fields and an additional 13 sampling sites that were sequentially abandoned. Gleeson and Tilman (1990) presented the biomass data graphically, and the data were extracted from their figures. Apparently because of complete overlap of two points, only 34 data points were found on each of the three figures (leaf, stem, and root biomass). Component data for each of the 34 fields were summed and fit to the logistic function. In contrast to a linear function (as used by Gleeson and Tilman), the logistic function provides a logical asymptote of mass accumulation with time. Observed and predicted biomass were correlated with $r^2 = 0.49$.

### 10.4.3 Results – C Balance

The estimated rate of peat addition to the overburden is based on a criterion used for quality topsoil of 2-5% organic material by weight. As a result, a goal of 5% peat mixture was chosen. While the disturbed areas may vary in area and slope, the rate of peat addition will be at about 550 cubic yards of peat per acre (information from Christie Kearney, Barr Engineering, 12 October 2011). This is equivalent to about 145 Mg of C /ha.

In contrast to both the data from Leisman (1957) and Gleeson and Tilman (1990) that was specific to year, the data from the empirical yield tables was by 10-year age classes (Hahn and Raile, 1982). The first data point was the midpoint of the 0 to 10 year class, or 5 years. The C accretion of the woody vegetation for the first five years of site occupancy was simply extrapolated from 0 to the five-year data point. The assumption was that at time = 0 there was no vegetation, and hence no C, and at 5 years and beyond the vegetation C was as estimated by the logistic function.

The resulting balance of gain and loss of C can be examined by cumulative changes. The loss of C from peat, under all scenarios, is nearly linear with time because the material is primarily recalcitrant organic matter (Fig. 3). Soil C shows a monotonic increase, based on Leisman's (1957) data. The continual increase in both soil and vegetation C more than balances the loss of C from the added peat in the woodland scenarios, but not in the herbaceous scenario.

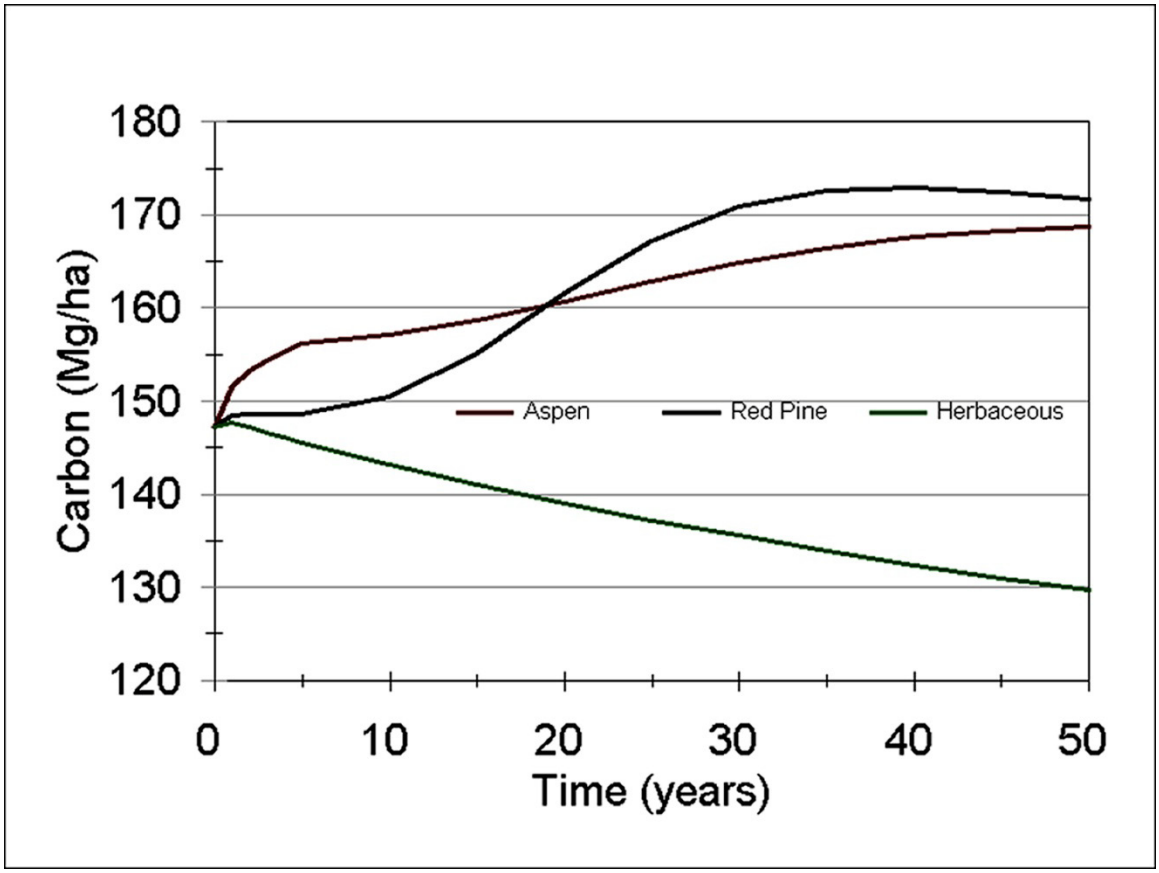



**Figure 1** **Cumulative ecosystem carbon change with time on disturbed areas with a 5% peat admixture revegetating to three alternative scenarios**

Under the scenario of herbaceous cover, the ecosystem loses about 10% of its C over a 50-year period (Fig. 3). Although the herbaceous cover shows a net negative C flux over time, herbs are a transient vegetation type in northern Minnesota. Vegetation succession in the region is clearly to woody cover. The critical question is the time-sequence of woody invasion. Gleeson and Tilman (1990) state that the outcome of succession at their site is generally assumed to be oak savannah or oak forest, based on both the pre-agricultural vegetation of the site and the slow, but significant, increase in woody plant biomass during succession. Based on Leisman's (1957) work, woody cover development on revegetated areas at the mine site would likely consist of quaking aspen and balsam poplar. Based on Leisman's work, combined with input from Barr botanists familiar with vegetation succession in the iron-range area of Minnesota, woody cover development on revegetated areas at the mine site would likely be underway within five years of reclamation and seeding with an herbaceous mix. Based on this succession and a loss of approximately 5Mg/ha over the first five years after reclamation, Attachment D provides a rough estimate of potential additional carbon losses associated with the first 5 years after reclamation for each of the reclaimed areas at the site of about 8,500 metric tons.

### 10.4.4 Caveats

This analysis is based on limited data, and therefore there is uncertainty in the details regarding its analyses. The rate of C loss from the peat may be higher or lower than the estimate used here. There is no question that hemic peat is recalcitrant, and the rate used here indicates loss of about one-third of the C in 50 years, a reasonably rapid rate. The actual rate of vegetation regrowth is also uncertain. At the mine site, fertilization and other management techniques will be used to enhance vegetation growth, and the data used in this analysis did not include those measures. However, from simple consideration of the general rates of C accumulation in forested ecosystems relative to the modest rates of C flux to the atmosphere from the use of peat as a reclamation aid, it appears that the use of the peat amendment will not result in net C flux to the atmosphere under those scenarios. The herbaceous scenario, if cover is maintained in herbs, shows a net C loss, but the inevitable succession to woodlands will lead to net C accumulation. There is uncertainty, however, in the temporal sequence of those changes.

# 11.0 Conclusions

The potential annual direct and indirect GHG emissions from the Project are estimated as follows (as metric tons $CO_2$-e): direct = 186,342, indirect = 511,000, total = 697,342. A comparison of the estimated direct GHG emissions for the Project to statewide, national, and global GHG emissions shows that the potential GHG emissions from the Project are a small fraction of those emissions. The GHG emissions from the Project are approximately 0.12% of estimated statewide emissions, 0.003% of national emissions, and 0.00038% of global emissions (Table 4).

Available information from Bateman (2005) and identifies that hydrometallurgical processes have 50% lower energy demand than a pyrometallurgical process.

There are also other factors, such as improved metal recoveries and reduced $SO_x$ emissions that would seem to make hydrometallurgical processing a better overall alternative for the Project from an environmental impact perspective. Aside from using a hydrometallurgical process rather than a smelting process, there are limited options available to further reduce GHG emissions from the Project. However, PolyMet will purchase energy efficient equipment when available and choose the lowest $CO_2$ emitting fuel option for most emission units.

Indirect emissions of GHGs related to power production are important for all mining and manufacturing facilities in Minnesota and elsewhere. Because of legal limitations, PolyMet does not have an option for an electricity provider and must use Minnesota Power. As alternative energy sources become more prominent in electricity production, indirect emissions from power production will likely decrease and thereby decrease the potential indirect emissions associated with the Project.

In addition to the direct and indirect industrial $CO_2$ emissions, quantitative estimates for six carbon cycle impacts were calculated:

1) Total carbon stored in the above-ground vegetation of wetlands and forests lost to Project activities [treated as a one-time emission] = 167,546 metric tons of $CO_2$
2) Annual emissions from the stockpiling of excavated peat = 1,176 metric tons of $CO_2$ per year
3) Possible carbon loss from peat used in reclamation activities = 8,524 metric tons of $CO_2$
4) Annual emissions from indirectly impacted wetlands = 7.41 metric tons of $CO_2$ per acre per year

5) The loss of annual carbon sequestration capacity due to the disturbance of wetland and forest plant communities = 2,982 metric tons of $CO_2$ per year
6) The reduction in annual carbon sequestration capacity in indirectly impacted wetlands = 3.34 metric tons per year

Apart from the one-time aboveground carbon loss estimate, these impacts are minimal compared to the direct and indirect industrial emissions: Additionally, the aboveground carbon lost (a) will not take place as an actual one-time $CO_2$ emission event but will be a staged process; and (b) is a likely overestimate given the value of long-lived forest products that will be potentially available for harvest.

Potential GHG emissions estimated for the Project are small compared to state, national, and global GHG emissions.

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# Attachments

# Attachment A

## Mine Site and Plant Site Emission Calculations
## PolyMet Mining Inc., NorthMet Project
## Direct Emissions of Greenhouse Gases:

**PolyMet - Hoyt Lakes, Minnesota**

**Table A-1: Estimate of Potential Greenhouse Gas Emissions at the Mine Site**

| Stack ID | Emission Unit ID | Emission Unit Description | APCD ID | Throughput Maximum (Units/hr) | Note | Throughput Maximum (Units/yr) | Note | Throughput Projected Actual (Units/yr) | Note | Units | Pollutant | Emission Factor (lb/Unit) | Note | Maximum Emissions [1] (lb/hr) | Maximum Emissions [1] (ston/yr) | Projected Actual Emissions [2] (ston/yr) | CO2-e Factor (Global Warming Potential)[3] | Max. Emissions (CO2-e)[4] (lb/hr) | Max. Emissions (CO2-e)[4] (ston/yr) | Projected Actual Emissions (CO2-e) [5] (ston/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mine Point Sources | | | | | | | | | | | | | | | | | | | | |
| SV 326 | EU 332 | WWTF Back up Generator | NA | 5.236 | [201] | 2,618 | [301] | 2,618 | [401] | MMBtu | CO2 | 161.30 | [101] | 844.54 | 211 | 211.14 | 1 | 844.54 | 211.14 | 211.14 |
| SV 337 | EU 344 | Generator to Move Electrical Equipment | NA | 7.7 | [202] | 3,850 | [302] | 801 | [402] | MMBtu | CO2 | 161.30 | [102] | 1,242 | 310 | 64.58 | 1 | 1,241.98 | 310.49 | 64.58 |
| WWTP | EU 331 | WWTF Propane Fired Space Heaters | NA | 0.0219 | [203] | 191 | [303] | 95.74 | [403] | Mgal | CO2 | 12,725 | [103] | 278 | 1,218 | 609.12 | 1 | 278.14 | 1,218.25 | 609.12 |
| WWTP | | | | 0.0219 | [203] | 191 | [303] | 95.74 | [403] | Mgal | CH4 | 0.18 | [104] | 0.00 | 0 | 0.01 | 21 | 0.08 | 0.37 | 0.18 |
| WWTP | | | | 0.0219 | [203] | 191 | [303] | 95.74 | [403] | Mgal | N2O | 0.81 | [104] | 0.02 | 0 | 0.04 | 310 | 5.47 | 23.95 | 11.97 |
| Mine Sources Subject to PSD Permitting | | | | | | | | | | | | | | | | | | | | |
| Greenhouse Gas Totals (short tons) | | | | | | | | | | | $CO_2$ | | | 2,365 | 1,739.9 | 885 | 1 | 2,365 | 1,740 | 885 |
| | | | | | | | | | | | $CH_4$ | | | 0.00 | 0.02 | 0.01 | 21 | 0.08 | 0.37 | 0.18 |
| | | | | | | | | | | | $N_2O$ | | | 0.02 | 0.08 | 0.04 | 310 | 5.47 | 23.95 | 11.97 |
| | | | | | | | | | | | TOTAL GHGs | | | | | | | 2,370 | 1,764 | 897 |

| | | | | | | | | | | | | | | Maximum Emissions [1] (kg/hr) | Maximum Emissions [1] (m.t./yr) | Projected Actual Emissions [2] (m.t./yr) | CO2-e Factor (Global Warming Potential)[3] | Max. Emissions (CO2-e)[4] (kg/hr) | Max. Emissions (CO2-e)[4] (m.t./yr) | Projected Actual Emissions (CO2-e) [5] (m.t./yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mine Sources Subject to PSD Permitting | | | | | | | | | | | | | | | | | | | | |
| Greenhouse Gas Totals (metric tons) | | | | | | | | | | | $CO_2$ | | | 1,072 | 1,578 | 803 | 1 | 1,072 | 1,578 | 803 |
| | | | | | | | | | | | $CH_4$ | | | 0 | 0.02 | 0.01 | 21 | 0 | 0.33 | 0.17 |
| | | | | | | | | | | | $N_2O$ | | | 0 | 0.07 | 0.04 | 310 | 2 | 21.72 | 10.86 |
| | | | | | | | | | | | TOTAL GHGs | | | | | | | 1,075 | 1,600 | 814 |

| Stack ID | Emission Unit ID | Emission Unit Description | APCD ID | Throughput Maximum (Units/hr) | Note | Throughput Maximum (Units/yr) | Note | Throughput Projected Actual (Units/yr) | Note | Units | Pollutant | Emission Factor (kg/Unit) | Note | Max. Emissions (kg/hr) | Max. Emissions (m.t./yr) | Projected Actual Emissions (m.t./yr) | CO2-e Factor (Global Warming Potential) | Max. Emissions (CO2-e) (kg/hr) | Max. Emissions (CO2-e) (m.t./yr) | Projected Actual Emissions (CO2-e) (m.t./yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mine Site Mobile Sources | | | | | | | | | | | | | | | | | | | | |
| N/A | N/A | Mine Haul Trucks | NA | 275.28 | [204] | 2,378,436 | [304] | 2,378,436 | [401] | gal | $CO_2$ | 10.15 | [105] | 2,795 | 24,145 | 24,145.26 | 1 | 2,795 | 24,145 | 24,145.26 |
| N/A | | | | 275.28 | [204] | 2,378,436 | [304] | 2,378,436 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.16 | 1.379 | 1.38 | 21 | 3.35 | 28.97 | 28.97 |
| N/A | | | | 275.28 | [204] | 2,378,436 | [304] | 2,378,436 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.07 | 0.618 | 0.62 | 310 | 22.19 | 191.70 | 191.70 |
| N/A | N/A | Diesel Drill | NA | 19.49 | [204] | 168,394 | [304] | 168,394 | [401] | gal | $CO_2$ | 10.15 | [105] | 198 | 1,709 | 1,709.49 | 1 | 198 | 1,709 | 1,709.49 |
| N/A | | | | 19.49 | [204] | 168,394 | [304] | 168,394 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.01 | 0.098 | 0.10 | 21 | 0.24 | 2.05 | 2.05 |
| N/A | | | | 19.49 | [204] | 168,394 | [304] | 168,394 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.01 | 0.044 | 0.04 | 310 | 2 | 14 | 13.57 |
| N/A | N/A | Secondary Production Excavator | NA | 8.49 | [204] | 73,389 | [304] | 73,389 | [401] | gal | $CO_2$ | 10.15 | [105] | 86 | 745 | 745.02 | 1 | 86 | 745 | 745.02 |
| N/A | | | | 8.49 | [204] | 73,389 | [304] | 73,389 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.043 | 0.04 | 21 | 0.10 | 0.894 | 0.89 |
| N/A | | | | 8.49 | [204] | 73,389 | [304] | 73,389 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.019 | 0.02 | 310 | 1 | 6 | 5.92 |
| N/A | N/A | Track Dozer | NA | 33.39 | [204] | 288,476 | [304] | 288,476 | [401] | gal | $CO_2$ | 10.15 | [105] | 339 | 2,929 | 2,928.53 | 1 | 339 | 2,929 | 2,928.53 |
| N/A | | | | 33.39 | [204] | 288,476 | [304] | 288,476 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.02 | 0.167 | 0.17 | 21 | 0.41 | 3.51 | 3.51 |
| N/A | | | | 33.39 | [204] | 288,476 | [304] | 288,476 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.01 | 0.075 | 0.08 | 310 | 2.69 | 23.25 | 23.25 |
| N/A | N/A | Grader | NA | 8.61 | [204] | 74,391 | [304] | 74,391 | [401] | gal | $CO_2$ | 10.15 | [105] | 87 | 755 | 755.20 | 1 | 87 | 755 | 755.20 |
| N/A | | | | 8.61 | [204] | 74,391 | [304] | 74,391 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.043 | 0.04 | 21 | 0.10 | 0.91 | 0.91 |
| N/A | | | | 8.61 | [204] | 74,391 | [304] | 74,391 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.019 | 0.02 | 310 | 0.69 | 6.00 | 6.00 |
| N/A | N/A | Rubber Tire Dozer | NA | 5.85 | [204] | 50,585 | [304] | 50,585 | [401] | gal | $CO_2$ | 10.15 | [105] | 59 | 514 | 513.53 | 1 | 59 | 514 | 513.53 |
| N/A | | | | 5.85 | [204] | 50,585 | [304] | 50,585 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.029 | 0.03 | 21 | 0.07 | 0.62 | 0.62 |
| N/A | | | | 5.85 | [204] | 50,585 | [304] | 50,585 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.013 | 0.01 | 310 | 0.47 | 4.08 | 4.08 |
| N/A | N/A | Transfer Loader | NA | 2.56 | [204] | 22,097 | [304] | 22,097 | [401] | gal | $CO_2$ | 10.15 | [105] | 26 | 224 | 224.32 | 1 | 26 | 224 | 224.32 |
| N/A | | | | 2.56 | [204] | 22,097 | [304] | 22,097 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.013 | 0.01 | 21 | 0.03 | 0.27 | 0.27 |
| N/A | | | | 2.56 | [204] | 22,097 | [304] | 22,097 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.006 | 0.01 | 310 | 0.21 | 1.78 | 1.78 |
| N/A | N/A | Backhoe With Hammer | NA | 0.08 | [204] | 723 | [304] | 723 | [401] | gal | $CO_2$ | 10.15 | [105] | 1 | 7 | 7.33 | 1 | 1 | 7 | 7.33 |
| N/A | | | | 0.08 | [204] | 723 | [304] | 723 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.000 | 0.00 | 21 | 0.00 | 0.01 | 0.01 |
| N/A | | | | 0.08 | [204] | 723 | [304] | 723 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.000 | 0.00 | 310 | 0.01 | 0.06 | 0.06 |
| N/A | N/A | Water/Sand Truck | NA | 9.86 | [204] | 85,158 | [304] | 85,158 | [401] | gal | $CO_2$ | 10.15 | [105] | 100 | 864 | 864.50 | 1 | 100 | 864 | 864.50 |
| N/A | | | | 9.86 | [204] | 85,158 | [304] | 85,158 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.01 | 0.049 | 0.05 | 21 | 0.12 | 1.04 | 1.04 |
| N/A | | | | 9.86 | [204] | 85,158 | [304] | 85,158 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.022 | 0.02 | 310 | 0.79 | 6.86 | 6.86 |
| N/A | N/A | Integrated Tool Handler | NA | 0.80 | [204] | 6,942 | [304] | 6,942 | [401] | gal | $CO_2$ | 10.15 | [105] | 8 | 70 | 70.48 | 1 | 8 | 70 | 70.48 |
| N/A | | | | 0.80 | [204] | 6,942 | [304] | 6,942 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.004 | 0.00 | 21 | 0.01 | 0.08 | 0.08 |
| N/A | | | | 0.80 | [204] | 6,942 | [304] | 6,942 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.002 | 0.00 | 310 | 0.06 | 0.56 | 0.56 |
| N/A | N/A | Pickup Trucks | NA | 4.46 | [204] | 38,573 | [304] | 38,573 | [401] | gal | $CO_2$ | 10.15 | [105] | 45 | 392 | 391.59 | 1 | 45 | 392 | 391.59 |
| N/A | | | | 4.46 | [204] | 38,573 | [304] | 38,573 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.00 | 0.022 | 0.02 | 21 | 0.05 | 0.47 | 0.47 |
| N/A | | | | 4.46 | [204] | 38,573 | [304] | 38,573 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.00 | 0.010 | 0.01 | 310 | 0.36 | 3.11 | 3.11 |
| N/A | N/A | Other Miscellaneous Equipment Fuel Use | NA | 36.89 | [204] | 318,716 | [304] | 318,716 | [401] | gal | $CO_2$ | 10.15 | [105] | 374 | 3,236 | 3,235.52 | 1 | 374 | 3,236 | 3,235.52 |
| N/A | | | | 36.89 | [204] | 318,716 | [304] | 318,716 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.02 | 0.185 | 0.18 | 21 | 0.45 | 3.88 | 3.88 |
| N/A | | | | 36.89 | [204] | 318,716 | [304] | 318,716 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.01 | 0.083 | 0.08 | 310 | 2.97 | 25.69 | 25.69 |
| N/A | N/A | Main Line Ore Haulage Locomotives | NA | 24.52 | [206] | 211,841 | [303] | 211,841 | [401] | gal | $CO_2$ | 10.15 | [105] | 249 | 2,151 | 2,150.55 | 1 | 249 | 2,151 | 2,150.55 |
| N/A | | | | 24.52 | [206] | 211,841 | [303] | 211,841 | [401] | gal | $CH_4$ | 5.80E-04 | [105] | 0.01 | 0.123 | 0.12 | 21 | 0.30 | 2.580 | 2.58 |
| N/A | | | | 24.52 | [206] | 211,841 | [303] | 211,841 | [401] | gal | $N_2O$ | 2.60E-04 | [105] | 0.01 | 0.055 | 0.06 | 310 | 2 | 17 | 17.07 |
| Mine Site Mobile Sources | | | | | | | | | | | | | | | | | | | | |
| Greenhouse Gas Totals (metric tons) | | | | | | | | | | | $CO_2$ | | | 4,368 | 37,741.32 | 37,741.32 | | 4,368.21 | 37,741.32 | 37,741.32 |
| | | | | | | | | | | | $CH_4$ | | | 0.25 | 2.21 | 2.16 | | 5.24 | 45.28 | 45.28 |

**PolyMet - Hoyt Lakes, Minnesota**
**Table A-1: Estimate of Potential Greenhouse Gas Emissions at the Mine Site**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $N_2O$ | | | 0.11 | 1.19 | 0.97 | | 34.68 | 299.65 | 299.65 |
| | TOTAL GHGs | | | | | | | | 38,086 | 38,086 |

| Mine Site Totals | | | | Max. Emissions (kg/hr) | Max. Emissions (m.t./yr) | Projected Actual Emissions (m.t./yr) | CO2-e Factor (Global Warming Potential) | Max. Emissions (CO2-e) (kg/hr) | Max. Emissions (CO2-e) (m.t./yr) | Projected Actual Emissions (CO2-e) (m.t./yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Greenhouse Gas Totals (metric tons) | $CO_2$ | | | 5,441 | 39,320 | 38,544 | 1 | 5,441 | 39,320 | 38,544 |
| | $CH_4$ | | | 2.2 | 21.0 | 5.3 | 21 | 45.4 | 46 | 45 |
| | $N_2O$ | | | 1.0 | 310.0 | 37.2 | 310 | 310.5 | 321 | 311 |
| | TOTAL GHGs | | | | | | | | 39,687 | 38,900 |
| | | | | | % of total | | $CO_2$ | | 99.1% | 99.1% |
| | | | | | | | $CH_4$ | | 0.1% | 0.1% |
| | | | | | | | $N_2O$ | | 0.8% | 0.8% |

**PolyMet - Hoyt Lakes, Minnesota**

**Table A-1: Estimate of Potential Greenhouse Gas Emissions at the Mine Site**

**Notes:**

**General References:**

[1] Max. Emissions (kg/hr) = EF (kg/unit) x Max. Hourly Throughput (units/hr).
Max. Uncontrolled Emissions (m.t./yr) = EF (kg/unit) x Max. Annual Throughput (units/yr) / 1,000 (kg/m.t.).

[2] Projected Actual Emissions (m.t./yr) = EF (kg/unit) x Projected Actual Throughput (units/yr) / 1,000 (kg/m.t.).

[3] Global Warming Potentials from MPCA as listed in the July 2008 "General Guidance for Carbon Footprint Development in Environmental Review", <http://www.eia.doe.gov/oiaf/1605/gwp.html>

[4] Max. Emissions (CO2-e) (kg/hr) = Max. Uncontrolled Emissions (kg/hr) x (CO2-e Factor).
Max. Controlled Emissions (m.t./yr) = Max. Uncontrolled Emissions (m.t./yr) x (CO2-e Factor).

[5] Projected Actual Emissions (CO2-e) (m.t./yr) = EF (kg/unit) x Projected Actual Throughput (units/yr) / 1,000 (kg/m.t.)

**Emission Factor References:**

[101] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table 12.1 (Distillate Fuel Oil). Emission factor converted from kg/MMBtu to lb/MMBtu by kg/MMBtu * 2.205 lb/kg. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.

[102] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table 12.1 (Distillate Fuel Oil). Emission factor converted from kg/MMBtu to lb/MMBtu by kg/MMBtu * 2.205 lb/kg. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.

[103] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table12.1. Emission factor converted from kg/MMBtu to lb/Mgal by kg/MMBtu * 2.205 lb/kg * 91.5 MMBtu/Mgal. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.

[104] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table 12.7. Factors converted from g/MMBtu to lb/Mgal by lb/Mgal = g/MMBtu * (1 lb/453.59 g) * 91.5 MMBtu/Mgal. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.

[105] Emission factors taken from The Climate Registry's General Reporting Protocol, May 2008, Tables 13.1 and 13.6.

| | CO2 | CH4 | N2O |
|---|---|---|---|
| Diesel Emissions (kg/gal): | 10.15 | | |
| Construction / Large Utility Non-highway Vehicles, diesel (g/gal): | | 0.58 | 0.26 |
| Construction / Large Utility Non-highway Vehicles, gasoline (g/gal): | | 0.5 | 0.22 |

**Maximum Hourly Throughput References:**

[201] Based on preliminary design of waste water treatment facility by Barr, critical power demand is about 500 kW. It was assumed that a Caterpillar Standby 500 ekW would be installed. Based on literature available on the manufacturer's website, the fuel consumption at maximum load is 37.4 gallons/hr. This is converted to MMBtu/hr by 37.4 gal/hr * 140,000 Btu/gallon / 10^6 Btu/MMBtu = 5.236 MMBtu/hr.

[202] A portable generator will be used to provide temporary power to move large electric powered mining vehicles (e.g. excavators and drills). The generator will only provide power while the equipment is moved from one location with available electrical power to another. It was estimated that a 1100 hp engine would provide sufficient power for this operation.

[203] Based on preliminary design of waste water treatment facility by Barr, maximum heating demand for propane fired heaters is 2 MMBtu/hr.
This can be converted to Mgal propane/hr by: 2.0 MMBtu/hr / 91.5 MMBtu/Mgal = 0.022 MGal/hr. A conservative estimate of annual usage was made by assuming 40% utilization for the heaters; detailed calculations for other heaters at the Plant Site showed a significantly lower percent utilization (10 - 20%).

[204] Annual fuel usage based on fuel consumption modeling performed by mining consultant. Mining schedule of 360 days/year assumed in hourly fuel usage calculation.

| Unit | Manufacturer | Model | Engine | Engine Power | Max Daily Fuel Usage (gal) | Max Annual Fuel Usage (gal) |
|---|---|---|---|---|---|---|
| Mine Haul Trucks | Caterpillar | 830E | Cat 793C | 2300 hp | 6606.8 | 2,378,436 |
| Diesel Drill | Atlas Copco | PV 351 | Cummins QSK45 / Cat 3512 | 1550 hp | 467.8 | 168,394 |
| Secondary Production Excavator | Caterpillar | 994 | Cat 3516 | 1577 hp | 203.9 | 73,389 |
| Track Dozer | Caterpillar | 1D10R | Cat 3412E | 646 hp | 801.3 | 288,476 |
| Grader | Caterpillar | 16H | Cat 3406 | 275 hp | 206.6 | 74,391 |
| Rubber Tire Dozer | Caterpillar | 834G | Cat 3456 | 481 hp | 140.5 | 50,585 |
| Transfer Loader | Caterpillar | 990 | 990 | 800 hp | 61.4 | 22,097 |
| Backhoe With Hammer | Caterpillar | 446D | 3114 DIT | 110 hp | 2.0 | 723 |
| Water/Sand Truck | Caterpillar | 777D | 3408 B | 938 hp | 236.5 | 85,158 |
| Integrated Tool Handler | Caterpillar | IT62H | C7 ACERT Tier 3 | 230 hp | 19.3 | 6,942 |
| Pickup Trucks | Unknown | Unknown | Unknown | Unknown | 107.1 | 38,573 |
| Other Miscellaneous Equipment Fuel Use | - | - | - | - | 885.3 | 318,716 |

Note: Specific engine information for Pickup Trucks is not known at this time. Fuel estimates by Gordon Zurowski in a November 2007 email, or from Wardrop, 35 gal/min, Year 6-20 worst case (Year 10).
"Other Miscellaneous Equipment Fuel Use" has been estimated as 10% of the total fuel use among equipment and is intended to reflect any unforeseen equipment not included in the emission calculation estimates.

[205] Load factor assume the same as for ore haul locomotives (15%), but with only a single 700 hp engine. Annual usage equals daily usage times 360 mining days per year.

Switching Locomotive

| | | |
|---|---|---|
| Daily Estimate Total Fuel Usage | 131 | gallons/day |
| Hourly Average Fuel Use | 5.45 | gph |

[206] Fuel usage for each ore haul locomotive calculated by PolyMet. Annual usage equals daily usage times 360 mining days per year.

| | | |
|---|---|---|
| Daily Estimate Total Fuel Usage | 1,177 | gallons/day |
| Hourly Average Fuel Use | 49.04 | gph |

**Maximum Annual Throughput References:**

[301] As recommended by EPA guidance, annual fuel usage for calculating potential emissions for the emergency generator is based on 500 hours per year of operation.

[302] Use of this equipment has an inherent restraint as with emergency generators. The generator is intended to provide temporary power for relocating large electrical mining vehicles, an inherently infrequent activity. As allowed for emergency generators, potential emissions were calculated based on 500 hours per year of operation.

[303] Maximum annual throughput = maximum hourly throughput * 8760 hours per year.

[304] Maximum annual throughput = maximum hourly throughput * 24 hours per day * 360 days per year. See number 204 above.

**Projected Actual Throughput References**

[401] Projected actual emissions are equivalent to potential emissions.

[402] Actual operation estimated as two hours per week or 104 hours per year.

[403] Projected actual emissions based on 50% utilization, a conservative assumption for heating systems.

**PolyMet - Hoyt Lakes, Minnesota**
**Table A-2: Calculation of Potential Greenhouse Gas Emissions at Processing Plant**

| Stack ID | Emission Unit | | APCD ID | Throughput | | | | | | | Pollutant | Emission Factor | | Maximum Emissions [1] | | Projected Actual | CO2-e Factor | Max. Emissions (CO2-e)[4] | | Projected Actual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | | Maximum | | | | Projected Actual | | Units | | | | | | | | | | |
| | | | | (Units/hr) | Note | (Units/yr) | Note | (Units/yr) | Note | | | (lb/Unit) | Note | (lb/hr) | (ston/yr) | (ston/yr) | (Global | (lb/hr) | (ston/yr) | (ston/yr) |
| Plant Site Point Sources | | | | | | | | | | | | | | | | | | | | |
| SV 301 | EU 301 | Autoclave Startup Boiler - Natural Gas | NA | 0.048 | [201] | 418.861 | [301] | 25.132 | [401] | MM cu. ft. | CO2 | 122,847.165 | [100] | 5,873.966 | 25,728 | 1,543.678 | 1 | 5,873.966 | 25,727.973 | 1,543.678 |
| SV 301 | | Natural gas | | 0.048 | [201] | 418.861 | [301] | 25.132 | [401] | MM cu. ft. | N2O | 2.083 | [101] | 0.100 | 0.436 | 0.026 | 310 | 30.881 | 135.260 | 8.116 |
| SV 301 | | | | 0.048 | [201] | 418.861 | [301] | 25.132 | [401] | MM cu. ft. | CH4 | 2.083 | [101] | 0.100 | 0.436 | 0.026 | 21 | 2.092 | 9.163 | 0.550 |
| SV 328 | EU 335 | Oxygen Plant Adsorber Regeneration Heater | NA | 0.002 | [202] | 17.103 | [301] | 11.402 | [402] | MM cu. ft. | CO2 | 122,847.165 | [100] | 239.844 | 1,050.519 | 700.346 | 1 | 239.844 | 1,050.519 | 700.346 |
| SV 328 | | | | 0.002 | [202] | 17.103 | [301] | 11.402 | [402] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.018 | 0.012 | 310 | 1.261 | 5.523 | 3.682 |
| SV 328 | | | | 0.002 | [202] | 17.103 | [301] | 11.402 | [402] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.018 | 0.012 | 21 | 0.085 | 0.374 | 0.249 |
| CoarseCrush | EU 302 | Space Heating (Natural Gas Fired-total direct) | NA | 0.009 | [203] | 78.840 | [301] | 10.561 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 1,105.624 | 4,842.635 | 648.674 | 1 | 1,105.624 | 4,842.635 | 648.674 |
| CoarseCrush | | | | 0.009 | [203] | 78.840 | [301] | 10.561 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.019 | 0.082 | 0.011 | 310 | 5.813 | 25.459 | 3.410 |
| CoarseCrush | | | | 0.009 | [203] | 78.840 | [301] | 10.561 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.019 | 0.082 | 0.011 | 21 | 0.394 | 1.725 | 0.231 |
| CoarseCrush1 | EU 302 | Space Heating (Natural Gas Fired- Indirect RB AHU 1) | NA | 0.000 | [203] | 0.000 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 0.000 | 0.000 | 0.000 | 1 | 0.000 | 0.000 | 0.000 |
| CoarseCrush1 | | | | 0.000 | [203] | 0.000 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.000 | 0.000 | 0.000 | 310 | 0.000 | 0.000 | 0.000 |
| CoarseCrush1 | | | | 0.000 | [203] | 0.000 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.000 | 0.000 | 0.000 | 21 | 0.000 | 0.000 | 0.000 |
| CoarseCrush2 | EU 302 | Space Heating (Natural Gas Fired- Indirect AHU 2) | NA | 0.001 | [203] | 8.343 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 116.997 | 512.448 | 0.000 | 1 | 116.997 | 512.448 | 0.000 |
| CoarseCrush2 | | | | 0.001 | [203] | 8.343 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.002 | 0.009 | 0.000 | 310 | 0.615 | 2.694 | 0.000 |
| CoarseCrush2 | | | | 0.001 | [203] | 8.343 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.002 | 0.009 | 0.000 | 21 | 0.042 | 0.183 | 0.000 |
| CoarseCrush3 | EU 302 | Space Heating (Natural Gas Fired- Indirect Off/CR) | NA | 0.000 | [203] | 0.250 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 3.510 | 15.373 | 0.000 | 1 | 3.510 | 15.373 | 0.000 |
| CoarseCrush3 | | | | 0.000 | [203] | 0.250 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.000 | 0.000 | 0.000 | 310 | 0.018 | 0.081 | 0.000 |
| CoarseCrush3 | | | | 0.000 | [203] | 0.250 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.000 | 0.000 | 0.000 | 21 | 0.001 | 0.005 | 0.000 |
| DH1 | EU 302 | Space Heating (Natural Gas Fired- Indirect DH AHU 1) | NA | 0.000 | [203] | 3.587 | [301] | 2.607 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 50.309 | 220.353 | 160.111 | 1 | 50.309 | 220.353 | 160.111 |
| DH1 | | | | 0.000 | [203] | 3.587 | [301] | 2.607 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.004 | 0.003 | 310 | 0.264 | 1.158 | 0.842 |
| DH1 | | | | 0.000 | [203] | 3.587 | [301] | 2.607 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.004 | 0.003 | 21 | 0.018 | 0.078 | 0.057 |
| DH2 | EU 302 | Space Heating (Natural Gas Fired- Indirect DH AHU 2) | NA | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 50.309 | 220.353 | 0.000 | 1 | 50.309 | 220.353 | 0.000 |
| DH2 | | | | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 310 | 0.264 | 1.158 | 0.000 |
| DH2 | | | | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 21 | 0.018 | 0.078 | 0.000 |
| DH3 | EU 302 | Space Heating (Natural Gas Fired- Indirect DH AHU 3) | NA | 0.000 | [203] | 3.587 | [302] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 50.309 | 220.353 | 0.000 | 1 | 50.309 | 220.353 | 0.000 |
| DH3 | | | | 0.000 | [203] | 3.587 | [302] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 310 | 0.264 | 1.158 | 0.000 |
| DH3 | | | | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 21 | 0.018 | 0.078 | 0.000 |
| DH4 | EU 302 | Space Heating (Natural Gas Fired- Indirect DH AHU 4) | NA | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 50.309 | 220.353 | 0.000 | 1 | 50.309 | 220.353 | 0.000 |
| DH4 | | | | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 310 | 0.264 | 1.158 | 0.000 |
| DH4 | | | | 0.000 | [203] | 3.587 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 21 | 0.018 | 0.078 | 0.000 |
| FineCrush | EU 302 | Space Heating (Natural Gas Fired-total direct) | NA | 0.008 | [203] | 67.869 | [301] | 40.778 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 951.773 | 4,168.766 | 2,504.737 | 1 | 951.773 | 4,168.766 | 2,504.737 |
| FineCrush | | | | 0.008 | [203] | 67.869 | [301] | 40.778 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.016 | 0.071 | 0.042 | 310 | 5.004 | 21.917 | 13.168 |
| FineCrush | | | | 0.008 | [203] | 67.869 | [301] | 40.778 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.016 | 0.071 | 0.042 | 21 | 0.339 | 1.485 | 0.892 |
| FineCrush1 | EU 302 | Space Heating (Natural Gas Fired- Indirect FTCF AHU 1) | NA | 0.001 | [203] | 5.840 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 81.898 | 358.714 | 0.000 | 1 | 81.898 | 358.714 | 0.000 |
| FineCrush1 | | | | 0.001 | [203] | 5.840 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.006 | 0.000 | 310 | 0.431 | 1.886 | 0.000 |
| FineCrush1 | | | | 0.001 | [203] | 5.840 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.006 | 0.000 | 21 | 0.029 | 0.128 | 0.000 |
| FineCrush2 | EU 302 | Space Heating (Natural Gas Fired- Indirect FTCF AHU 2) | NA | 0.001 | [203] | 5.840 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 81.898 | 358.714 | 0.000 | 1 | 81.898 | 358.714 | 0.000 |
| FineCrush2 | | | | 0.001 | [203] | 5.840 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.006 | 0.000 | 310 | 0.431 | 1.886 | 0.000 |
| FineCrush2 | | | | 0.001 | [203] | 5.840 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.006 | 0.000 | 21 | 0.029 | 0.128 | 0.000 |
| FineCrush3 | EU 302 | Space Heating (Natural Gas Fired- Indirect FMF AHU 1) | NA | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 224.635 | 983.900 | 0.000 | 1 | 224.635 | 983.900 | 0.000 |
| FineCrush3 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 310 | 1.181 | 5.173 | 0.000 |
| FineCrush3 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 21 | 0.080 | 0.350 | 0.000 |
| FineCrush4 | EU 302 | Space Heating (Natural Gas Fired- Indirect FMF AHU 2) | NA | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 224.635 | 983.900 | 0.000 | 1 | 224.635 | 983.900 | 0.000 |
| FineCrush4 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 310 | 1.181 | 5.173 | 0.000 |
| FineCrush4 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 21 | 0.080 | 0.350 | 0.000 |
| FineCrush5 | EU 302 | Space Heating (Natural Gas Fired- Indirect FMF AHU 3) | NA | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 224.635 | 983.900 | 0.000 | 1 | 224.635 | 983.900 | 0.000 |
| FineCrush5 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 310 | 1.181 | 5.173 | 0.000 |
| FineCrush5 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 21 | 0.080 | 0.350 | 0.000 |
| FineCrush6 | EU 302 | Space Heating (Natural Gas Fired- Indirect FMF AHU 4) | NA | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 224.635 | 983.900 | 0.000 | 1 | 224.635 | 983.900 | 0.000 |
| FineCrush6 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 310 | 1.181 | 5.173 | 0.000 |
| FineCrush6 | | | | 0.002 | [203] | 16.018 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.017 | 0.000 | 21 | 0.080 | 0.350 | 0.000 |
| Conc B V1 | EU 302 | Space Heating (Natural Gas Fired- Indirect CLL AHU 1) | NA | 0.002 | [203] | 20.023 | [301] | 98.394 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 280.794 | 1,229.876 | 6,043.724 | 1 | 280.794 | 1,229.876 | 6,043.724 |
| Conc B V1 | | | | 0.002 | [203] | 20.023 | [301] | 98.394 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.021 | 0.102 | 310 | 1.476 | 6.466 | 31.774 |
| Conc B V1 | | | | 0.002 | [203] | 20.023 | [301] | 98.394 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.021 | 0.102 | 21 | 0.100 | 0.438 | 2.152 |
| Conc B V2 | EU 302 | Space Heating (Natural Gas Fired- Indirect CLL AHU 2) | NA | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 280.794 | 1,229.876 | 0.000 | 1 | 280.794 | 1,229.876 | 0.000 |
| Conc B V2 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 310 | 1.476 | 6.466 | 0.000 |
| Conc B V2 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 21 | 0.100 | 0.438 | 0.000 |
| Conc B V3 | EU 302 | Space Heating (Natural Gas Fired- Indirect CLL AHU 3) | NA | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 280.794 | 1,229.876 | 0.000 | 1 | 280.794 | 1,229.876 | 0.000 |
| Conc B V3 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 310 | 1.476 | 6.466 | 0.000 |
| Conc B V3 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 21 | 0.100 | 0.438 | 0.000 |
| Conc B V4 | EU 302 | Space Heating (Natural Gas Fired- Indirect CLL AHU 4) | NA | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 280.794 | 1,229.876 | 0.000 | 1 | 280.794 | 1,229.876 | 0.000 |
| Conc B V4 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 310 | 1.476 | 6.466 | 0.000 |
| Conc B V4 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 21 | 0.100 | 0.438 | 0.000 |
| Conc B V5 | EU 302 | Space Heating (Natural Gas Fired- Indirect CLL AHU 5) | NA | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 280.794 | 1,229.876 | 0.000 | 1 | 280.794 | 1,229.876 | 0.000 |
| Conc B V5 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 310 | 1.476 | 6.466 | 0.000 |
| Conc B V5 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 21 | 0.100 | 0.438 | 0.000 |
| Conc B V6 | EU 302 | Space Heating (Natural Gas Fired- Indirect CLL AHU 6) | NA | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 280.794 | 1,229.876 | 0.000 | 1 | 280.794 | 1,229.876 | 0.000 |
| Conc B V6 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 310 | 1.476 | 6.466 | 0.000 |
| Conc B V6 | | | | 0.002 | [203] | 20.023 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.021 | 0.000 | 21 | 0.100 | 0.438 | 0.000 |
| Conc B V7 | EU 302 | Space Heating (Natural Gas Fired- Indirect CML AHU 1) | NA | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 355.672 | 1,557.842 | 0.000 | 1 | 355.672 | 1,557.842 | 0.000 |
| Conc B V7 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 310 | 1.870 | 8.190 | 0.000 |
| Conc B V7 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 21 | 0.127 | 0.555 | 0.000 |
| Conc B V8 | EU 302 | Space Heating (Natural Gas Fired- Indirect CML AHU 2) | NA | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 355.672 | 1,557.842 | 0.000 | 1 | 355.672 | 1,557.842 | 0.000 |
| Conc B V8 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 310 | 1.870 | 8.190 | 0.000 |
| Conc B V8 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 21 | 0.127 | 0.555 | 0.000 |
| Conc B V9 | EU 302 | Space Heating (Natural Gas Fired- Indirect CML AHU 3) | NA | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 355.672 | 1,557.842 | 0.000 | 1 | 355.672 | 1,557.842 | 0.000 |

**PolyMet - Hoyt Lakes, Minnesota**
**Table A-2: Calculation of Potential Greenhouse Gas Emissions at Processing Plant**

| Stack ID | Emission Unit ID | Emission Unit Description | APCD ID | Throughput Maximum (Units/hr) | Note | Maximum (Units/yr) | Note | Projected Actual (Units/yr) | Note | Units | Pollutant | Emission Factor (lb/Unit) | Note | Maximum Emissions [1] (lb/hr) | (ston/yr) | Projected Actual (ston/yr) | CO2-e Factor (Global | Max. Emissions (CO2-e)[4] (lb/hr) | (ston/yr) | Projected Actual (ston/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc B V9 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 310 | 1.870 | 8.190 | 0.000 |
| Conc B V9 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 21 | 0.127 | 0.555 | 0.000 |
| Conc B V10 | EU 302 | Space Heating (Natural Gas Fired- Indirect CML AHU 4) | NA | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 355.672 | 1,557.842 | 0.000 | 1 | 355.672 | 1,557.842 | 0.000 |
| Conc B V10 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 310 | 1.870 | 8.190 | 0.000 |
| Conc B V10 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 21 | 0.127 | 0.555 | 0.000 |
| Conc B V11 | EU 302 | Space Heating (Natural Gas Fired- Indirect CML AHU 5) | NA | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 355.672 | 1,557.842 | 0.000 | 1 | 355.672 | 1,557.842 | 0.000 |
| Conc B V11 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 310 | 1.870 | 8.190 | 0.000 |
| Conc B V11 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 21 | 0.127 | 0.555 | 0.000 |
| Conc B V12 | EU 302 | Space Heating (Natural Gas Fired- Indirect CML AHU 6) | NA | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 355.672 | 1,557.842 | 0.000 | 1 | 355.672 | 1,557.842 | 0.000 |
| Conc B V12 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 310 | 1.870 | 8.190 | 0.000 |
| Conc B V12 | | | | 0.003 | [203] | 25.362 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.026 | 0.000 | 21 | 0.127 | 0.555 | 0.000 |
| Conc B V13 | EU 302 | Space Heating (Natural Gas Fired- Indirect CUBAN) | NA | 0.001 | [203] | 8.343 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 116.997 | 512.448 | 0.000 | 1 | 116.997 | 512.448 | 0.000 |
| Conc B V13 | | | | 0.001 | [203] | 8.343 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.002 | 0.009 | 0.000 | 310 | 0.615 | 2.694 | 0.000 |
| Conc B V13 | | | | 0.001 | [203] | 8.343 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.002 | 0.009 | 0.000 | 21 | 0.042 | 0.183 | 0.000 |
| Conc B V14 | EU 302 | Space Heating (Natural Gas Fired- Indirect CUBAS) | NA | 0.000 | [203] | 3.629 | [301] | 0.000 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 50.894 | 222.915 | 0.000 | 1 | 50.894 | 222.915 | 0.000 |
| Conc B V14 | | | | 0.000 | [203] | 3.629 | [301] | 0.000 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 310 | 0.268 | 1.172 | 0.000 |
| Conc B V14 | | | | 0.000 | [203] | 3.629 | [301] | 0.000 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.004 | 0.000 | 21 | 0.018 | 0.079 | 0.000 |
| Flot V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.003 | [204] | 26.481 | [301] | 5.972 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 371.362 | 1,626.564 | 366.812 | 1 | 371.362 | 1,626.564 | 366.812 |
| Flot V | | | | 0.003 | [204] | 26.481 | [301] | 5.972 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.006 | 0.028 | 0.006 | 310 | 1.952 | 8.551 | 1.928 |
| Flot V | | | | 0.003 | [204] | 26.481 | [301] | 5.972 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.006 | 0.028 | 0.006 | 21 | 0.132 | 0.579 | 0.131 |
| Reagent V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.002 | [204] | 17.825 | [301] | 4.002 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 249.968 | 1,094.858 | 245.813 | 1 | 249.968 | 1,094.858 | 245.813 |
| Reagent V | | | | 0.002 | [204] | 17.825 | [301] | 4.002 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.019 | 0.004 | 310 | 1.314 | 5.756 | 1.292 |
| Reagent V | | | | 0.002 | [204] | 17.825 | [301] | 4.002 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.019 | 0.004 | 21 | 0.089 | 0.390 | 0.088 |
| Conc Dewa V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.001 | [204] | 7.835 | [301] | 1.831 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 109.872 | 481.239 | 112.448 | 1 | 109.872 | 481.239 | 112.448 |
| Conc Dewa V | | | | 0.001 | [204] | 7.835 | [301] | 1.831 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.002 | 0.008 | 0.002 | 310 | 0.578 | 2.530 | 0.591 |
| Conc Dewa V | | | | 0.001 | [204] | 7.835 | [301] | 1.831 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.002 | 0.008 | 0.002 | 21 | 0.039 | 0.171 | 0.040 |
| Conc LO V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.000 | [204] | 2.996 | [301] | 0.727 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 42.018 | 184.040 | 44.664 | 1 | 42.018 | 184.040 | 44.664 |
| Conc LO V | | | | 0.000 | [204] | 2.996 | [301] | 0.727 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.001 | 0.003 | 0.001 | 310 | 0.221 | 0.968 | 0.235 |
| Conc LO V | | | | 0.000 | [204] | 2.996 | [301] | 0.727 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.001 | 0.003 | 0.001 | 21 | 0.015 | 0.066 | 0.016 |
| Rebuild V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.007 | [204] | 61.028 | [301] | 13.237 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 855.837 | 3,748.567 | 813.045 | 1 | 855.837 | 3,748.567 | 813.045 |
| Rebuild V | | | | 0.007 | [204] | 61.028 | [301] | 13.237 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.015 | 0.064 | 0.014 | 310 | 4.499 | 19.707 | 4.274 |
| Rebuild V | | | | 0.007 | [204] | 61.028 | [301] | 13.237 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.015 | 0.064 | 0.014 | 21 | 0.305 | 1.335 | 0.290 |
| Main WH V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.003 | [204] | 22.930 | [301] | 3.452 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 321.557 | 1,408.419 | 212.049 | 1 | 321.557 | 1,408.419 | 212.049 |
| Main WH V | | | | 0.003 | [204] | 22.930 | [301] | 3.452 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.005 | 0.024 | 0.004 | 310 | 1.691 | 7.405 | 1.115 |
| Main WH V | | | | 0.003 | [204] | 22.930 | [301] | 3.452 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.005 | 0.024 | 0.004 | 21 | 0.115 | 0.502 | 0.076 |
| Spares WH V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.002 | [204] | 18.698 | [301] | 2.843 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 262.220 | 1,148.522 | 174.622 | 1 | 262.220 | 1,148.522 | 174.622 |
| Spares WH V | | | | 0.002 | [204] | 18.698 | [301] | 2.843 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.004 | 0.019 | 0.003 | 310 | 1.379 | 6.038 | 0.918 |
| Spares WH V | | | | 0.002 | [204] | 18.698 | [301] | 2.843 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.004 | 0.019 | 0.003 | 21 | 0.093 | 0.409 | 0.062 |
| Hydromet V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.007 | [204] | 57.886 | [301] | 12.895 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 811.775 | 3,555.576 | 792.032 | 1 | 811.775 | 3,555.576 | 792.032 |
| Hydromet V | | | | 0.007 | [204] | 57.886 | [301] | 12.895 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.014 | 0.060 | 0.013 | 310 | 4.268 | 18.693 | 4.164 |
| Hydromet V | | | | 0.007 | [204] | 57.886 | [301] | 12.895 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.014 | 0.060 | 0.013 | 21 | 0.289 | 1.266 | 0.282 |
| Heat Pl V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.004 | [204] | 35.773 | [301] | 7.776 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 501.663 | 2,197.285 | 477.660 | 1 | 501.663 | 2,197.285 | 477.660 |
| Heat Pl V | | | | 0.004 | [204] | 35.773 | [301] | 7.776 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.009 | 0.037 | 0.008 | 310 | 2.637 | 11.552 | 2.511 |
| Heat Pl V | | | | 0.004 | [204] | 35.773 | [301] | 7.776 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.009 | 0.037 | 0.008 | 21 | 0.179 | 0.783 | 0.170 |
| Gen Shop V | EU 302 | Space Heating (Natural Gas Fired) | NA | 0.029 | [204] | 257.858 | [301] | 55.646 | [403] | MM cu. ft. | CO2 | 122,847.165 | [100] | 3,616.107 | 15,838.547 | 3,417.973 | 1 | 3,616.107 | 15,838.547 | 3,417.973 |
| Gen Shop V | | | | 0.029 | [204] | 257.858 | [301] | 55.646 | [403] | MM cu. ft. | N2O | 2.083 | [101] | 0.061 | 0.269 | 0.058 | 310 | 19.011 | 83.268 | 17.969 |
| Gen Shop V | | | | 0.029 | [204] | 257.858 | [301] | 55.646 | [403] | MM cu. ft. | CH4 | 2.083 | [101] | 0.061 | 0.269 | 0.058 | 21 | 1.288 | 5.641 | 1.217 |
| SV 108 | EU 128 | Existing Backup Generator 1 | NA | 11.300 | [205] | 5,650.000 | [302] | 2,712.000 | [404] | MMBtu | CO2 | 161.296 | [102] | 1,822.642 | 455.660 | 218.717 | 1 | 1,822.642 | 455.660 | 218.717 |
| SV 109 | EU 129 | Existing Backup Generator 2 | NA | 11.300 | [205] | 5,650.000 | [302] | 2,712.000 | [404] | MMBtu | CO2 | 161.296 | [102] | 1,822.642 | 455.660 | 218.717 | 1 | 1,822.642 | 455.660 | 218.717 |
| SV 304 | EU 304 | Fire Pump #1 | NA | 0.532 | [206] | 266.000 | [303] | 34.048 | [405] | MMBtu | CO2 | 161.296 | [102] | 85.809 | 21.452 | 2.746 | 1 | 85.809 | 21.452 | 2.746 |
| SV 305 | EU 305 | Fire Pump #2 | NA | 0.532 | [206] | 266.000 | [303] | 34.048 | [405] | MMBtu | CO2 | 161.296 | [102] | 85.809 | 21.452 | 2.746 | 1 | 85.809 | 21.452 | 2.746 |
| SV 427 | EU 413 | Aministration Building New Boiler | NA | 0.023 | [207] | 201.049 | [304] | 33.000 | [406] | Mgal | CO2 | 12,724.846 | [103] | 292.046 | 1,279.160 | 209.960 | 1 | 292.046 | 1,279.160 | 209.960 |
| SV 427 | | | | 0.023 | [207] | 201.049 | [304] | 33.000 | [406] | Mgal | CH4 | 0.182 | [104] | 0.004 | 0.018 | 0.003 | 21 | 0.088 | 0.383 | 0.063 |
| SV 427 | | | | 0.023 | [207] | 201.049 | [304] | 33.000 | [406] | Mgal | N2O | 0.807 | [104] | 0.019 | 0.081 | 0.013 | 310 | 5.741 | 25.145 | 4.127 |
| SV 430 | EU 417 | Adminstration Building Old Boiler (Backup) | NA | 0.018 | [208] | 160.361 | [304] | 0.000 | [407] | Mgal | CO2 | 12,724.846 | [103] | 232.941 | 1,020.282 | 0.000 | 1 | 232.941 | 1,020.282 | 0.000 |
| SV 430 | | | | 0.018 | [208] | 160.361 | [304] | 0.000 | [407] | Mgal | CH4 | 0.182 | [104] | 0.003 | 0.015 | 0.000 | 21 | 0.070 | 0.306 | 0.000 |
| SV 430 | | | | 0.018 | [208] | 160.361 | [304] | 0.000 | [407] | Mgal | N2O | 0.807 | [104] | 0.015 | 0.065 | 0.000 | 310 | 4.579 | 20.056 | 0.000 |
| Area1BV | EU 334 | Area 1 Shop Space Heaters (propane fired) | NA | 0.118 | [209] | 1,031.210 | [301] | 515.605 | [408] | Mgal | CO2 | 12,724.846 | [103] | 1,497.944 | 6,560.994 | 3,280.497 | 1 | 1,497.944 | 6,560.994 | 3,280.497 |
| Area1BV | | | | 0.118 | [209] | 1,031.210 | [301] | 515.605 | [408] | Mgal | CH4 | 0.182 | [104] | 0.021 | 0.094 | 0.047 | 21 | 0.449 | 1.966 | 0.983 |
| Area1BV | | | | 0.118 | [209] | 1,031.210 | [301] | 515.605 | [408] | Mgal | N2O | 0.807 | [104] | 0.095 | 0.416 | 0.208 | 310 | 29.446 | 128.972 | 64.486 |
| Area2BV | EU 130 | Area 2 Shop Space Heaters (propane fired) | NA | 0.109 | [210] | 957.377 | [301] | 478.689 | [408] | Mgal | CO2 | 12,724.846 | [103] | 1,390.694 | 6,091.238 | 3,045.619 | 1 | 1,390.694 | 6,091.238 | 3,045.619 |
| Area2BV | | | | 0.109 | [210] | 957.377 | [301] | 478.689 | [408] | Mgal | CH4 | 0.182 | [104] | 0.020 | 0.087 | 0.043 | 21 | 0.417 | 1.825 | 0.913 |
| Area2BV | | | | 0.109 | [210] | 957.377 | [301] | 478.689 | [408] | Mgal | N2O | 0.807 | [104] | 0.088 | 0.386 | 0.193 | 310 | 27.337 | 119.738 | 59.869 |
| SV 428 | EU 415 | Tailings Basin WWTP Process Fuel Combustion - natural gas (if needed) | NA | 0.000 | [211] | 0.000 | [305] | 0.000 | [409] | MM cu. ft. | CO2 | 122,847.165 | [100] | 0.000 | 0.000 | 0.000 | 1 | 0.000 | 0.000 | 0.000 |
| SV 428 | | | | 0.000 | [211] | 0.000 | [305] | 0.000 | [409] | MM cu. ft. | N2O | 2.083 | [101] | 0.000 | 0.000 | 0.000 | 310 | 0.000 | 0.000 | 0.000 |
| SV 428 | | | | 0.000 | [211] | 0.000 | [305] | 0.000 | [409] | MM cu. ft. | CH4 | 2.083 | [101] | 0.000 | 0.000 | 0.000 | 21 | 0.000 | 0.000 | 0.000 |
| TBWWTPBV | EU 414 | Tailings Basin WWTP Space Heaters (natural gas fired) | NA | 0.008 | [212] | 69.246 | [305] | 27.698 | [410] | MM cu. ft. | CO2 | 122,847.165 | [100] | 971.078 | 4,253.320 | 1,701.328 | 1 | 971.078 | 4,253.320 | 1,701.328 |
| TBWWTPBV | | | | 0.008 | [212] | 69.246 | [305] | 27.698 | [410] | MM cu. ft. | N2O | 2.083 | [101] | 0.016 | 0.072 | 0.029 | 310 | 5.105 | 22.361 | 8.944 |
| TBWWTPBV | | | | 0.008 | [212] | 69.246 | [305] | 27.698 | [410] | MM cu. ft. | CH4 | 2.083 | [101] | 0.016 | 0.072 | 0.029 | 21 | 0.346 | 1.515 | 0.606 |
| SV 426 | EU 412 | Tailings Basin WWTP Back-up Generator | NA | 5.236 | [213] | 2,618.000 | [303] | 2,618.000 | [411] | MMBtu | CO2 | 161.296 | [102] | 844.545 | 211.136 | 211.136 | 1 | 844.545 | 211.136 | 211.136 |
| SV 2532 | EU 2012 | Autoclave vent (1 unit) | CE 201 | 4.941 | [214] | 43,284.836 | [301] | 38,956.352 | [412] | ton gas | CO2 | 0.064 | [105] | 0.316 | 1.384 | 1.245 | 1 | 0.316 | 1.384 | 1.245 |
| SV 2532 | EU 3512 | Iron and Aluminum Precipitation Tanks (3) | CE 204 | 10.616 | [215] | 92,998.361 | [301] | 83,698.525 | [412] | ton gas | CO2 | 882.279 | [106] | 9,366.500 | 41,025.270 | 36,922.743 | 1 | 9,366.500 | 41,025.270 | 36,922.743 |

Sources Subject to PSD Permitting

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Greenhouse Gas Totals (short tons) | | | | | | | | | | | $CO_2$ | | | 39,097 | 151,994 | 64,074 | 1 | 39,097 | 151,994 | 64,074 |
| | | | | | | | | | | | $CH_4$ | | | 0.42 | 1.82 | 0.43 | 21 | 9 | 38 | 9 |
| | | | | | | | | | | | $N_2O$ | | | 0.58 | 2.56 | 0.75 | 310 | 181 | 793 | 233 |

**PolyMet - Hoyt Lakes, Minnesota**
**Table A-2: Calculation of Potential Greenhouse Gas Emissions at Processing Plant**

| Stack ID | Emission Unit ID | Emission Unit Description | APCD ID | Throughput Maximum (Units/hr) | Note | Maximum (Units/yr) | Note | Projected Actual (Units/yr) | Note | Units | Pollutant | Emission Factor (lb/Unit) | Note | Maximum Emissions [1] (lb/hr) | (ston/yr) | Projected Actual (ston/yr) | CO2-e Factor (Global | Max. Emissions (CO2-e)[4] (lb/hr) | (ston/yr) | Projected Actual (ston/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | TOTAL GHGs | | | | | | | 39,287 | 152,825 | 64,316 |

Sources Subject to PSD Permitting

| | | | | Maximum Emissions [1] (kg/hr) | (m.t./yr) | Projected Actual (m.t./yr) | CO2-e Factor (Global | Max. Emissions (CO2-e)[4] (kg/hr) | (m.t./yr) | Projected Actual (m.t./yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Greenhouse Gas Totals (metric tons) | $CO_2$ | | | 17,731 | 137,887 | 58,127 | 1 | 17,731 | 137,887 | 58,127 |
| | $CH_4$ | | | 0.19 | 2 | 0 | 21 | 3.96 | 35 | 8 |
| | $N_2O$ | | | 0.26 | 2 | 1 | 310 | 82.06 | 719 | 212 |
| | TOTAL GHGs | | | | | | | 17,817 | 138,641 | 58,347 |

Plant Site Fugitive Sources

| Stack ID | Emission Unit ID | Emission Unit Description | APCD ID | Throughput Maximum (Units/hr) | Note | Maximum (Units/yr) | Note | Projected Actual (Units/yr) | Note | Units | Pollutant | Emission Factor (kg/Unit) | Note | Maximum Emissions [1] (kg/hr) | (m.t./yr) | Projected Actual (m.t./yr) | CO2-e Factor (Global | Max. Emissions (CO2-e)[4] (kg/hr) | (m.t./yr) | Projected Actual (m.t./yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FS 012 | FS 012 | Haul Truck Traffic | NA | 0.97 | [216] | 21.33 | [306] | 21.33 | [413] | VMT | $CO_2$ | 1.45 | [107] | 1.41E+00 | 3.09E-02 | 0.03 | 1 | 1.41 | 0.03 | 0.03 |
| FS 012 | | (accounts for both Plant Site and Mine Site) | | 0.97 | [216] | 21.33 | [306] | 21.33 | [413] | VMT | $CH_4$ | 5.10E-06 | [107] | 4.95E-06 | 1.09E-07 | 1.09E-07 | 21 | 1.04E-04 | 2.28E-06 | 2.28E-06 |
| FS 012 | | | | 0.97 | [216] | 21.33 | [306] | 21.33 | [413] | VMT | $N_2O$ | 4.80E-06 | [107] | 4.65E-06 | 1.02E-07 | 1.02E-07 | 310 | 1.44E-03 | 3.17E-05 | 3.17E-05 |
| FS 012 | | Light Truck Traffic | NA | 63.18 | [217] | 43,046.24 | [307] | 43,046.24 | [413] | VMT | $CO_2$ | 0.68 | [107] | 4.28E+01 | 2.91E+01 | 29.13 | 1 | 42.75 | 29.13 | 29.13 |
| FS 012 | | (accounts for both Plant Site and Mine Site) | | 63.18 | [217] | 43,046.24 | [307] | 43,046.24 | [413] | VMT | $CH_4$ | 1.10E-06 | [107] | 6.95E-05 | 4.74E-05 | 4.74E-05 | 21 | 1.46E-03 | 0.00 | 9.94E-04 |
| FS 012 | | | | 63.18 | [217] | 43,046.24 | [307] | 43,046.24 | [413] | VMT | $N_2O$ | 1.70E-06 | [107] | 1.07E-04 | 7.32E-05 | 7.32E-05 | 310 | 3.33E-02 | 0.02 | 2.27E-02 |
| FS 012 | | Fuel Tanker Travel | NA | 2.09 | [218] | 4,571.83 | [308] | 4,571.83 | [413] | VMT | $CO_2$ | 1.45 | [107] | 3.03E+00 | 6.63E+00 | 6.63 | 1 | 3.03 | 6.63 | 6.63 |
| FS 012 | | (accounts for both Plant Site and Mine Site) | | 2.09 | [218] | 4,571.83 | [308] | 4,571.83 | [413] | VMT | $CH_4$ | 5.10E-06 | [107] | 1.06E-05 | 2.33E-05 | 2.33E-05 | 21 | 2.24E-04 | 4.90E-04 | 4.90E-04 |
| FS 012 | | | | 2.09 | [218] | 4,571.83 | [308] | 4,571.83 | [413] | VMT | $N_2O$ | 4.80E-06 | [107] | 1.00E-05 | 2.19E-05 | 2.19E-05 | 310 | 3.11E-03 | 6.80E-03 | 6.80E-03 |
| FS 012 | | WWTF Trucks | NA | 6.65 | [219] | 15,337.74 | [309] | 15,337.74 | [413] | VMT | $CO_2$ | 1.45 | [107] | 9.65E+00 | 2.22E+01 | 22.24 | 1 | 9.65 | 22.24 | 22.24 |
| FS 012 | | | | 6.65 | [219] | 15,337.74 | [309] | 15,337.74 | [413] | VMT | $CH_4$ | 5.10E-06 | [107] | 3.39E-05 | 7.82E-05 | 7.82E-05 | 21 | 7.13E-04 | 1.64E-03 | 1.64E-03 |
| FS 012 | | | | 6.65 | [219] | 15,337.74 | [309] | 15,337.74 | [413] | VMT | $N_2O$ | 4.80E-06 | [107] | 3.19E-05 | 7.36E-05 | 7.36E-05 | 310 | 9.90E-03 | 2.28E-02 | 2.28E-02 |
| FS 016 | FS 016 | Tailings Basin Traffic | NA | 63.18 | [217] | 43,046 | [307] | 43,046 | [413] | VMT | $CO_2$ | 1.45 | [107] | 9.16E+01 | 6.24E+01 | 62.42 | 1 | 91.61 | 62.42 | 62.42 |
| FS 016 | | | | 63.18 | [217] | 43,046 | [307] | 43,046 | [413] | VMT | $CH_4$ | 5.10E-06 | [107] | 3.22E-04 | 2.20E-04 | 2.20E-04 | 21 | 6.77E-03 | 4.61E-03 | 4.61E-03 |
| FS 016 | | | | 63.18 | [217] | 43,046 | [307] | 43,046 | [413] | VMT | $N_2O$ | 4.80E-06 | [107] | 3.03E-04 | 2.07E-04 | 2.07E-04 | 310 | 9.40E-02 | 6.41E-02 | 6.41E-02 |
| MDS 604 | NA | Locomotive Switcher | NA | 5.45 | [221] | 47,730 | [301] | 47,730 | [413] | gal | CO2 | 10.15 | [107] | 5.53E+01 | 4.84E+02 | 484.45 | 1 | 55.30 | 484.45 | 484.45 |
| | | | | 5.45 | [221] | 47,730 | [301] | 47,730 | [413] | gal | CH4 | 5.80E-04 | [107] | 3.16E-03 | 2.77E-02 | 2.77E-02 | 21 | 6.64E-02 | 5.81E-01 | 5.81E-01 |
| | | | | 5.45 | [221] | 47,730 | [301] | 47,730 | [413] | gal | N2O | 2.60E-04 | [107] | 1.42E-03 | 1.24E-02 | 1.24E-02 | 310 | 4.39E-01 | 3.85E+00 | 3.85E+00 |
| MDS 603 | NA | Locomotive Ore Haul | NA | 24.52 | [222] | 211,841 | [301] | 211,841 | [413] | gal | CO2 | 10.15 | [107] | 2.49E+02 | 2.15E+03 | 2150.18 | 1 | 248.86 | 2,150.18 | 2150.18 |
| | | | | 24.52 | [222] | 211,841 | [301] | 211,841 | [413] | gal | CH4 | 5.80E-04 | [107] | 1.42E-02 | 1.23E-01 | 1.23E-01 | 21 | 2.99E-01 | 2.58E+00 | 2.58E+00 |
| | | | | 24.52 | [222] | 211,841 | [301] | 211,841 | [413] | gal | N2O | 2.60E-04 | [107] | 6.37E-03 | 5.51E-02 | 5.51E-02 | 310 | 1.98E+00 | 1.71E+01 | 1.71E+01 |
| MDS 605 | NA | Tailings Basin Haul Trucks - Tier 4 (59.9 ton payload) | NA | 420 | [223] | 462,000 | [310] | 462,000 | [413] | gal | CO2 | 10.15 | [107] | 4.26E+03 | 4.69E+03 | 4689.30 | 1 | 4,263.00 | 4,689.30 | 4689.30 |
| | | | | 420 | [223] | 462,000 | [310] | 462,000 | [413] | gal | CH4 | 5.80E-04 | [107] | 2.44E-01 | 2.68E-01 | 2.68E-01 | 21 | 5.12E+00 | 5.63E+00 | 5.63E+00 |
| | | | | 420 | [223] | 462,000 | [310] | 462,000 | [413] | gal | N2O | 2.60E-04 | [107] | 1.09E-01 | 1.20E-01 | 1.20E-01 | 310 | 3.39E+01 | 3.72E+01 | 3.72E+01 |
| MDS 605 | NA | Track Dozer | NA | 8.07 | [224] | 8,879 | [310] | 8,879 | [413] | gal | CO2 | 10.15 | [107] | 8.19E+01 | 9.01E+01 | 90.12 | 1 | 81.92 | 90.12 | 90.12 |
| | | | | 8.07 | [224] | 8,879 | [310] | 8,879 | [413] | gal | CH4 | 5.80E-04 | [107] | 4.68E-03 | 5.15E-03 | 5.15E-03 | 21 | 9.83E-02 | 1.08E-01 | 1.08E-01 |
| | | | | 8.07 | [224] | 8,879 | [310] | 8,879 | [413] | gal | N2O | 2.60E-04 | [107] | 2.10E-03 | 2.31E-03 | 2.31E-03 | 310 | 6.51E-01 | 7.16E-01 | 7.16E-01 |
| MDS 605 | NA | Grader | | 6.84 | [224] | 7,522 | [310] | 7,522 | [413] | gal | CO2 | 10.15 | [107] | 6.94E+01 | 7.64E+01 | 7.64E+01 | 1 | 6.94E+01 | 7.64E+01 | 7.64E+01 |
| | | | | 6.84 | [224] | 7,522 | [310] | 7,522 | [413] | gal | CH4 | 5.80E-04 | [107] | 3.97E-03 | 4.36E-03 | 4.36E-03 | 21 | 8.33E-02 | 9.16E-02 | 9.16E-02 |
| | | | | 6.84 | [224] | 7,522 | [310] | 7,522 | [413] | gal | N2O | 2.60E-04 | [107] | 1.78E-03 | 1.96E-03 | 1.96E-03 | 310 | 5.51E-01 | 6.06E-01 | 6.06E-01 |
| MDS 605 | NA | Compactor | | 5.40 | [224] | 5,936 | [310] | 5,936 | [413] | gal | CO2 | 10.15 | [107] | 5.48E+01 | 6.03E+01 | 6.03E+01 | 1 | 5.48E+01 | 6.03E+01 | 6.03E+01 |
| | | | | 5.40 | [224] | 5,936 | [310] | 5,936 | [413] | gal | CH4 | 5.80E-04 | [107] | 3.13E-03 | 3.44E-03 | 3.44E-03 | 21 | 6.57E-02 | 7.23E-02 | 7.23E-02 |
| | | | | 5.40 | [224] | 5,936 | [310] | 5,936 | [413] | gal | N2O | 2.60E-04 | [107] | 1.40E-03 | 1.54E-03 | 1.54E-03 | 310 | 4.35E-01 | 4.78E-01 | 4.78E-01 |
| MDS 605 | NA | Tailings Basin Excavator (8 yd^3 bucket) | NA | 24.33 | [224] | 26,764 | [310] | 26,764 | [413] | gal | CO2 | 10.15 | [107] | 2.47E+02 | 2.72E+02 | 271.65 | 1 | 246.96 | 271.65 | 271.65 |
| | | | | 24.33 | [224] | 26,764 | [310] | 26,764 | [413] | gal | CH4 | 5.80E-04 | [107] | 1.41E-02 | 1.55E-02 | 1.55E-02 | 21 | 2.96E-01 | 3.26E-01 | 3.26E-01 |
| | | | | 24.33 | [224] | 26,764 | [310] | 26,764 | [413] | gal | N2O | 2.60E-04 | [107] | 6.33E-03 | 6.96E-03 | 6.96E-03 | 310 | 1.96E+00 | 2.16E+00 | 2.16E+00 |

Plant Site Mobile Sources

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Greenhouse Gas Totals (metric tons) | $CO_2$ | | | 5168.67 | 7942.75 | 7942.75 | 1 | 5168.67 | 7942.75 | 7942.75 |
| | $CH_4$ | | | 0.29 | 0.45 | 0.45 | 21 | 6.03 | 9.39 | 9.39 |
| | $N_2O$ | | | 0.13 | 0.20 | 0.20 | 310 | 40.01 | 62.23 | 62.23 |
| | TOTAL GHGs | | | | | | | 5,215 | 8,014 | 8,014 |

Plant Site Totals

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Greenhouse Gas Totals (metric tons) | $CO_2$ | | | 22,900 | 145,830 | 66,070 | 1 | 22,900 | 145,830 | 66,070 |
| | $CH_4$ | | | 0.48 | 2.10 | 0.84 | 21 | 10.00 | 44.10 | 17.62 |
| | $N_2O$ | | | 0.39 | 2.52 | 0.88 | 310 | 122.07 | 781.24 | 273.98 |
| | TOTAL GHGs | | | | | | | | 146,655 | 66,361 |

| | | | |
|---|---|---|---|
| % of total | CO2 | 99.4% | 99.6% |
| | N2O | 0.0% | 0.0% |
| | CH4 | 0.53% | 0.41% |

**Notes:**

**General References:**

[1] Max. Emissions (kg/hr) = EF (kg/unit) x Max. Hourly Throughput (units/hr).
Max. Uncontrolled Emissions (m.t./yr) = EF (kg/unit) x Max. Annual Throughput (units/yr) / 1,000 (kg/m.t.).

[2] Projected Actual Emissions (m.t./yr) = EF (kg/unit) x Projected Actual Throughput (units/yr) / 1,000 (kg/m.t.).

[3] Global Warming Potentials from 2001 IPCC Guidelines, found through "Comparison of Global Warming Potentials from the Second and Third Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC)" <http://www.eia.doe.gov/oiaf/1605/gwp.html>

**PolyMet - Hoyt Lakes, Minnesota**

**Table A-2: Calculation of Potential Greenhouse Gas Emissions at Processing Plant**

| Stack ID | Emission Unit | | APCD ID | Throughput | | | | | | | Pollutant | Emission Factor | | Maximum Emissions [1] | | Projected Actual | CO2-e Factor | Max. Emissions (CO2-e)[4] | | Projected Actual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | | Maximum | | | | Projected Actual | | Units | | | | | | | | | | |
| | | | | (Units/hr) | Note | (Units/yr) | Note | (Units/yr) | Note | | | (lb/Unit) | Note | (lb/hr) | (ston/yr) | (ston/yr) | (Global | (lb/hr) | (ston/yr) | (ston/yr) |

[4] Max. Emissions (CO2-e) (kg/hr) = Max. Uncontrolled Emissions (kg/hr) x (CO2-e Factor).
Max. Controlled Emissions (m.t./yr) = Max. Uncontrolled Emissions (m.t./yr) x (CO2-e Factor).
[5] Projected Actual Emissions (CO2-e) (m.t./yr) = EF (kg/unit) x Projected Actual Throughput (units/yr) / 1,000 (kg/m.t.)

**Emission Factor References:**

[100] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table12.1 (Weighted U.S. Average Entry). Emission factor converted from kg/MMBtu to lb/MMcf by kg/MMBtu * 2.205 lb/kg * 1050 MMBtu/MMcf. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.
[101] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table 12.7. Factors converted from g/MMBtu to lb/Mgal by lb/Mgal = g/MMBtu * (1 lb/453.59 g) * 1050 MMBtu/MMcf. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.
[102] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table 12.1 (Distillate Fuel Oil). Emission factor converted from kg/MMBtu to lb/MMBtu by kg/MMBtu * 2.205 lb/kg. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.
[103] FFrom Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table12.1. Emission factor converted from kg/MMBtu to lb/Mgal by kg/MMBtu * 2.205 lb/kg * 91.5 MMBtu/Mgal. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar..
[104] From Climate Registry General Reporting Protocol (Version 1.1, May 2008) Table 12.7. Factors converted from g/MMBtu to lb/Mgal by lb/Mgal = g/MMBtu * (1 lb/453.59 g) * 91.5 MMBtu/Mgal. This emission factor source is generally used for carbon footprint assessment and is applicable for air permitting. AP-42 factors are similar.
[105] CO2 emission rate taken from MetSim flow simulation results transmitted by Glenn Stieper of Bateman as a spreadsheet attached to a February 9, 2011 e-mail. Rate = 0.000143 Mtons/hour * 1.1023 Mton/ston = 0.000158 ston/hr * 2000 lb/ton = 0.315 lb/hr. Emission factor is emission rate divided by ton/hr exhaust gas flow.
[106] CO2 emission rate taken from MetSim flow simulation results transmitted by Glenn Stieper of Bateman as a spreadsheet attached to a February 9, 2011 e-mail. Rate = 4.2486 Mtons/hour * 1.1023 Mton/ston = 4.6832 ston/hr * 2000 lb/ton = 9366.5 lb/hr. Emission factor is emission rate divided by ton/hr exhaust gas flow.
[107] For Diesel Heavy-Duty Vehicles and Diesel Light Trucks: Emission factors taken from The Climate Registry's General Reporting Protocol, May 2008, Tables 13.1 and 13.3. For conversion purposes, truck efficiency assumed at 7 mpg for haul trucks and 15 mpg for light trucks.
For Non-Highway Vehicles: Emission factors taken from The Climate Registry's General Reporting Protocol, May 2008, Tables 13.1 and 13.6.

| | CO2 | CH4 | N2O |
|---|---|---|---|
| Diesel Emissions (kg/gal): | 10.15 | | |
| Diesel Heavy-Duty Vehicles, uncontrolled (g/mi): | | 0.0051 | 0.0048 |
| Diesel Light Trucks, uncontrolled (g/mi): | | 0.0011 | 0.0017 |
| Construction / Large Utility Non-highway Vehicles, diesel (g/gal): | | 0.58 | 0.26 |
| Construction / Large Utility Non-highway Vehicles, gasoline (g/gal): | | 0.5 | 0.22 |

**Maximum Hourly Throughput References:**

[201] Max. Hourly Capacity = 52,970 MJ/hr per Clayton as communicated in May 3, 2006 e-mail from Mike Wardell-Johnson of Bateman.
Fuel usage: 52,970 MJ/hr * 10^6 J/MJ * 9.47831 * 10^-4 Btu/J / 10^6 Btu/MMBtu / 1,050 MMBtu/MMcu.ft. (heating value of natural gas) = 0.0478 MMcf/hr.
[202] Heating demand for adsorber regeneration estimated as 600 kW by engineer working on oxygen plant design. Heater may be electric or natural gas fired. Assumed natural gas fired as worst case.
Hourly heat input is: 600 kW * 0.94783 (Btu/sec)/kW * 3600 sec/hour / 10^6 MMBtu/Btu = 2.05 MMBtu/hr.
[203] Design heater capacity and annual actual fuel usage estimates taken from Phase I design work completed by mechanical design contractor. Heating capacity separated into direct fired, which will vent out general bulding vents, and invididual indirect fired units, which will have separate stacks, for use in refined modeling if needed.
[204] Total design space heating capacity for new buildings estimated by Barr based on available data. Actual annual fuel usage estimated with historic temperature data from a nearby location.
[205] Based a fuel consumption test performed on the generators before they were delivered with a result of 587 lb fuel/hr @ 100% power. From AP-42 Section 3.4.1, footnote "a", the heat content of diesel fuel is 19,300 btu/lb. The maximum heat input is then 587 lb fuel/hr * 19,300 Btu/lb / 10^6 Btu/MMBtu = 11.3 MMBtu/hr.
[206] Existing fire pumps will be replaced with two Clarke JU4H-UF58 diesel powered pumps. Maximum fuel consumption rate is 3.8 gal/hr (0.0038 Mgal/hr) per data obtained from the manufacturer. Heat input = 3.8 gal/hr * 140,000 Btu/gallon / 10^6 Btu/MMBtu = 0.532 MMBtu/hr.
Annual potential heat input based on 500 hours per year based on EPA guidance for equipment used for emergency purposes.
[207] New boiler has a maximum heat input of 2.1 MMBtu/hr per manufacturer information.
[208] Burner capacity based on information from Manufacturer.
[209] Total heat input of the propane fired space heaters at the Area 1 Shop based on a quotation for upgrade of the system from 1990. Heat input = 8.976 MMBtu/hr.
[210] New propane fired infrared space heaters will be installed in the Area 2 shops. Maximum capacity assumed the same as existing boiler (10 MMBtu/hr ). The heaters are expected to have a lower maximum heat input than the existing boiler due to higher efficiency.
[211] The preferred option for the WWTP is to ship brine offsite, but if this is not feasible, an evaporator/crystallizer would be operated on-site. It may be electric or natural gas fired. As the worst case of the alternatives under consideration, a gas fired unit is assumed in the emission calculations. Based on design work completed to date for comparison of alternatives, the maximum energy usage is 5 MMBtu/hr; assuming 80% efficiency, the maxmum heat input for a gas fired unit is 6 MMBtu/hr. A 10 MMBtu unit was assumed to provide a safety factor.
[212] Based on preliminary design of Mine Site waste water treatment facility for DEIS by Barr, maximum heating demand for natural gas fired heaters is estimated as 8.3 MMBtu/hr. The MIne Site heater rating has since been refined and this value may be as well as design work proceeds. A conservative estimate of annual usage was made by assuming 40% utilization for the heaters; detailed calculations for other heaters at the Plant Site showed a significantly lower percent utilization. Assumes natural gas line will be extended to WWTP.
[213] Based on preliminary design of Mine Site waste water treatment facility by Barr, critical power demand is about 500 kW. This was considered a conservative estimate of critical power demands at the Area 5 WWTF. It was assumed that a Caterpillar Standby 500 ekW would be installed. Based on literature available on the manufacturer's website, the fuel consumption at maximum load is 37.4 gallons/hr (0.0374 Mgal/hr). This is converted to MMBtu/hr by 37.4 gal/hr * 140,000 Btu/gallon / 10^6 Btu/MMBtu = 5.236 MMBtu/hr.
[214] Gas exhaust rate taken from MetSim flow simulation results transmitted by Glenn Stieper of Bateman as a spreadsheet attached to a February 9, 2011 e-mail. Rate = 4.4826 Mtons/hour * 1.1023 Mton/ston = 4.9411 ston/hr.
[215] Total gas exhaust rate for three tanks taken from MetSim flow simulation results transmitted by Glenn Stieper of Bateman as a spreadsheet attached to a February 9, 2011 e-mail. Rate = 9.631 Mtons/hour * 1.1023 Mton/ston = 10.616 ston/hr.
[216] The NorthMet Project Description (Version 2, April 15, 2011) indicates that haul trucks would be expected to go to Area 1 for maintenance two times per year for major repairs and that a maximum of 9 haul trucks will be used for mining. Two additional haul trucks may be used for mining for a total of 11. Total annual trips are then 2 round trips/year/truck * 11 trucks = 22 round trips * 2 trips/round trip = 44 trips. The approximate average maintenance interval in days is 365/2 = 180 days. Average trips per day are then 1/180 trips/truck/day * 11 trucks = 0.06 trips/day. A conservative worst case hourly VMT was estimated as having 2 trucks make a one way trip in the hour. This was also assumed to be the daily maximum. Haul Trucks use Road Segments: B2, J, and J2; the hourly VMT =(0.16 mi +0.09 mi+ 0.24mi) x 2 trips/hr. See Note [220].
[217] Hourly light truck traffic at tailings basin estimated by scaling data from when the tailings basin was operated by Cliffs Erie. The previous estimates of VMT were scaled by the relative quantity of tailings produced or 30,887 ton/day / 66,000 ton/day. Tailings generation rate taken from MetSim Rev. U3. The Cliffs Erie VMT estimate was based on a maximum of 9 trucks traveling 15 mph. Annual light truck traffic at tailings basin estimated by scaling data from when the tailings basin was operated by Cliffs Erie. The previous estimates of VMT were scaled by the relative quantity of tailings produced or 30,881 ton/day / 66,000 ton/day.
[218] Three 7,500 gallon fuel tankers per day would be needed. Only one trip per hour would likely be completed. Annual trips = 3 tankers/day * 2 trips/round trip * 365 days/year = 2190 trips/year. Fuel Tankers use road segments: B2, C, and H; the hourly VMT = (0.16 mi + 1.928 mi) * 1 trip/hr. See Note [220].
[219] Maximum throughput for waste water treatment facility estimated as approximately 4,500 tpy lime in and 27,000 tpy sludge out. Lime will be transported from Plant Site in 40 ton over the road trucks with 20 ton payload. Similar trucks will haul sludge back to Plant Site. Assume different trucks used as worst case. Annual trips = (4500 ton + 27000 ton) /20 ton/truck = 1575 round trips/yr * 2 = 3150 trips/year. Assume 5 day per week, 52 week per year trucking schedule: 1575 / (5 * 52) = 6.06 truck per day, round up to 7 trucks per day.
Additonally, in Years 1-3, 2 truck per day will tranport brine from the Plant Site WWTP to the Mine Site WWTF for a total of: 2 trucks/day * 2 trips/round trip * 365 days/year = 1460 trips/year. Grand total is 3150 + 1460 = 4610 trips/year.
WWTF trucks use road segments: B2, C, D, E, and F; the hourly VMT = (0.16 mi + 1.928 mi + 0.148 mi + 0.722 mi + 0.370 mi) * 2 trips/hr. See Note [220].
[220] All mine personnel will drive personal vehicles to Area 2. From there, equipment operators and others who work all day at the mine will be transported by bus to the Mine Site. Other staff based at Area 2 will travel to the Mine Site during the work day as indicated by the number of trips in the table above. The road segments traveled are also included in the table. Maximum hourly emissions will occur at shift changes where the vehicles transporting both shifts could be on the road during the same hour. To be conservative it was assumed that all travel would occur between the eight hour shifts although at least some railroad personnel will be working 12 hour shifts and other personnel may travel at other times. The maximum daily and hourly trips are shown in the table above as well as the hourly and annual miles.
Only segments B2, C, D, E, F and H are at the Plant Site. Emissions from other segments are included with the Mine Site Calcs. All of segment H on PolyMet property is paved.

| Category | Location | 1st shift | 2nd Shift | 3rd Shift | Road Segments Traveled |
|---|---|---|---|---|---|
| Mine Ops | Mine (Bus) | 1 | 1 | 1 | A, B2, B3, C, D |
| Mine Tech Serv | to Mine | 4 | 0 | 0 | A, B2, B3, C, D |
| Mine Manage. | to Mine | 7 | 2 | 2 | A, B2, B3, C, D |
| RR Ops | to Mine | 6 | 4 | 4 | A, B2, B3, C, D |
| Other | to Mine | 2 | 0 | 0 | A, B2, B3, C, D |
| Total Employees | to Area 2 | 28 | 35 | 28 | D, H |
| EHS | PP to mine | 3 | 0 | 0 | A, B2, B3, C, D, E, F |
| Total | | 51 | 42 | 35 | |

| Road Segment | Dist. (miles) | Max Hourly Trips | Max Daily Trips | Hourly VMT | Annual VMT | Daily VMT |
|---|---|---|---|---|---|---|
| A | 0.800 | 23 | 74 | 18.40 | 21613.40 | 59.21 |
| B2 | 0.160 | 23 | 74 | 3.68 | 4317.16 | 11.83 |
| B3 | 1.166 | 23 | 74 | 26.82 | 31493.66 | 86.28 |
| C | 1.928 | 23 | 74 | 44.34 | 52068.78 | 142.65 |
| D | 0.148 | 64 | 256 | 9.45 | 13791.83 | 37.79 |

**PolyMet - Hoyt Lakes, Minnesota**
**Table A-2: Calculation of Potential Greenhouse Gas Emissions at Processing Plant**

| Stack ID | Emission Unit | | APCD ID | Throughput | | | | | | Pollutant | Emission Factor | | Maximum Emissions [1] | | Projected Actual | CO2-e Factor | Max. Emissions (CO2-e)[4] | | Projected Actual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ID | Description | | Maximum | | | | Projected Actual | | Units | | | | | | | | | | |
| | | | | (Units/hr) | Note | (Units/yr) | Note | (Units/yr) | Note | | | (lb/Unit) | Note | (lb/hr) | (ston/yr) | (ston/yr) | (Global | (lb/hr) | (ston/yr) | (ston/yr) |
| | | E | 0.722 | 3 | | 6 | | 2.17 | 1580.93 | | | | | | | 4.33 | | | | |
| | | F | 0.370 | 3 | | 6 | | 1.11 | 810.25 | | | | | | | 2.22 | | | | |
| | | H | 0.000 | 93 | | 182 | | 0.00 | 0.00 | | | | | | | 0.00 | | | | |
| | | Total | 5.293 | | | | | 106.0 | 125676 | | | | | | | 344.3 | | | | |

| Miscellaneous Road Lengths | |
|---|---|
| Description | Length (miles) |
| J | 0.09 |
| J2 | 0.24 |
| TB WWTP | 0.60 |

[221] Load factor assume the same as for ore haul locomotives (15%), but with only a single 700 hp engine. Annual usage equals daily usage times 360 mining days per year.

Switching Locomotive

| | | |
|---|---|---|
| Daily Estimate Total Fuel Usage | 131 | gallons/day |
| Hourly Average Fuel Use | 5.45 | gph |

[222] Fuel usage for each ore haul locomotive calculated by PolyMet. Annual usage equals daily usage times 360 mining days per year.

| | | |
|---|---|---|
| Daily Estimate Total Fuel Usage | 1,177 | gallons/day |
| Hourly Average Fuel Use | 49.04 | gph |

[223] Fuel usage based on operations at a taconite tailings basin with the same model truck. Estimated fuel consumption is 15 gallons/hr times maximum 28 trucks = 420 gallons per hour. Annual and daily consumption based on construction schedule of one 10 hour shift for 110 day construction season.

[224] Hourly fuel consumption estimated by assuming same load factor as primary production excavators at Mine Site, rounded up to the nearest 5%, although Mine Site units are electric and Tailings Basin units will be diesel powered. Annual and daily consumption based on construction schedule of one 10 hour shift for 110 day construction season.

**Maximum Annual Throughput References:**

[301] Max. Annual Fuel Usage (or heat input) = Max. Hourly Fuel Usage (or heat input) * 8,760 hr/yr. Projected utilization varies by process area , but all will be less than 8760 hr/yr.

[302] Assumes 140,000 Btu/gal No. 2 Fuel Oil. As recommended by EPA guidance, 500 hours per year operation was assumed for emergency generators. Annual throughput is then hourly throughput * 500 hours/year.

[303] As recommended by EPA guidance, 500 hours per year operation was assumed for emergency generators. Annual throughput is then hourly throughput * 500 hours/year.

[304] Assume 91.5 MMBtu/Mgal propane. Annual usage is 8,760 hrs/year

[305] Assume 1050 MMBtu/MMscf NG. Annual usage is 8,760 hrs/year

[306] The NorthMet Project Description (Version 2, April 15, 2011) indicates that haul trucks would be expected to go to Area 1 for maintenance two times per year for major repairs and that a maximum of 9 haul trucks will be used for mining. Two additional haul trucks may be used for mining for a total of 11. Total annual trips are then 2 round trips/year/truck * 11 trucks = 22 round trips * 2 trips/round trip = 44 trips. Haul Trucks use Road Segments: B2, J, and J2; the Annual VMT =(0.16 mi +0.09 mi+ 0.24mi) x 44 trips/yr. See Note [220].

[307] Annual light truck traffic at tailings basin estimated by scaling data from when the tailings basin was operated by Cliffs Erie. The previous estimates of VMT were scaled by the relative quantity of tailings produced or 30,881 ton/day / 66,000 ton/day.

[308] Annual trips = 3 tankers/day * 2 trips/round trip * 365 days/year = 2190 trips/year. Fuel Tankers use road segments: B2, C, and H; the hourly VMT = (0.16 mi + 1.928 mi) * 2190 trips/yr. See Note [220].

[309] Annual trips = (4500 ton + 27000 ton) /20 ton/truck = 1575 round trips/yr * 2 = 3150 trips/year. WWTF trucks use road segments: B2, C, D, E, and F; the hourly VMT = (0.16 mi + 1.928 mi + 0.148 mi + 0.722 mi + 0.370 mi) * 3150 trips/yr. See Note [220].

[310] Annual based on constructions schedule of one 10 hour shift for 110 day construction season

**Projected Actual Throughput References**

[401] Estimated actual emissions based on 6% utilization as per specification prepared by Bateman dated 2/17/06.

[402] Projected actual emissions based on 16 hours per day operation.

[403] Design heater capacity and annual actual fuel usage estimates taken from Phase I design work completed by mechanical design contractor. Heating capacity separated into direct fired, which will vent out general bulding vents, and invididual indirect fired units, which will have separate stacks, for use in refined modeling if needed. Actual annual fuel usage not split out by individual unit, but is arbitrarily assigned to the first entry for each building.

[404] Projected actual emissions assume 10 days per year or 240 hours operation. This is expected to be a conservative assumption since most operation will be for testing and occasionally to safely shut down plant during power outage. Annual throughput = 240 hours * hourly heat input rate.

[405] Annual actual operating hours estimated as 1 hour per week for testing and 12 hours per year operation for a total of 64 hours. Annual throughput = 64 * hourly heat input.

[406] Annual usage estimated from historic fuel usage with old boiler.

[407] Annual projected usage is 0 because this boiler is a backup unit for EU 413, so all fuel usage is assigned to that unit.

[408] Projected actual usage based on 50% utilization for the heating system, a conservative assumption.

[409] Actual fuel usage assumed to be 80% of potential as a conservative estimate.

[410] A conservative estimate of annual usage was made by assuming 40% utilization for the heaters.

[411] Assumes actual use is 500 hours per year

[412] Actual annual emissions assume 90% availability or 7884 hours per year

[413] Projected acutal emissions are equivalent to potential emissions

**PolyMet - Hoyt Lakes, Minnesota**

**Table A-3: Calculation of Potential NorthMet Greenhouse Gas Emissions from Construction Activities**

| | Potential Emissions (tpy) | | | | Projected Actual Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|
| Year 0 | CO2 | N2O | CH3 | CO2e | CO2 | N2O | CH4 | CO2e |
| Plant Site Point | 90129 | 2.2 | 1.5 | 90829 | 20931.1 | 0.6 | 0.3 | 21132 |
| Plant Site Mobile | 5450 | 0.1 | 0.3 | 5499 | 5449.6 | 0.1 | 0.3 | 5499 |
| Mine Site Point | 310 | 0.0 | 0.0 | 310 | 64.6 | 0.0 | 0.0 | 65 |
| Mine Site Mobile | 2605 | 0.1 | 0.1 | 2629 | 2605.5 | 0.1 | 0.1 | 2629 |
| Other Construction [3] | 2062 | 0.1 | 0.1 | 2081 | 2061.9 | 0.1 | 0.1 | 2081 |
| Total | 100557 | 2.4 | 2.1 | 101349 | 31112.8 | 0.9 | 0.9 | 31406 |

| | Potential Emissions (tpy) | | | | Projected Actual Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|
| Year 2 | CO2 | N2O | CH3 | CO2e | CO2 | N2O | CH4 | CO2e |
| Plant Site Point (tpy) | [1] | [1] | [1] | [1] | [1] | [1] | [1] | [1] |
| Plant Site Mobile (tpy) | [1] | [1] | [1] | [1] | [1] | [1] | [1] | [1] |
| Mine Site Point | [1] | [1] | [1] | [1] | [1] | [1] | [1] | [1] |
| Mine Site Mobile | [1] | [1] | [1] | [1] | [1] | [1] | [1] | [1] |
| Other Construction [3] | 1031 | 0.0 | 0.1 | 1040 | 1031 | 0.0 | 0.1 | 1040 |
| Total | 1031 | 0.0 | 0.1 | 1040 | 1031 | 0.0 | 0.1 | 1040 |
| Total Project (Stons) | | | | 102389 | | | | 32447 |
| Total Project (mt) | | | | 92885 | | | | 29435 |

Global Warming Potentials

| | |
|---|---|
| CO2 | 1 |
| CH4 | 21 |
| N2O | 310 |

**Details on Estimated Emissions from Other Construction Activities [2]**

| | | |
|---|---|---|
| Phase I Construction (Flotation Concentrate - Year 0) | | |
| New Buildings | | |
| Fine Grading | 2335 | lbs/day |
| Paving/grading | 3545 | lbs/day |
| Paving/grading/building | 5728 | lbs/day |
| Building | 2183 | lbs/day |
| Building/Coating | 2248 | lbs/day |
| Coating | 66 | lbs/day |
| Max Daily Emissions | 5728 | lbs/day |
| Conservative Annual Estimate [4] | 1031 | Tons/year |
| | | |
| Work on existing buildings [5] | 1031 | tons/year |
| | | |
| Total | 2062 | tons/year |
| | | |
| Phase 2 Hydrometallurgical Plant Construction (Same footprint as Year 0 new Buildings - about 125,000 ft^2) | | |
| New Buildings | | |
| Fine Grading | 2335 | lbs/day |
| Paving/grading | 3545 | lbs/day |
| Paving/grading/building | 5728 | lbs/day |
| Building | 2183 | lbs/day |
| Building/Coating | 2248 | lbs/day |
| Coating | 66 | lbs/day |
| Max Daily Emissions | 5728 | lbs/day |
| Conservative Annual Estimate | 1031 | Tons/year |
| | | |
| Work on existing buildings [6] | 0 | tons/year |
| | | |
| Total | 1031 | tons/year |

[1] Point and mobile source emissions included in Tables A-1 and A-2 for operating years.
[2] Estimated with Urbemis 2007 Version 9.2.4
[3] Urbemis only estimates CO2 emissions, ratio of N2O and CH4 assumed to be same as that for mobile sources
[4] As a conservative estimate of total emissions assumed maximum emissions rate for 360 days per year.
[5] Assumed work on existing buildings has same carbon footprint as new building construction
[6] Work on existing buildings completed during Phase I

**PolyMet - Hoyt Lakes, Minnesota**

**Table A-4: Calculation of Potential NorthMet Greenhouse Gas Emissions for Reclamation Period**

| | Potential Emissions (tpy) | | | | Projected Actual Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|
| **Plant Site** | CO2 | N2O | CH3 | CO2e | CO2 | N2O | CH4 | CO2e |
| Plant Site Point | 18937.57 | 0.96 | 0.28 | 19241.46 | 7901.79 | 0.41 | 0.11 | 8030.87 |
| Plant Site Mobile | 558.63 | 0.01 | 0.03 | 563.54 | 534.11 | 0.01 | 0.03 | 538.99 |
| Total | 19496 | 1.0 | 0.3 | 19805 | 8436 | 0.4 | 0.1 | 8570 |
| Estimated Years of Reclamation | 20 | | | | | | | |
| Total Reclamation Emissions | 389924 | 20 | 6 | 396100 | 168718 | 8 | 3 | 171397 |

| | Potential Emissions (tpy) | | | | Projected Actual Emissions (tpy) | | | |
|---|---|---|---|---|---|---|---|---|
| **Mine Site** | CO2 | N2O | CH3 | CO2e | CO2 | N2O | CH4 | CO2e |
| Mine Site Point | 1429.38 | 0.08 | 0.02 | 1453.70 | 698.44 | 0.03 | 0.01 | 708.16 |
| Mine Site Mobile | 9.68 | 0.00 | 0.00 | 9.69 | 9.68 | 0.00 | 0.00 | 9.69 |
| Total | 1439.07 | 0.08 | 0.02 | 1463.39 | 708.12 | 0.03 | 0.01 | 717.85 |
| Estimated Years of Closure | 60 | | | | | | | |
| Total Closure Emissions | 86344 | 5 | 1 | 87803 | 42487 | 2 | 0 | 43071 |

Global Warming Potentials

| | |
|---|---|
| CO2 | 1 |
| CH4 | 21 |
| N2O | 310 |

| | | | |
|---|---|---|---|
| Total for Project (stons) | 483904 | | 214469 |
| Total for Project (mt) | 438988 | | 194562 |

# Attachment B

## Indirect Emission Calculations

# Indirect Emission Calculations

Indirect Emissions Related to Generating Electricity for the project

PolyMet Mining, Inc. (PolyMet), will purchase electricity to meet the Project's electrical needs, which are anticipated to be approximately 59.5megawatts of power. $CO_2$ emissions are estimated using MPCA guidance emission factors for Minnesota electricity providers.

**Table B-1. Potential Indirect Emissions from Electricity Generated for the Project**

| Electrical Load (MWh Total)[1] | Emission Factor (m.t. $CO_2$ / MWh)[2,3] | $CO_2$ Emissions (m.t./yr) |
|---|---|---|
| 521,220 | 0.98 | 511,000 |

(1) Total demand is 59.5 MW, assumed at full operation (8760 hours/year)

(2) Following MPCA's General Guidance for Carbon Footprint Development in Environmental Review. Electricity provider Minnesota Power in Table 5 of the document.

Minnesota Power Emission Factor: 2159.5 lb $CO_2$ / MWh

The MPCA's values are based on the Environmental Disclosure information filed annually by the electric utilities.

(3) A conversion of 2204.6 lb per metric ton is used: (2159.5 lb $CO_2$ / MWh) * (1 m.t. $CO_2$ / 2204.6 lb $CO_2$) = 0.98 m.t. $CO_2$ / MWh

# Attachment C

## Combustion Fuel Alternatives Emissions

**Table C-1. Comparison of Emissions from Potential Sources for Space Heating in PolyMet's Process Plant**

| Natural Gas [1] | | | |
|---|---|---|---|
| Hourly Max Throughput (MMCF/hr) | Annual Max Throughput (MMCF/yr) | Demand (MMBtu/hr) | Emissions (m.t.CO2-e / yr) |
| 0.119 | 1039 | 125 | 63819 |

| Propane [5, 6] | | |
|---|---|---|
| Hourly Max Throughput (Mgal/hr) | Annual Max Throughput (Mgal/yr) | Emissions (m.t.CO2-e / yr) |
| 1.36 | 11923 | 162355 |

| Autoclave Waste Heat & Remaining Natural Gas [4] | | | |
|---|---|---|---|
| Demand (MMBtu/hr) | Demand Reduction (MMBtu/hr) | Annual Max Throughput (MMCF/yr) | Emissions (m.t.CO2-e / yr) |
| 102 | 23 | 876 | 52289 |

| Electricity [2,3] | | |
|---|---|---|
| Hourly Max Throughput (kWh/hr) | Annual Max Throughput (kWh/yr) | Emissions (m.t.CO2-e / yr) |
| 36500 | 319738403 | 313184 |

(1) Conversion factor of 1050 Btu/SCF for natural gas

(2) 0.9795 m.t. CO2 / MWh electricity from MPCA General Guidance for Carbon Footprint in Environmental Review. Minnesota Power will be the electricity provider for PolyMet

(3) Conversion factor of 3412 Btu / kWh; efficiency assumed similar for natural gas fired and electric space heaters.

(4) Using waste heat is expected to reduce heating demand from 125 MMBtu/hr to 102 MMBtu.hr

(5) AP-42 Factor of 91.5 MMBtu/Mgal for propane

(6) Emission factors from Table 12.7 of The Climate Registry's General Reporting Protocol, May 2008. Converted from g/MMBtu to kg/Mgal by multiplying by the AP-42 factor of 91.5 MMBtu/Mgal for propane and 1000 g/kg.

**Table C-2. Comparison of Emissions from Potential Fuels for PolyMet's Mobile Sources, Generators, and Fire Pumps**

| Fuel | Emission Factor | | | Heat Content | |
|---|---|---|---|---|---|
| | TCR GRP Table 13.1 Units | | (kg $CO_2$ / MMBtu) | | |
| Biodiesel | 9.46 | kg CO2/gal | 79.97 | 118296 | Btu/gal (1) |
| Compressed Nat. Gas | 0.054 | kg CO2/scf | 52.58 | 1027 | BTU/scf |
| Diesel | 10.15 | kg CO2/gal | 73.18 | 138.69 | MMBtu/Mgal (2) |
| Gasoline | 8.81 | kg CO2/gal | 70.44 | 125.07 | MMBtu/Mgal (2) |

(1) National Biodiesel Board heating value of 118,296 Btu/gal for B100. (http://www.biodiesel.org/pdf_files/fuelfactsheets/BTU_Content_Final_Oct2005.pdf)

(2) MPCA General Guidance for Carbon Footprint Development in Environmental Review

**Table C-3. Comparison of Emissions from Potential Fuels for PolyMet's Area 1 Shop & Area 2 Shop Space Heating**

| Propane[1] | | | | Natural Gas [4,5] | | | Electricity [2,3] | | |
|---|---|---|---|---|---|---|---|---|---|
| Hourly Max Throughput (Mgal/hr) | Annual Max Throughput (Mgal/yr) | Demand (MMBtu/hr) | Max Emissions (m.t.CO2-e/yr) | Hourly Max Throughput (MMCF/hr) | Annual Max Throughput (MMCF/yr) | Max Emissions (m.t.CO2-e/yr) | Hourly Max Throughput (kWh/hr) | Annual Max Throughput (kWh/yr) | Max Emissions (m.t.CO2-e/yr) |
| 0.227 | 1989 | 21 | 12652 | 0.02 | 173 | 9212 | 6088 | 53328169 | 52235 |

(1) AP-42 Factor of 91.5 MMBtu/Mgal for propane

(2) 0.9795 m.t. CO2 / MWh electricity from MPCA General Guidance for Carbon Footprint in Environmental Review. Minnesota Power will be the electricity provider for PolyMet

(3) Conversion factor of 3412 Btu / kWh; efficiency assumed similar for natural gas fired and electric space heaters.

(4) Conversion factor of 1050 Btu/SCF for natural gas

(5) MPCA General Guidance for Carbon Footprint Development in Environmental Review, Table 4, 58.61 tons CO2/MMCF natural gas

# Attachment D

## Calculations of Carbon Flux for Peat Used in Restoration

**Table D-1. Estimated Carbon Loss From Peat Used in Reclamation**

| Project Year | Restored Acreage | Estimated Peat Carbon Loss (metric tons C) [1] | Notes |
|---|---|---|---|
| 0 | 0 | 0 | |
| 1 | 0 | 0 | |
| 2 | 63 | 127 | 63 acres Cat 1 |
| 3 | 0 | 0 | |
| 4 | 29 | 59 | 29 acres Cat 1 |
| 5 | 14 | 28 | 14 acres Cat 1 |
| 6 | 23 | 47 | 23 acres Cat 1 |
| 7 | 0 | 0 | |
| 8 | 0 | 0 | |
| 9 | 41 | 83 | 41 acres Cat 1 |
| 10 | 0 | 0 | |
| 11 | 76 | 154 | 10 Cat 4 Stockpile that does not become the Central Pit, 4 acres Cat 4 Ponds, 2 acres of Haul Roads, 60 acres Cat 1 |
| 12 | 11 | 22 | 11 acres of Haul Roads |
| 13 | 328 | 664 | 328 acres Cat 1 |
| 14 | 0 | 0 | |
| 15 | 31 | 63 | 31 acres Cat 2/3 |
| 16 | 33 | 67 | 30 acres Cat 2/3, 3 acres Cat 2/3 Ponds & Sumps |
| 17 | 30 | 61 | 30 acres Cat 2/3 |
| 18 | 32 | 65 | 30 acres Cat 2/3, 2 acres Cat 2/3 Ponds & Sumps |
| 19 | 30 | 61 | 30 acres Cat 2/3 |
| 20 | 57 | 115 | 30 acres Cat 2/3, 5 acres Cat 2/3 Ponds & Sumps, 22 acres of Haul Roads |
| 21 | 31 | 63 | 10 acres of remaining PW Ponds and sumps (OSP, Haul Roads, OSLA, RTH), 21 acres of stormwater ponds |
| 22 | 320 | 647 | 45 acres OSLA, 32 acres OSP, 4 acres RTH, 190 acres East/Central Pit, 49 acres of Haul Roads |
| Total Metric Tons (as carbon) | | 2,325 | |
| Total Metric Tons (as CO2e) | | 8,525 | |

[1] Estimated carbon loss based on 5 Mg/ha loss during first five years after restoration. Net sequestration assumed to occur as succesional forest develops on reclaimed areas. This assumes all reclaimed areas are originally planted in herbaceous cover as a "worst case' scenario

# Attachment E

## Aboveground Carbon Stock and Sequestration Capacity Loss Calculations

**Table E-1. Aboveground Carbon Storage and Sequestration Impacts**

| Ecosystem Type | Habitat Type | Project Impact Areas (acres) by Location | | | | | Total Impact Area | | Biomass Carbon Storage (Metric tonnes/ha) | Carbon Sequestration (Metric tonnes/ha/yr) | Project Impacts | | Notes & Assumptions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dunka Road/TWP | Hydromet Residue Facility | Mine Site | Railroad Connection | Tailings Basin | Total Acres | Total Hectares | | | Biomass Carbon Lost (Metric tonnes) | Carbon Sequestration Lost (Metric tonnes/year) | |
| Upland | Bare | 51.81 | 18.26 | 13.49 | 9.41 | 512.19 | 605.16 | 244.90 | 0 | 0 | 0.00 | 0.00 | *Habitat consists of roads, railroads, and rights-of-way. Assume carbon storage and sequestration are negligible. |
| | Deciduous Forest | 11.32 | 62.88 | 324.07 | 8.99 | 174.81 | 582.07 | 235.56 | 41.53 | 1.3 | 9,782.63 | 306.22 | Assume aspen represents the majority of tree cover in this type (birch does not likely represent a significant enough portion to exert an influence on carbon storage). Aspen is present in varying stages of regeneration - used 25 years as an average age of aspen - used carbon storage number for 25-year old aspen from COLE. Calculated carbon sequestration rate from COLE carbon stock data for 25 year old aspen. |
| | Grassland | 0.24 | 0 | 0 | 0 | 222.39 | 222.63 | 90.10 | 0 | 0.7 | 0.00 | 63.07 | *Assume negligible long-term storage in biomass of herbaceous vegetation. Use "MN specific conversion of marginal agricultural land to perennial grassland" for sequestration values. |
| | Mixed Forest | 21.27 | 0 | 635.91 | 0 | 0 | 657.18 | 265.95 | 66.24 | 0.45 | 17,616.11 | 119.68 | This forest type is some combination of black spruce (average of 25%), white spruce (average of 15%), balsam fir (average of 30%), jack pine (average of 14%), aspen (average of 7%), red pine (average of 5%), and white pine (average of 4%). The numbers associated with each species represent average relative dominance for each based on field reconnaissance and best professional judgement. Used a weighted average based on these relative abundances for each species using the average COLE storage numbers for these species. Did a weighted average using calculated carbon sequestration rates from COLE carbon stock data - used average rate across 100 years for each species. |
| | Shrubland | 15.22 | 0 | 0 | 0.58 | 47.97 | 63.77 | 25.81 | 16.80 | 0.22 | 433.56 | 5.68 | Shrublands are typically very young regenerating aspen - likely under 10 years old - assume an average of 5 year old aspen. Used carbon storage number for 5-year old aspen from COLE. Calculated carbon sequestration rate from COLE carbon stock data for 5 year old aspen. |
| | | | | | | | **2,130.81** | **862.31** | | | **27,832.30** | **494.64** | |
| Wetland | Coniferous Bog | 0.63 | 0 | 525.02 | 0 | 0 | 525.65 | 212.72 | 62.58 | 0.70 | 13,311.16 | 148.91 | Assume black spruce represents an average of 75% of the tree cover and tamarack represents an average of 25% of the tree cover in bogs. Used a weighted average based on these relative abundances using the average COLE storage numbers for black spruce and tamarack. Used the average of lower and upper bound for "Minnesota peatlands" for sequestration value. |
| | Coniferous Swamp | 0.74 | 0 | 68.73 | 0.24 | 5.38 | 75.09 | 30.39 | 71.43 | 0.37 | 2,170.46 | 11.24 | Assume black spruce represents an average of 50% of the tree cover, tamarack represents an average of 25% of the tree cover, and northern white cedar represents an average of 25% of the tree cover in coniferous swamps. Did a weighted average based on these relative abundances using the average COLE storage numbers for black spruce, tamarack, and northern white cedar. Did a weighted average using calculated carbon sequestration rates from COLE carbon stock data - used average rate across 100 years for each species. |
| | Hardwood Swamp | 0 | 0 | 12.39 | 0 | 0 | 12.39 | 5.01 | 66.60 | 0.62 | 333.94 | 3.11 | Assume black ash represents the majority of tree cover in this type (other species are likely not present in significant enough numbers to exert influences on carbon storage). Used average carbon storage number for black ash from COLE (this number is the same for black ash, American elm, and red maple). Calculated carbon sequestration rate from COLE black ash carbon stock data using the average rate across 100 years. |
| | Herbaceous Emergent Wetland | 0.34 | 35.06 | 61.48 | 0.07 | 345.72 | 442.67 | 179.14 | 0.00 | 0.70 | 0.00 | 125.40 | *Assume negligible long-term storage in herbaceous vegetation. Use "MN specific conversion of marginal agricultural land to perennial grassland" for sequestration values. |
| | Open Water | 0 | 0 | 0 | 0 | 509.11 | 509.11 | 206.03 | 0.00 | 0.00 | 0.00 | 0.00 | Assume neglibible long-term storage in any herbaceous vegetation growing in open water habitats. |
| | Shrub Scrub | 2.7 | 0 | 101.87 | 0.49 | 0.3 | 105.36 | 42.64 | 48.00 | 0.70 | 2,046.61 | 29.85 | *Biomass value for peatlands/mineral soil wetlands from Bridgham et al. 2006. Sequestration value for peatlands based on studies cited by Lennon and Nater 2006. |
| | | | | | | | **1,670.27** | **675.94** | | | **17,862.17** | **318.50** | |
| **Grand Total** | | | | | | | **3,801.08** | **1,538.25** | | | **45,694.46** | **813.15** | |

**Totals as CO2e**

| | Carbon Storage | Sequestration Loss |
|---|---|---|
| Upland | 102052 | 1814 |
| Wetland | 65495 | 1168 |
| Grand Total | 167546 | 2982 |

# Appendix B

## Website References Used in this Report

EPA United States Environmental Protection Agency

## Climate Change

# Causes of Climate Change

**ON THIS PAGE**


Earth's temperature is a balancing act
The Greenhouse Effect causes the atmosphere to retain heat
Changes in the sun's energy affect how much energy reaches Earth's system
Changes in reflectivity affect how much energy enters Earth's system


## Earth's temperature is a balancing act

Earth's temperature depends on the balance between energy entering and leaving the planet's system . When incoming energy from the sun is absorbed by the Earth system, Earth warms. When the sun's energy is reflected back into space, Earth avoids warming. When energy is released back into space, Earth cools. Many factors, both natural and human, can cause changes in Earth's energy balance, including:

- Changes in the greenhouse effect, which affects the amount of heat retained by Earth's atmosphere
- Variations in the sun's energy reaching Earth
- Changes in the reflectivity of Earth's atmosphere and surface

These factors have caused Earth's climate to change many times.

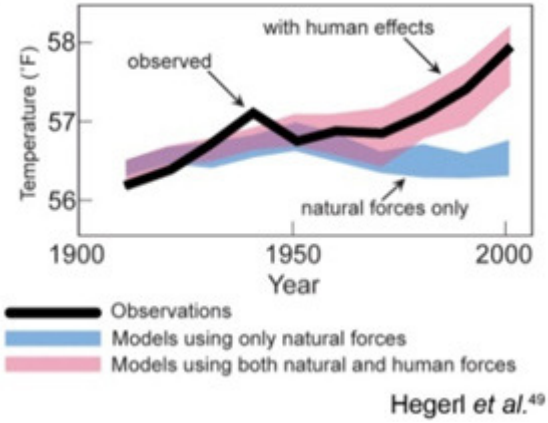
Scientists have pieced together a picture of Earth's climate, dating back hundreds of thousands of years, by analyzing a number of indirect measures of climate such as ice cores, tree rings, glacier lengths, pollen remains, and ocean sediments, and by studying changes in Earth's orbit around the sun. [1]

The historical record shows that the climate system varies naturally over a wide range of time scales. In general, climate changes prior to the Industrial Revolution in the 1700s can be explained by natural causes, such as changes in solar energy, volcanic eruptions, and natural changes in greenhouse gas (GHG) concentrations. [1]

Recent climate changes, however, cannot be explained by natural causes alone. Research indicates that natural causes are very unlikely to explain most observed warming, especially warming since the mid-20th century. Rather, human activities can very likely explain most of that warming. [1]

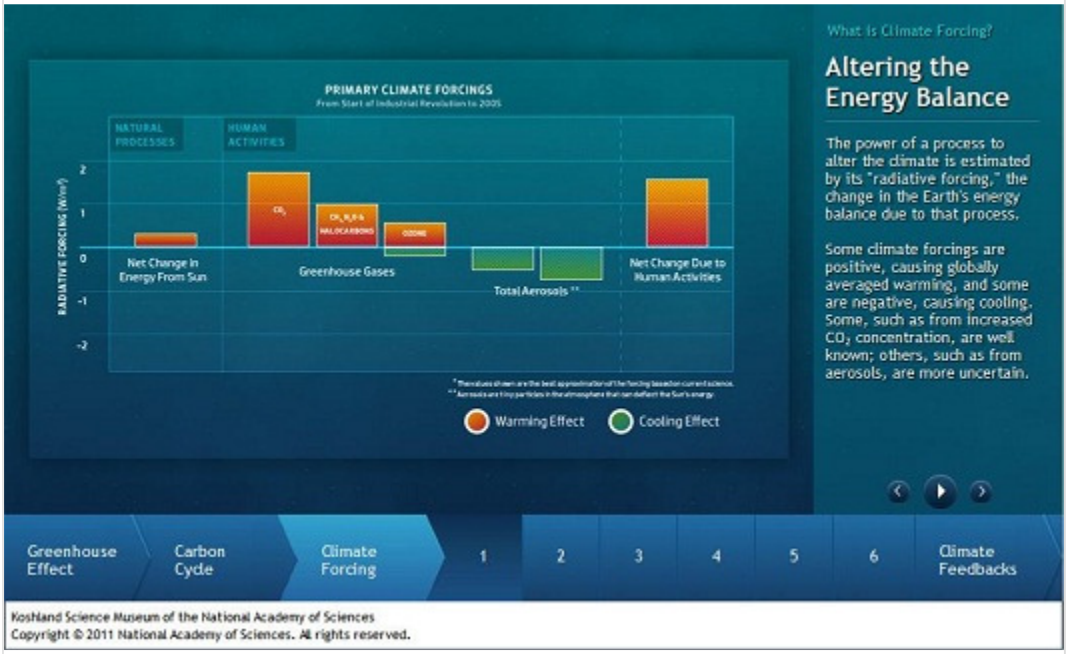
### Key Points

- Both natural and human factors change Earth's climate.
- Before humans, changes in climate resulted entirely from natural causes such as changes in Earth's orbit, changes in solar activity, or volcanic eruptions.
- Since the Industrial Era began, humans have had an increasing effect on climate, particularly by adding billions of tons of heat-trapping greenhouse gases to the atmosphere.
- Most of the observed warming since the mid-20th century is due to human-caused greenhouse gas emissions.




View enlarged image

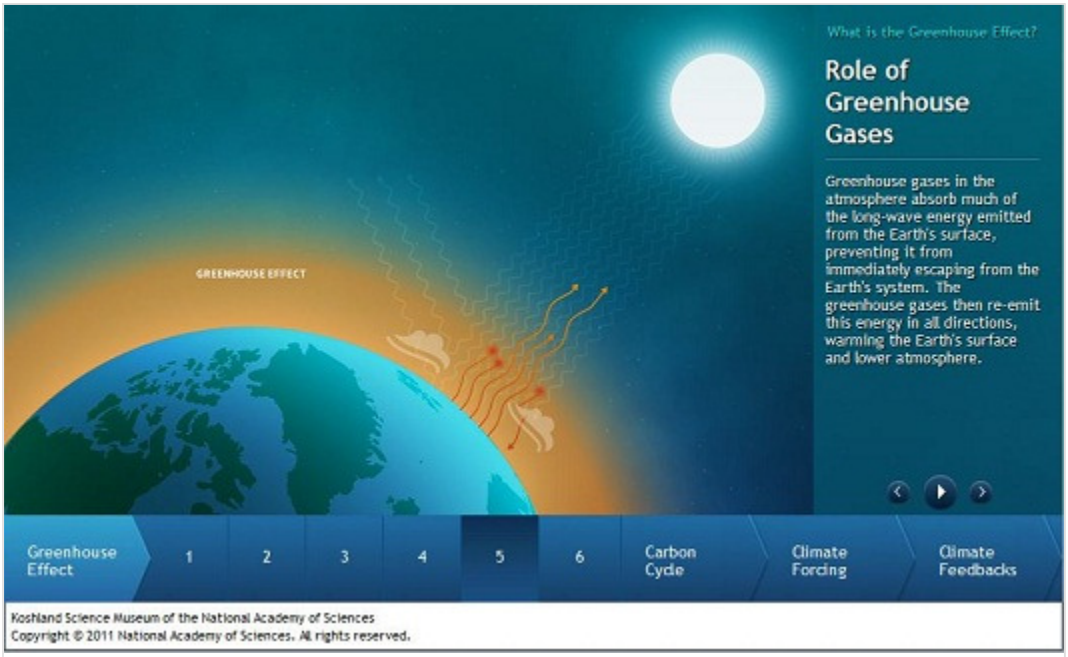
Models that account only for the effects of natural processes are not able to explain the warming over the past century. Models that also account for the greenhouse gases emitted by humans are able to explain this warming.
Source: USGRCP (2009)




Click on the image to open a lightbox that explains radiative forcing. The discussion includes both natural and human-induced climate forcings.

## The Greenhouse Effect causes the atmosphere to retain heat

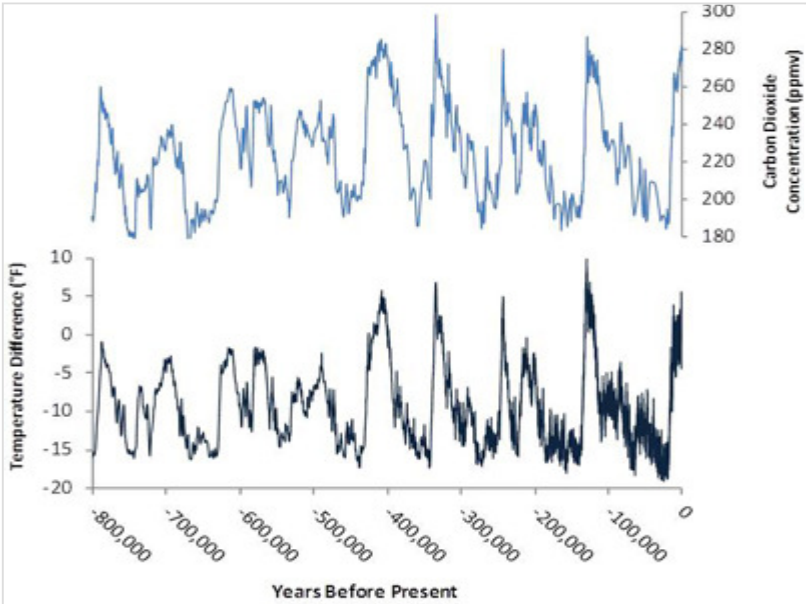
When sunlight reaches Earth's surface, it can either be reflected back into space or absorbed by Earth. Once absorbed, the planet releases some of the energy back into the atmosphere as heat (also called infrared radiation). Greenhouse gases (GHGs) like water vapor (H2O), carbon dioxide ($CO_2$), and methane ($CH_4$) absorb energy, slowing or preventing the loss of heat to space. In this way, GHGs act like a blanket, making Earth warmer than it would otherwise be. This process is commonly known as the "greenhouse effect".




This slideshow explains the Greenhouse Effect, among other topics.

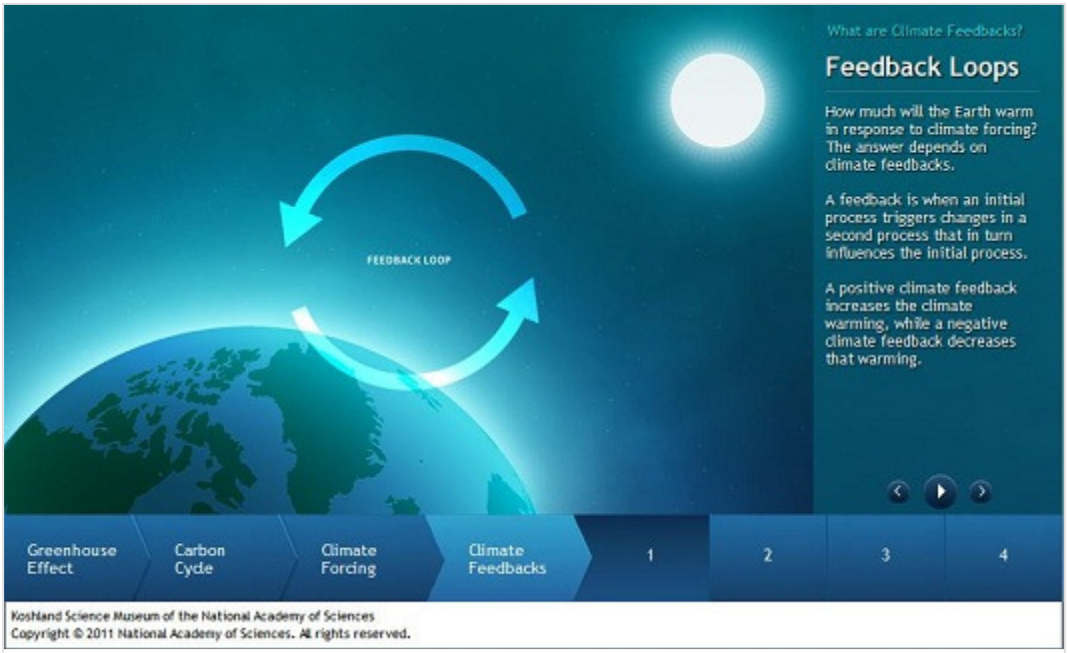
## *The Role of the Greenhouse Effect in the Past*

In the distant past (prior to about 10,000 years ago), $CO_2$ levels tended to track the glacial cycles. During warm 'interglacial' periods, $CO_2$ levels have been higher. During cool 'glacial' periods, $CO_2$ levels have been lower. [1] [2] This is because the heating or cooling of Earth's surface can cause changes in greenhouse gas concentrations. [1] These changes often act as a positive feedback, amplifying existing temperature changes. [1]




View enlarged image

Estimates of the Earth's changing carbon dioxide concentration (top) and Antarctic temperature (bc based on analysis of ice core data extending bac 800,000 years. Until the past century, natural fac caused atmospheric $CO_2$ concentrations to vary v range of about 180 to 300 parts per million by vol (ppmv). Warmer periods coincide with periods of high $CO_2$ concentrations. NOTE: The past centur temperature changes and rapid $CO_2$ rise (to 390 2010) are not shown here. Increases over the pa century are shown in the Recent Role section
Source: Based on data appearing in NRC (2010)




Click on the image to open a lightbox that explains radiative forcing.

## *The Recent Role of the Greenhouse Effect*

Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding $CO_2$ and other heat-trapping gases to the atmosphere. These greenhouse gas emissions have increased the greenhouse effect and caused Earth's surface temperature to rise. The primary human activity affecting the amount and rate of climate change is greenhouse gas emissions from the burning of fossil fuels.

### Related Links:

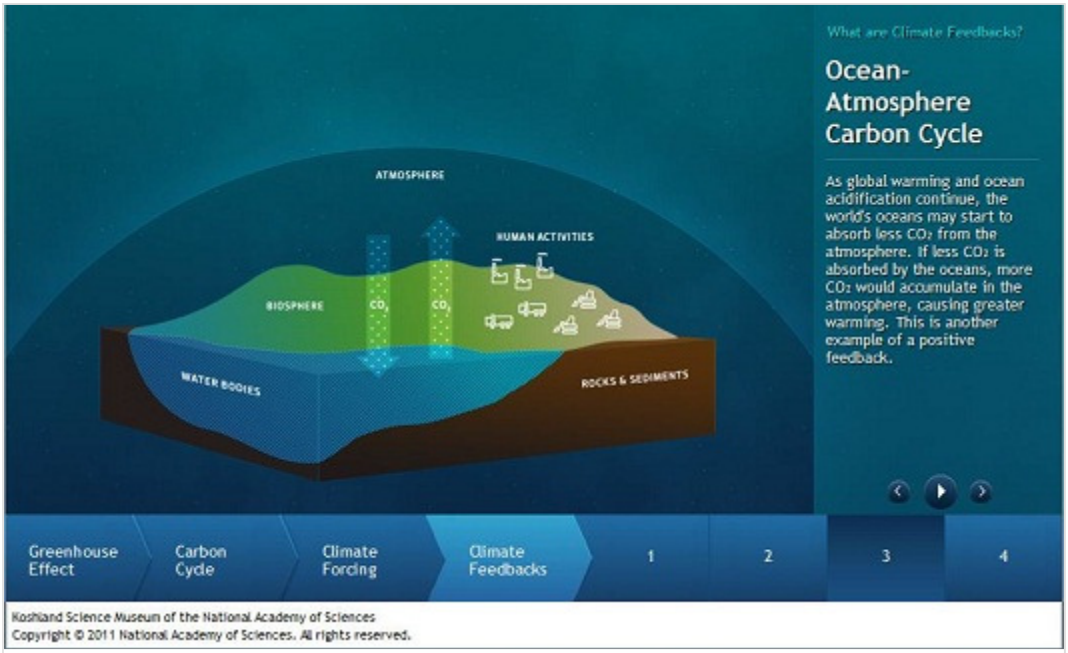
- NRC America's Climate Choices Reports EXIT Disclaimer
- IPCC Fourth Assessment Report EXIT Disclaimer
- USGCRP *Global Climate Change Impacts in the United States*
- NRC *Abrupt Climate Change: Inevitable Surprises* EXIT Disclaimer
- UNEP/WMO *Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers* EXIT Disclaimer

## *The Main Greenhouse Gases*

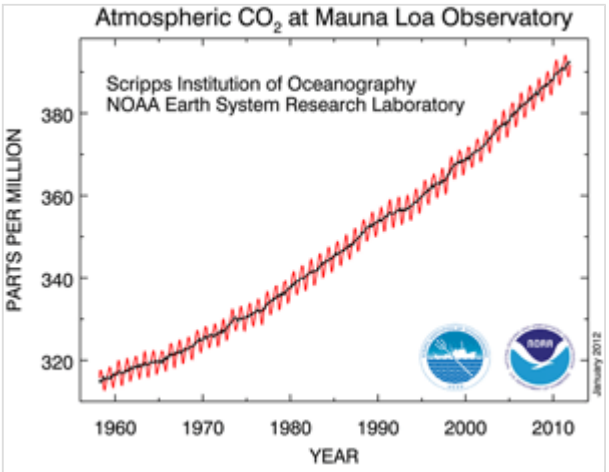
The most important GHGs directly emitted by humans include $CO_2$, $CH_4$, nitrous oxide ($N_2O$), and several others. The sources and recent trends of these gases are detailed below.

*Carbon dioxide*

Carbon dioxide is the primary greenhouse gas that is contributing to recent climate change. $CO_2$ is absorbed and emitted naturally as part of the carbon cycle, through animal and plant respiration, volcanic eruptions, and ocean-atmosphere exchange. Human activities, such as the burning of fossil fuels and changes in land use, release large amounts of carbon to the atmosphere, causing $CO_2$ concentrations in the atmosphere to rise.




This slideshow describes the carbon cycle, among other topics. {Click to play.}



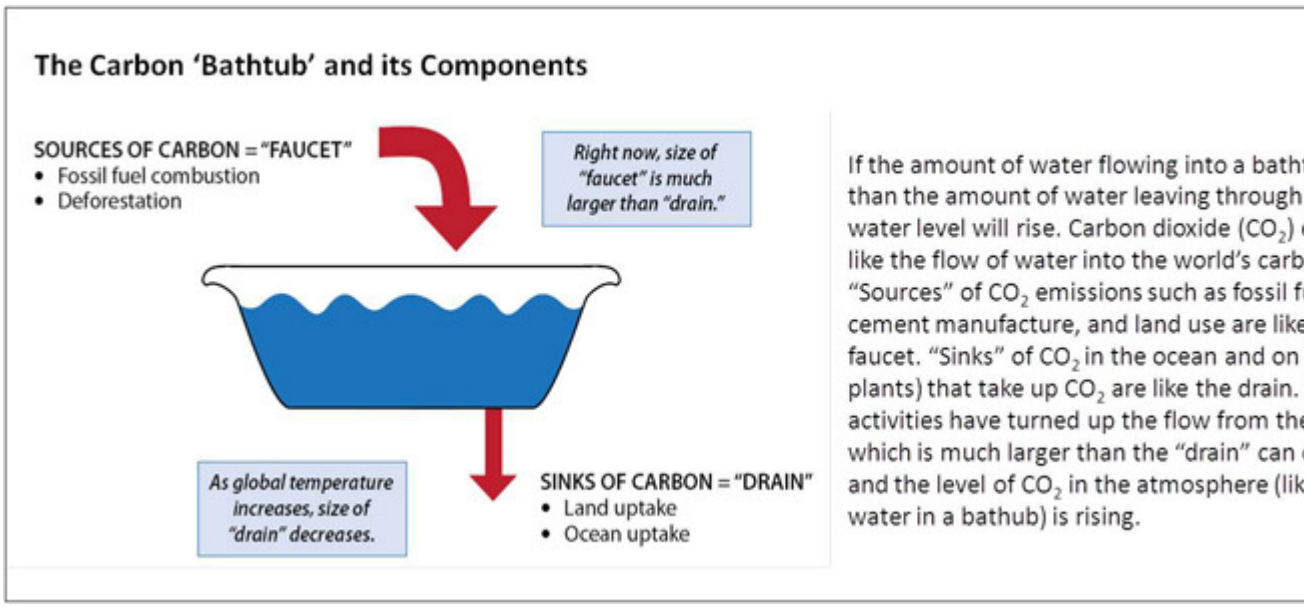

View enlarged image

Carbon dioxide concentration has risen from pre-industrial levels of 280 parts per million by volume (ppmv) to about 390 ppmv in 2010. Since 1958 alone (shown here), concentrations have risen by 75 ppmv. Source: NOAA

Atmospheric $CO_2$ concentrations have increased by almost 40% since pre-industrial times, from approximately 280 parts per million by volume (ppmv) in the 18th century to 390 ppmv in 2010. The current $CO_2$ level is higher than it has been in at least 800,000 years. [1]

Some volcanic eruptions released large quantities of $CO_2$ in the distant past. However, the U.S. Geological Survey (USGS) reports that human activities now emit more than 135 times as much $CO_2$ as volcanoes each year.

Human activities currently release over 30 billion tons of $CO_2$ into the atmosphere every year. [1] This build-up in the atmosphere is like a tub filling with water, where more water flows from the faucet than the drain can take away.



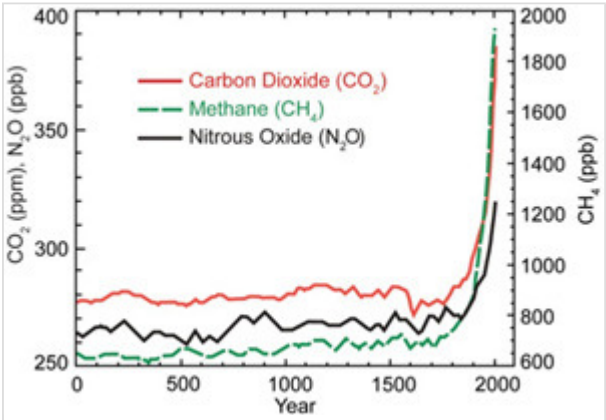

For more information on the human and natural sources and sinks of $CO_2$ emissions, see the Carbon Dioxide page in the Greenhouse Gas Emissions section of the website.

*Methane*

Methane is produced through both natural and human activities. For example, natural wetlands, agricultural activities, and fossil fuel extraction and transport all emit $CH_4$.

Methane is more abundant in Earth's atmosphere now than at any time in at least the past 650,000 years. [2] Due to human activities, $CH_4$ concentrations increased sharply during most of the 20th century and are now more than two-and-a-half times pre-industrial levels. In recent decades, the rate of increase has slowed considerably. [1]

For more information on $CH_4$ emissions and sources, and actions that can reduce emissions, see EPA's Methane page in the Greenhouse Gas Emissions section of the website.




View enlarged image

This graph shows the increase in greenhouse gas (GHG) concentrations in the atmosphere over the last 2,000 years. Increases in concentrations of these gases since 1750 are due to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air.
Source: USGCRP (2009)

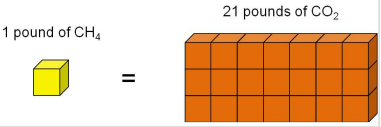
*Nitrous oxide*

Nitrous oxide is produced through natural and human activities, mainly through agricultural activities and natural biological processes. Fuel burning and some other processes also create $N_2O$. Concentrations of $N_2O$ have risen approximately 18% since the start of the Industrial Revolution, with a relatively rapid increase towards the end of the 20th century. [3] In contrast, the atmospheric concentration of $N_2O$ varied only slightly for a period of 11,500 years before the onset of the industrial period, as shown by ice core samples. [3] For more information on $N_2O$ emissions and sources, and actions that can reduce emissions, see EPA's Nitrous Oxide page in the Emissions section of the website.

## *Other Greenhouse Gases*

- Water vapor is the most abundant greenhouse gas and also the most important in terms of its contribution to the natural greenhouse effect, despite having a short atmospheric lifetime. Some human activities can influence local water vapor levels. However, on a global scale, the concentration of water vapor is controlled by temperature, which influences overall rates of evaporation and precipitation. [1] Therefore, the global concentration of water vapor is not substantially affected by direct human emissions.
- Tropospheric ozone (O3), which also has a short atmospheric lifetime, is a potent greenhouse gas. Chemical reactions create ozone from emissions of nitrogen oxides and volatile organic compounds from automobiles, power plants, and other industrial and commercial sources in the presence of sunlight. In addition to trapping heat, ozone is a pollutant that can cause respiratory health problems and damage crops and ecosystems.
- Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6), together called F-gases, are often used in coolants, foaming agents, fire extinguishers, solvents, pesticides, and aerosol propellants. Unlike water vapor and ozone, these F-gases have a long atmospheric lifetime, and some of these emissions will affect the climate for many decades or centuries.

Click on the image to open a lightbox that explains how global warming potentials describe the impact of each gas.




For more information on greenhouse gas emissions, see the Greenhouse Gas Emissions section. To learn more about actions that can reduce these emissions, see the What You Can Do section.

## Changes in the sun's energy affect how much energy reaches Earth's system

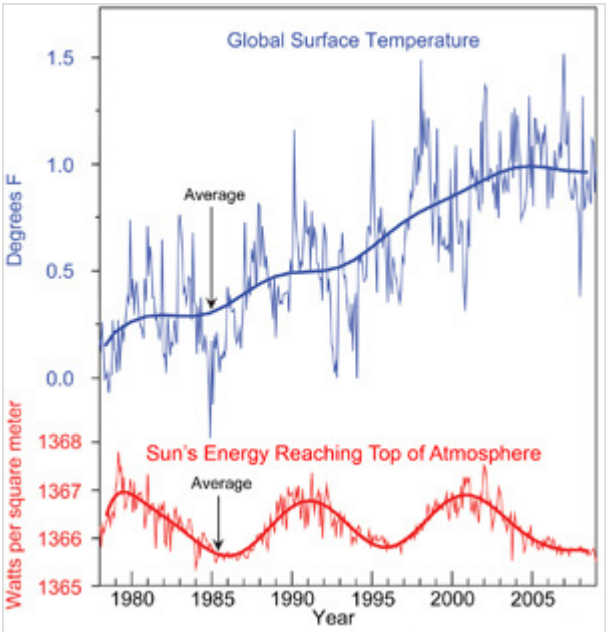
Climate is influenced by natural changes that affect how much solar energy reaches Earth. These changes include changes within the sun and changes in Earth's orbit.

Changes occurring in the sun itself can affect the intensity of the sunlight that reaches Earth's surface. The intensity of the sunlight can cause either warming (during periods of stronger solar intensity) or cooling (during periods of weaker solar intensity). The sun follows a natural 11-year cycle of small ups and downs in intensity, but the effect on Earth's climate is small. [1] [5]

Changes in the shape of Earth's orbit as well as the tilt and position of Earth's axis can also affect the amount of sunlight reaching Earth's surface. [1] [2]

### *The Role of the Sun's Energy in the Past*

Changes in the sun's intensity have influenced Earth's climate in the past. For example, the so-called "Little Ice Age" between the 17th and 19th centuries may have been partially caused by a low solar activity phase from 1645 to 1715, which coincided with cooler temperatures. The "Little




View enlarged image

The sun's energy received at the top of Earth's atmosphere has been measured by satellites since 1978. It has followed its natural 11-year cycle of small ups and downs, but with no net increase (bottom). Over the same period, global temperature has risen markedly (top).
Source: USGCRP (2009)

Ice Age" refers to a slight cooling of North America, Europe, and probably other areas around the globe. [1] [2]

Changes in Earth's orbit have had a big impact on climate over tens of thousands of years. In fact, the amount of summer sunshine on the Northern Hemisphere, which is affected by changes in the planet's orbit, appears to control the advance and retreat of ice sheets. These changes appear to be the primary cause of past cycles of ice ages, in which Earth has experienced long periods of cold temperatures (ice ages), as well as shorter interglacial periods (periods between ice ages) of relatively warmer temperatures. [1] [2]

Click on the image to open a lightbox that explains how rates of climate change have varied over time.



### *The Recent Role of the Sun's Energy*

Changes in solar energy continue to affect climate. However, solar activity has been relatively constant, aside from the 11-year cycle, since the mid-20th century and therefore does not explain the recent warming of Earth. Similarly, changes in the shape of Earth's orbit as well as the tilt and position of Earth's axis affect temperature on relatively long timescales (tens of thousands of years), and therefore cannot explain the recent warming.

## Changes in reflectivity affect how much energy enters Earth's system

When sunlight reaches Earth, it can be reflected or absorbed. The amount that is reflected or absorbed depends on Earth's surface and atmosphere. Light-colored objects and surfaces, like snow and clouds, tend to reflect most sunlight, while darker objects and surfaces, like the ocean, forests, or soil, tend to absorb more sunlight.

The term albedo refers to the amount of solar radiation reflected from an object or surface, often expressed as a percentage. Earth as a whole has an albedo of about 30%, meaning that 70% of the sunlight that reaches the planet is absorbed. [1] Absorbed sunlight warms Earth's land, water, and atmosphere.

Reflectivity is also affected by aerosols. Aerosols are small particles or liquid droplets in the atmosphere that can absorb or reflect sunlight. Unlike greenhouse gases (GHGs), the climate effects of aerosols vary depending on what they are made of and where they are emitted. Those aerosols that reflect sunlight, such as particles from volcanic eruptions or sulfur emissions from burning coal, have a cooling effect. Those that absorb sunlight, such as black carbon (a part of soot), have a warming effect.

### *The Role of Reflectivity in the Past*

Natural changes in reflectivity, like the melting of sea ice or increases in cloud cover, have contributed to climate change in the past, often acting as feedbacks to other processes.

Volcanoes have played a noticeable role in climate. Volcanic particles that reach the upper atmosphere can reflect enough sunlight back to space to cool the surface of the planet by a few tenths of a degree for several years. [1] These particles are an example of cooling aerosols. Volcanic particles from a single eruption do not produce long-term change because they remain in the atmosphere for a much shorter time than GHGs. [1] [7]

### *The Recent Role of Reflectivity*

Human changes in land use and land cover have changed Earth's reflectivity. Processes such as deforestation, reforestation, desertification, and urbanization often contribute to changes in climate in the places they occur. These effects may be significant regionally, but are smaller when averaged over the entire globe.

In addition, human activities have generally increased the number of aerosol particles in the atmosphere. Overall, human-generated aerosols have a net cooling effect offsetting about one-third of the total warming effect associated with human greenhouse gas emissions. Reductions in overall aerosol emissions can therefore lead to more warming. However, targeted reductions in black carbon emissions can reduce warming. [1] [8]

## References:

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[5] USGCRP (2009). *Global Climate Change Impacts in the United States* . Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

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http://www.epa.gov/climatechange/science/causes.html

WCMS
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National Aeronautics and Space Administration
Goddard Institute for Space Studies

## GISS Surface Temperature Analysis

### Global Temperature Trends: 2008 Annual Summation

*Originally posted Dec. 16, 2008, with meteorological year data. Updated Jan. 13, 2009, with calendar year data.*

Calendar year 2008 was the coolest year since 2000, according to the Goddard Institute for Space Studies analysis [see ref. 1] of surface air temperature measurements. In our analysis, 2008 is the ninth warmest year in the period of instrumental measurements, which extends back to 1880 (left panel of Fig. 1). The ten warmest years all occur within the 12-year period 1997-2008. The two-standard-deviation (95% confidence) uncertainty in comparing recent years is estimated as 0.05°C [ref. 2], so we can only conclude with confidence that 2008 was somewhere within the range from 7th to 10th warmest year in the record.

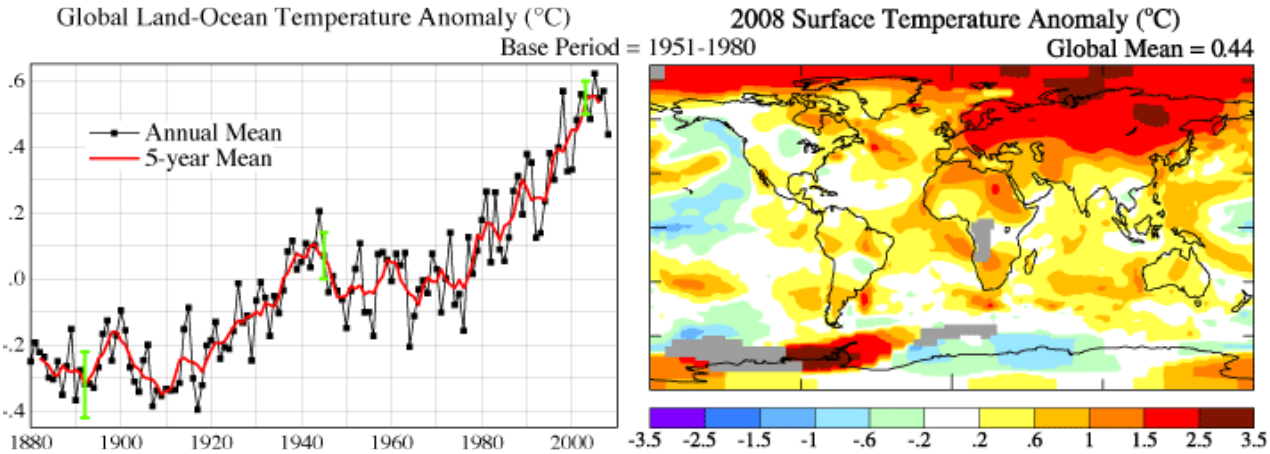



**Figure 1 above. Left:** Annual-means of global-mean temperature anomaly **Right:** Global map of surface temperature anomalies, in degrees Celsius, for 2008. (Click for PDF.)

The map of global temperature anomalies in 2008 (right panel of Fig. 1), shows that most of the world was either near normal or warmer than in the base period (1951-1980). Eurasia, the Arctic and the Antarctic Peninsula were exceptionally warm, while much of the Pacific Ocean was cooler than the long-term average. The relatively low temperature in the tropical Pacific was due to a strong La Niña that existed in the first half of the year. La Niña and El Niño are opposite phases of a natural oscillation of tropical temperatures, La Niña being the cool phase.

**Figure 2, at right. Top:** Seasonal-mean global and low latitude temperature anomalies relative to the 1951-1980 base period. (Click for large GIF or PDF.) **Bottom:** Monthly-mean global-ocean surface temperature anomaly, based on satellite temperature analyses of Reynolds and Smith (ref. 4]. (Click for large GIF or PDF.)

The top of Fig. 2 provides seasonal resolution of global and low latitude surface temperature, and an index that measures the state of the natural tropical temperature oscillation. The figure indicates that the La Niña cool cycle peaked in early 2008. The global effect of the tropical oscillation is made clear by the average temperature anomaly over the global ocean (bottom of Fig. 2). The "El Niño of the century", in 1997-98, stands out, as well as the recent La Niña.

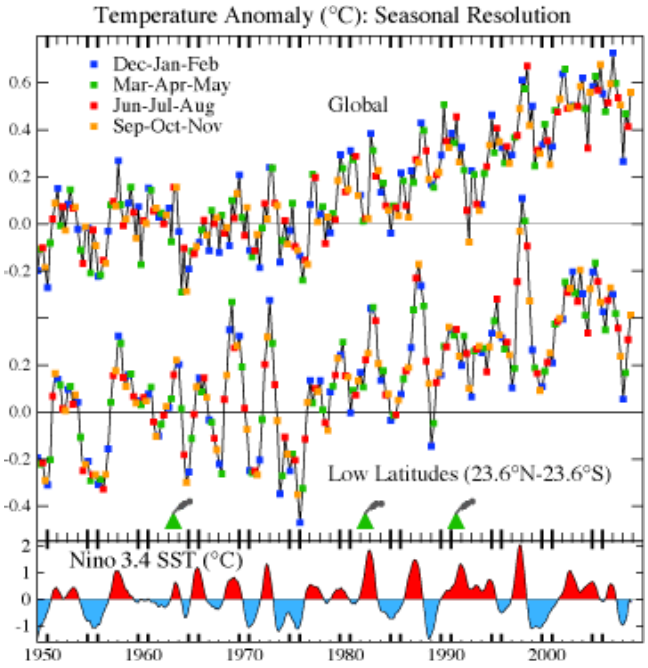
Figure 3 compares 2008 with the mean for the first seven years of this century. Except for the relatively cool Pacific Ocean, most of the world was either near normal or unusually warm in 2008. The temperature in the United States in 2008 was not much different than the 1951-1980 mean, which makes 2008 cooler than all of the previous years this decade. As shown by the right side of Fig. 3, most of the United States averaged between 0.5 and 1°C warmer than the long-term mean during 2001-2007.

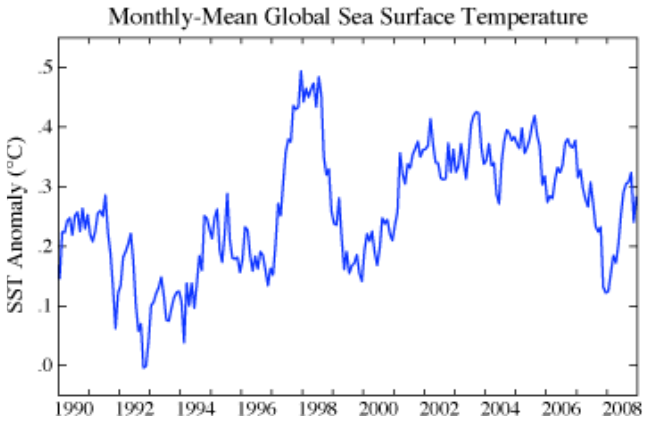
The GISS analysis of global surface temperature, documented in the scientific literature [refs. 1 and 2], incorporates data from three data bases made available monthly: (1) the Global Historical Climatology Network (GHCN) of the National Climate Data Center [ref. 3], (2) the satellite analysis of global sea surface temperature of Reynolds and Smith [ref. 4], and (3) Antarctic records of the Scientific Committee on Antarctic Research (SCAR) [ref. 5].

In the past our procedure has been to run the analysis program upon receipt of all three data sets and make the analysis publicly available immediately. This procedure worked very well from a scientific perspective, with the broad availability of the analysis helping reveal any

problems with input data sets. However, because confusion was generated in the media after one of the October 2008 input data sets was found to contain significant flaws (some October station records inadvertently repeated September data in the October data slot), we have instituted a new procedure. The GISS analysis is first made available internally before it is released publicly. If any suspect data are detected, they will be reported back to the data providers for resolution. This process may introduce significant delays. We apologize for any inconvenience due to this delay, but it should reduce the likelihood of instances of future confusion and misinformation.

Note that we provide the rank of global temperature for individual years because there is a high demand for it from journalists and the public. The rank has scientific significance in some cases, e.g., when a new record is established. However, otherwise rank has limited value and can be misleading. As opposed to the rank, Fig. 3 provides much more information about how the 2008 temperature compares with previous years, and why it was a bit cooler (again, note the change in the Pacific Ocean region).



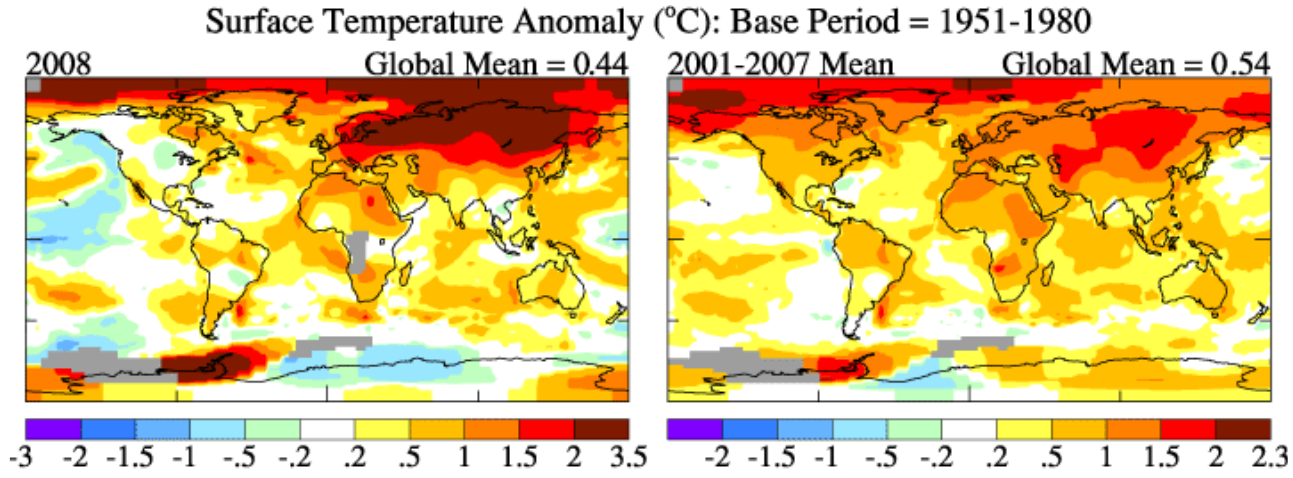



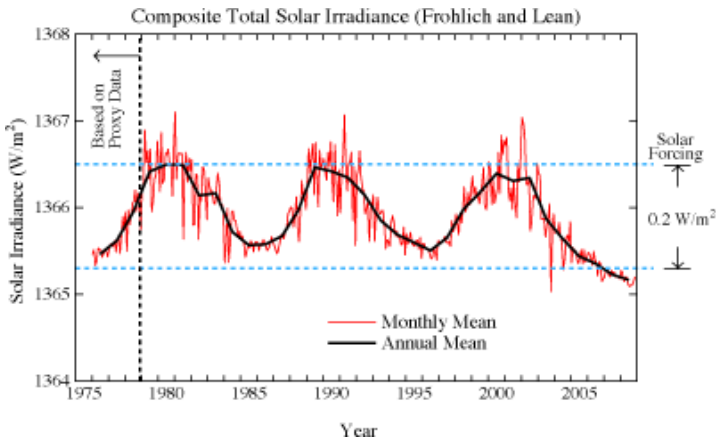

**Figure 3 above.** Comparison of 2008 (left) temperature anomalies with the mean 2001-2007 (right) anomalies. Notice that a somewhat different color bar has been used than in Figure 1 to show more structure in the right-hand map). (Click for PDF.)

Finally, in response to popular demand, we comment on the likelihood of a near-term global temperature record. Specifically, the question has been asked whether the relatively cool 2008 alters the expectation we expressed in last year's summary that a new global record was likely within the next 2-3 years (now the next 1-2 years). Response to that query requires consideration of several factors:

*Natural dynamical variability:* The largest contribution is the Southern Oscillation, the El Niño-La Niña cycle. The Niño 3.4 temperature anomaly (blue line in the top panel of Fig. 2), suggests that the La Niña may be almost over, but the anomaly fell back (cooled) to -0.7°C [illegible] December. It is [illegible] this tropical cycle could dip back into a strong La Niña, as happened, e.g., in 1975. However, [illegible] tropical Pacific to stay in that mode for both 2009 and 2010 would require a longer La Niña phase than has existed in the past half century, so it is unlikely. Indeed, subsurface and surface tropical ocean temperatures suggest that the system is "recharged", i.e., poised, for the next El Niño, so there is a good chance that one may occur in 2009. Global temperature anomalies tend to lag tropical anomalies by 3-6 months.

*Solar irradiance:* The solar output remains low (Fig. 4), at the lowest level in the period since satellite measurements began in the late 1970s, and the time since the prior solar minimum is already 12 years, two years longer than the prior two cycles. This has led some people to speculate that we may be entering a "Maunder Minimum" situation, a period of reduced irradiance that could last for decades. Most solar physicists expect the irradiance to begin to pick up in the next several months — there are indications, from the polarity of the few recent sunspots, that the new cycle is beginning.

**Figure 4, at right.** Solar irradiance through November 2008 from Frohlich and Lean [ref. 8]. (Click for large GIF or PDF.)




However, let's assume that the solar irradiance does not recover. In that case, the negative forcing, relative to the mean solar irradiance is equivalent to seven years of $CO_2$ increase at current growth rates. So do not look for a new "Little Ice Age" in any case. Assuming that the solar irradiance begins to recover this year, as expected, there is still some effect on the likelihood of a near-term global temperature record due to the unusually prolonged solar minimum. Because of the large thermal inertia of the ocean, the surface temperature response to the 10-12 year solar cycle lags the irradiance variation by 1-2 years. Thus, relative to the mean, i.e, the hypothetical case in which the sun had a constant average irradiance, actual solar irradiance will continue to provide a negative anomaly for the next 2-3 years.

*Volcanic aerosols:* Colorful sunsets the past several months suggest a non-negligible stratospheric aerosol amount at northern latitudes. Unfortunately, as noted in the 2008 Bjerknes Lecture [ref. 9], the instrument capable of precise measurements of aerosol optical depth depth (SAGE, the Stratospheric Aerosol and Gas Experiment) is sitting on a shelf at Langley Research Center. Stratospheric aerosol amounts are estimated from crude measurements to be moderate. The aerosols from an Aleutian volcano, which is thought to be the primary source, are at relatively low altitude and high latitudes, where they should be mostly flushed out this winter. Their effect in the next two years should be negligible.

*Greenhouse gases:* Annual growth rate of climate forcing by long-lived greenhouse gases (GHGs) slowed from a peak close to 0.05 W/m$^2$ per year around 1980-85 to about 0.035 W/m$^2$ in recent years due to slowdown of $CH_4$ and CFC growth rates [ref. 6]. Resumed methane growth, if it continued in 2008 as in 2007, adds about 0.005 W/m$^2$. From climate models and empirical analyses, this GHG forcing trend translates into a mean warming rate of ~0.15°C per decade.

*Summary:* The Southern Oscillation and increasing GHGs continue to be, respectively, the dominant factors affecting interannual and decadal temperature change. Solar irradiance has a non-negligible effect on global temperature [see, e.g., ref. 7, which empirically estimates a somewhat larger solar cycle effect than that estimated by others who have teased a solar effect out of data with different methods]. Given our expectation of the next El Niño beginning in 2009 or 2010, it still seems likely that a new global temperature record will be set within the next 1-2 years, despite the moderate negative effect of the reduced solar irradiance.

**Further Information**

GISS Surface Temperature Analysis (GISTEMP)

Past global temperature annual summations: 2007, 2005, 2004, 2003, 2002, and 2001.

Related NASA news releases: 2008, 2007, 2006, 2005, and 2004.

Other related 2008 news releases: NOAA, WMO, and Hadley Center.

Note: There was no summation written for 2006; see NASA news release for that year instead.

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**Contacts**

Please address all inquiries regarding GISS surface temperature trends analysis to Dr. James E. Hansen.

**Return to GISTEMP homepage**

NASA Official: James E. Hansen
GISS Website Curator: Robert B. Schmunk

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# Climate At A Glance

## Winter (Dec-Feb) Temperature
## Contiguous United States

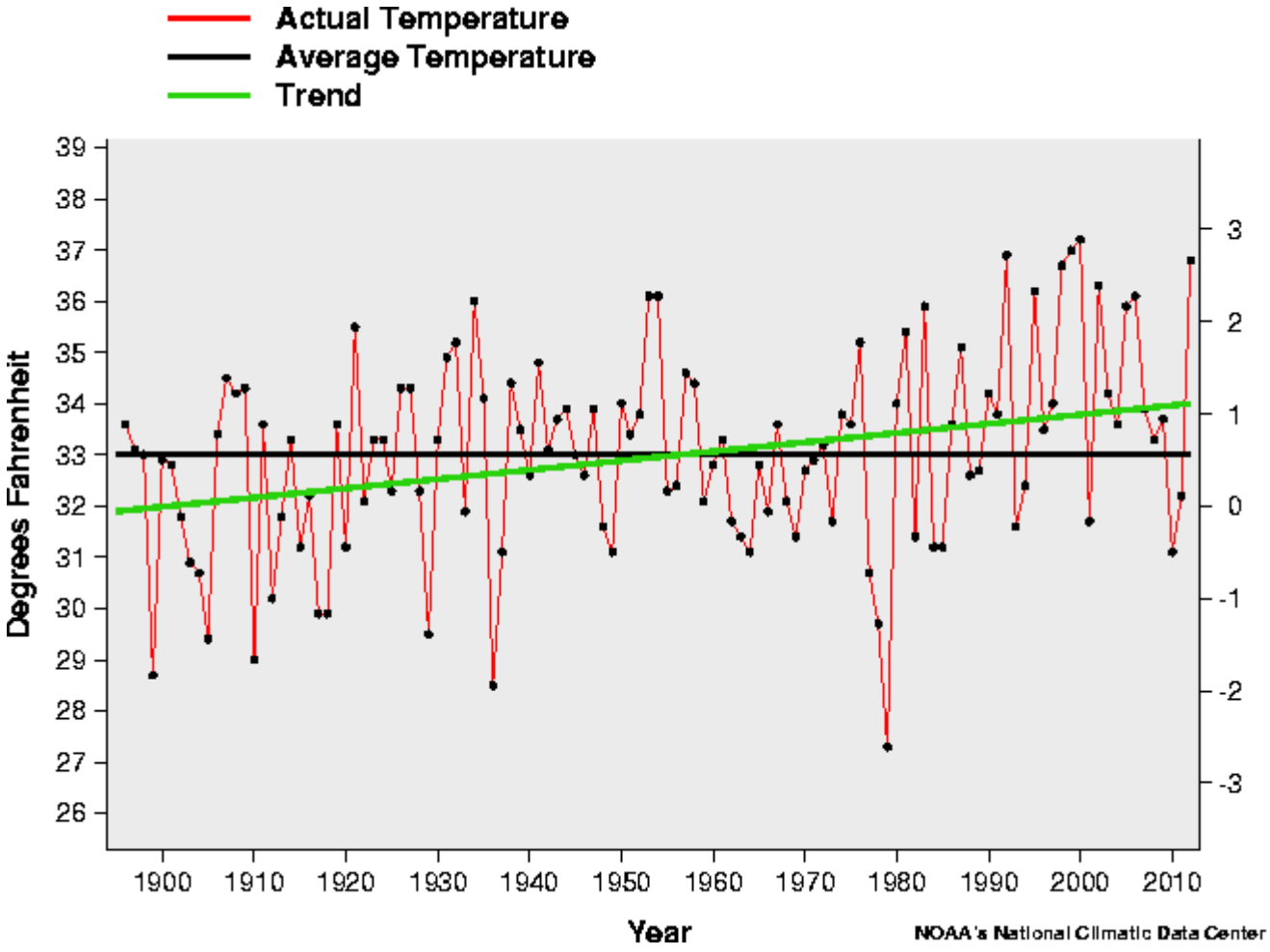
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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Winter (Dec-Feb) 1895 - 2012 Data Values:**

Winter (Dec-Feb) 2012: 36.83 degF Rank: 114

**Winter (Dec-Feb) 1901 - 2000 Average = 32.97 degF**
**Winter (Dec-Feb) 1895 - 2012 Trend = 0.17 degF / Decade**




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# Climate At A Glance

## Winter (Dec-Feb) Temperature
## Contiguous United States

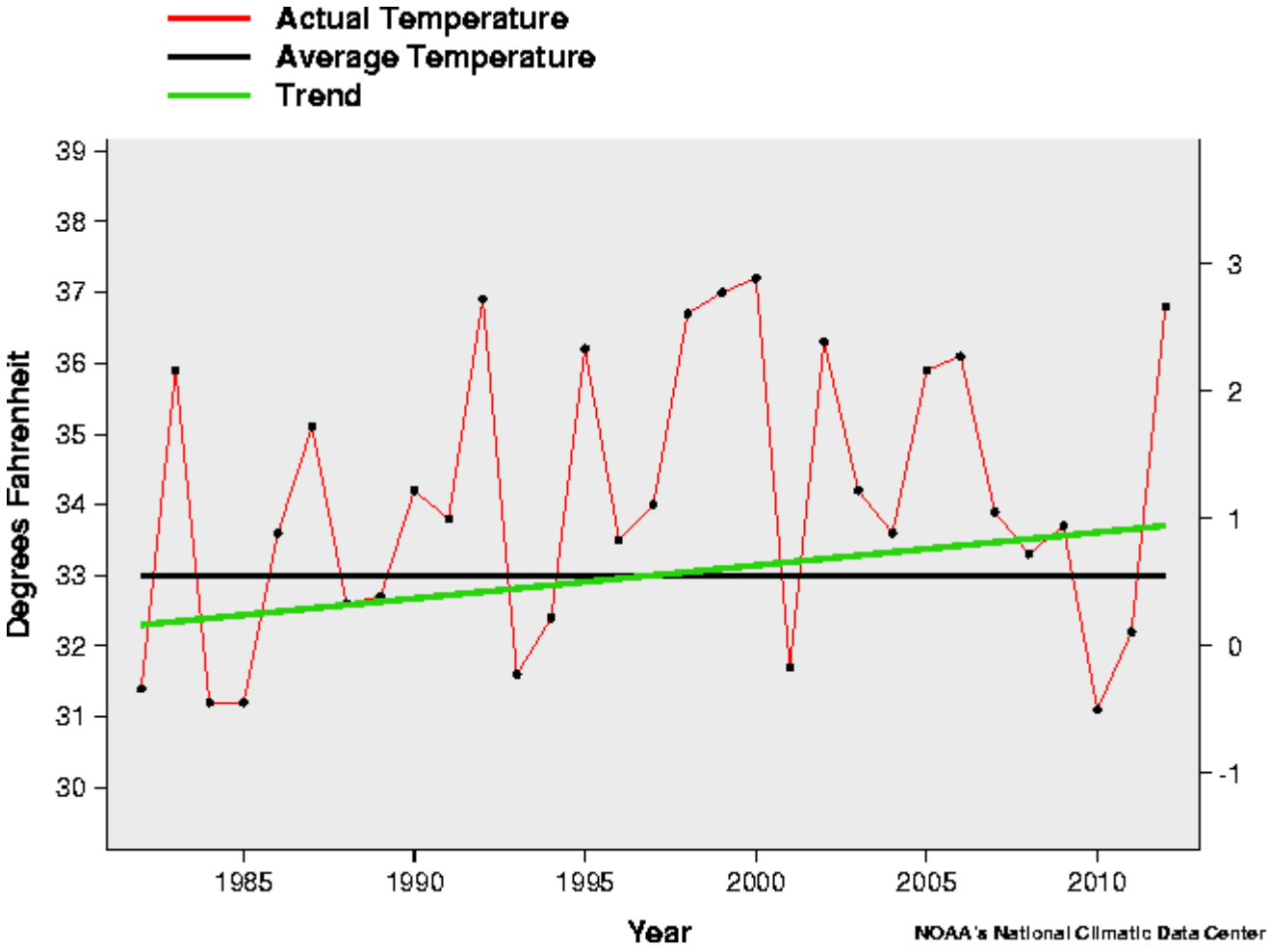
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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Winter (Dec-Feb) 1982 - 2012 Data Values:**

Winter (Dec-Feb) 2012: 36.83 degF Rank: 28

**Winter (Dec-Feb) 1901 - 2000 Average = 32.97 degF**
**Winter (Dec-Feb) 1982 - 2012 Trend = 0.46 degF / Decade**




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# Climate At A Glance

## Spring (Mar-May) Temperature
## Contiguous United States

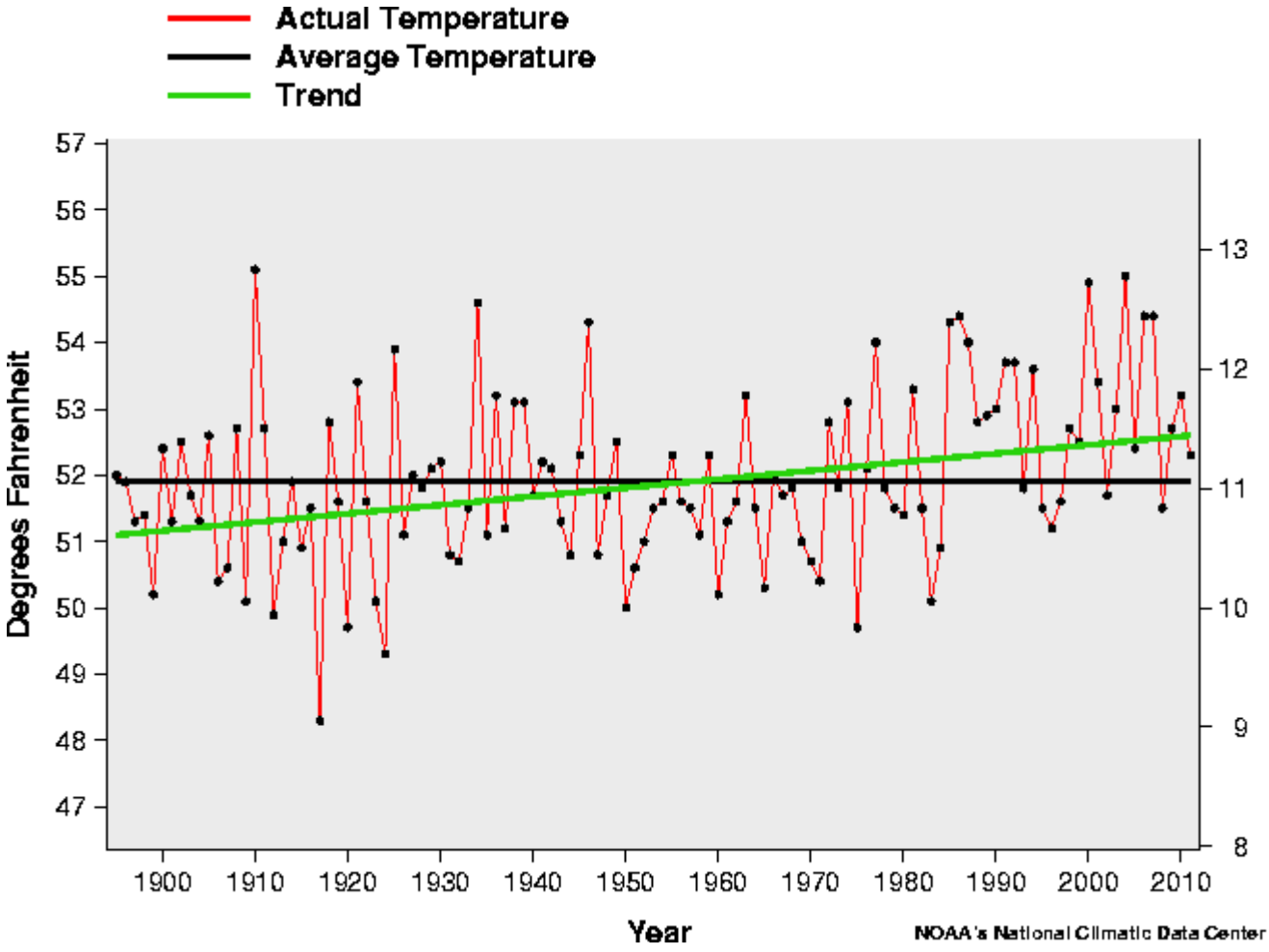
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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Spring (Mar-May) 1895 - 2011 Data**
**Values:**

Spring (Mar-May) 2011: 52.34 degF Rank: 76

**Spring (Mar-May) 1901 - 2000 Average = 51.87 degF**
**Spring (Mar-May) 1895 - 2011 Trend = 0.13 degF / Decade**




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# Climate At A Glance

## Summer (Jun-Aug) Temperature
## Contiguous United States

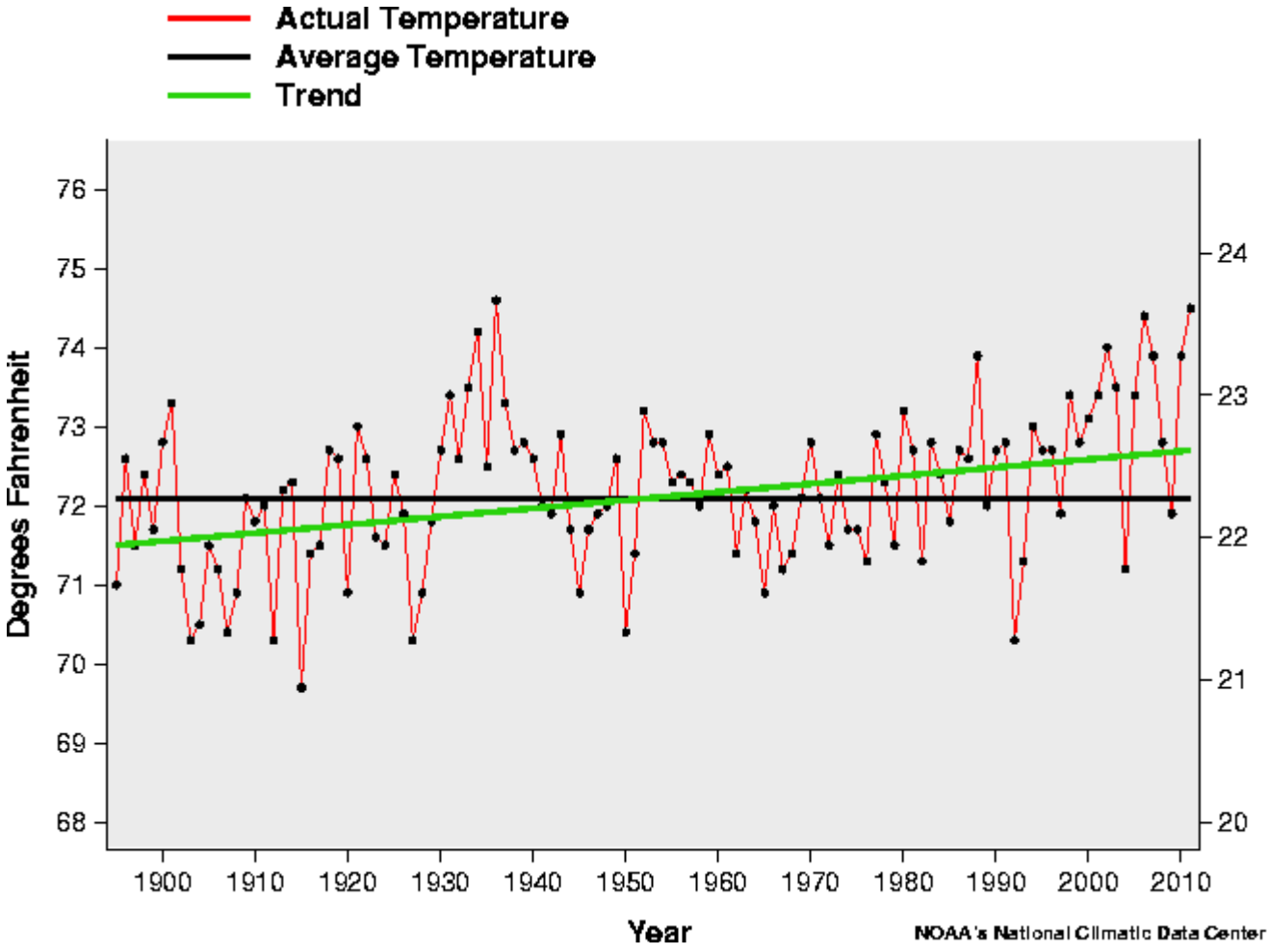
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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Summer (Jun-Aug) 1895 - 2011 Data Values:**

Summer (Jun-Aug) 2011: 74.49 degF Rank: 116

**Summer (Jun-Aug) 1901 - 2000 Average = 72.10 degF**
**Summer (Jun-Aug) 1895 - 2011 Trend = 0.11 degF / Decade**




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# Climate At A Glance

## Summer (Jun-Aug) Temperature
## Contiguous United States

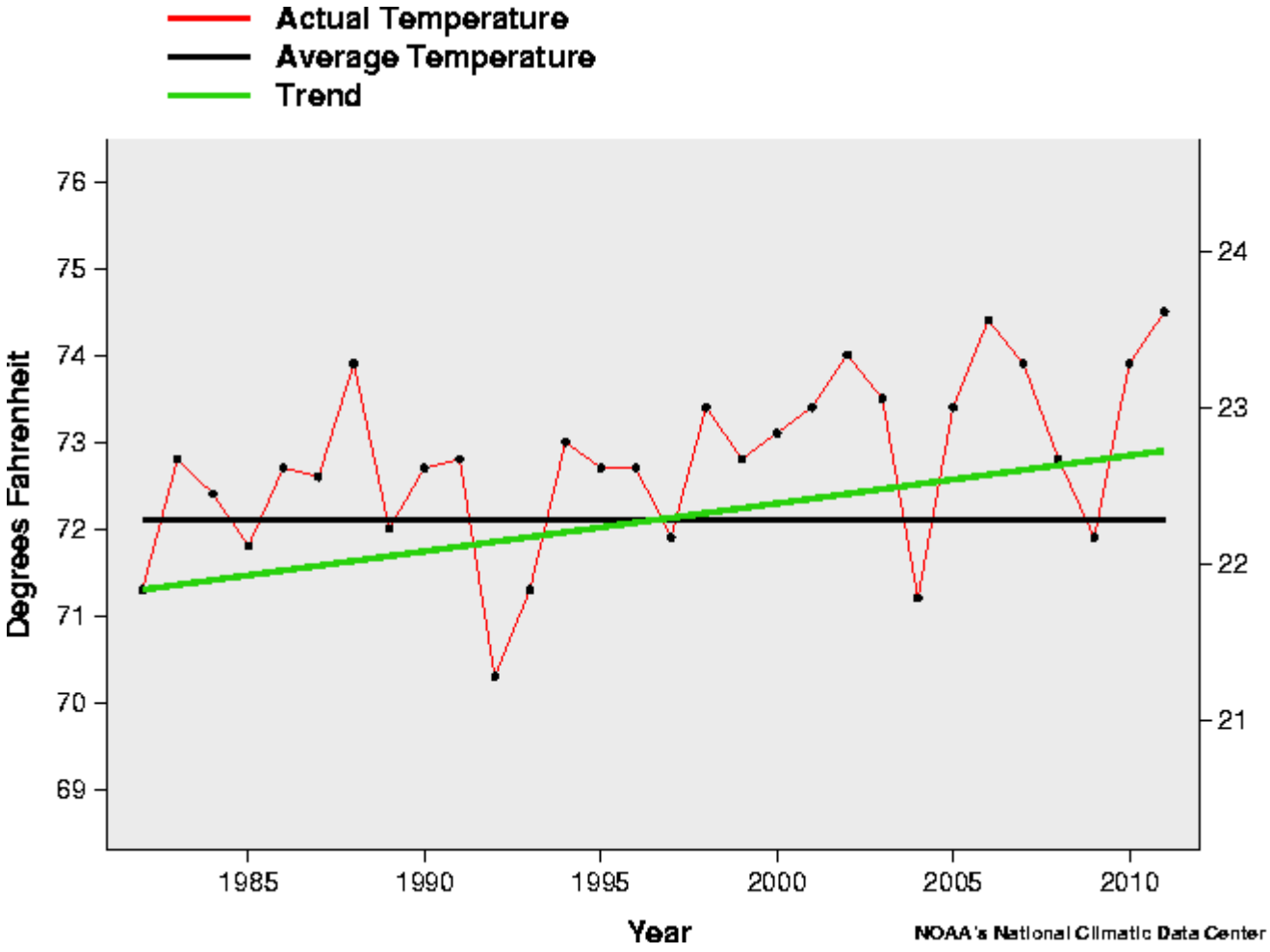
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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Summer (Jun-Aug) 1982 - 2011 Data Values:**

Summer (Jun-Aug) 2011: 74.49 degF Rank: 30

**Summer (Jun-Aug) 1901 - 2000 Average = 72.10 degF**
**Summer (Jun-Aug) 1982 - 2011 Trend = 0.52 degF / Decade**




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# Climate At A Glance

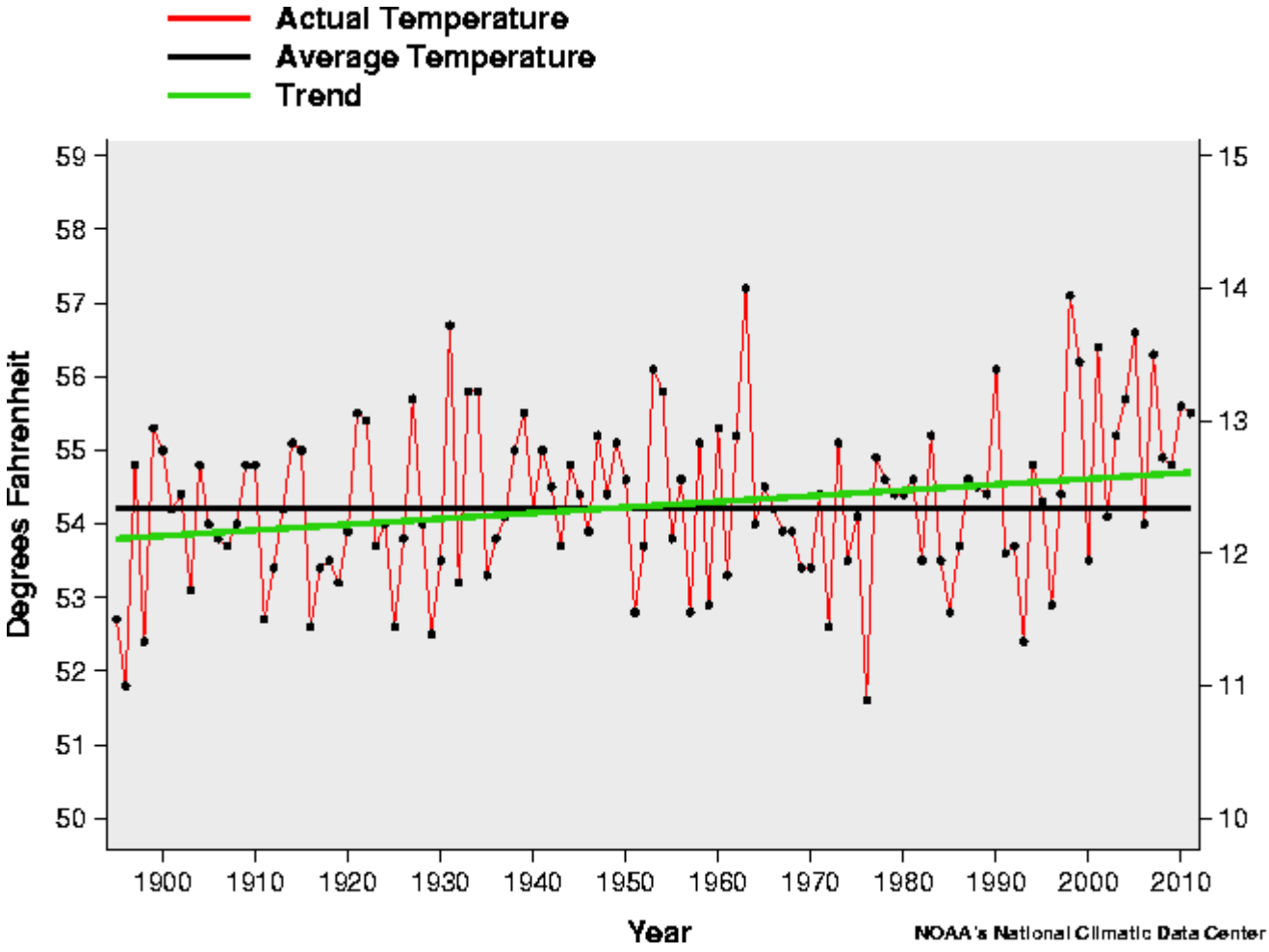
## Fall (Sep-Nov) Temperature
## Contiguous United States

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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Fall (Sep-Nov) 1895 - 2011 Data Values:**
Fall (Sep-Nov) 2011: 55.55 degF Rank: 102

**Fall (Sep-Nov) 1901 - 2000 Average = 54.23 degF**
**Fall (Sep-Nov) 1895 - 2011 Trend = 0.08 degF / Decade**




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# Climate At A Glance

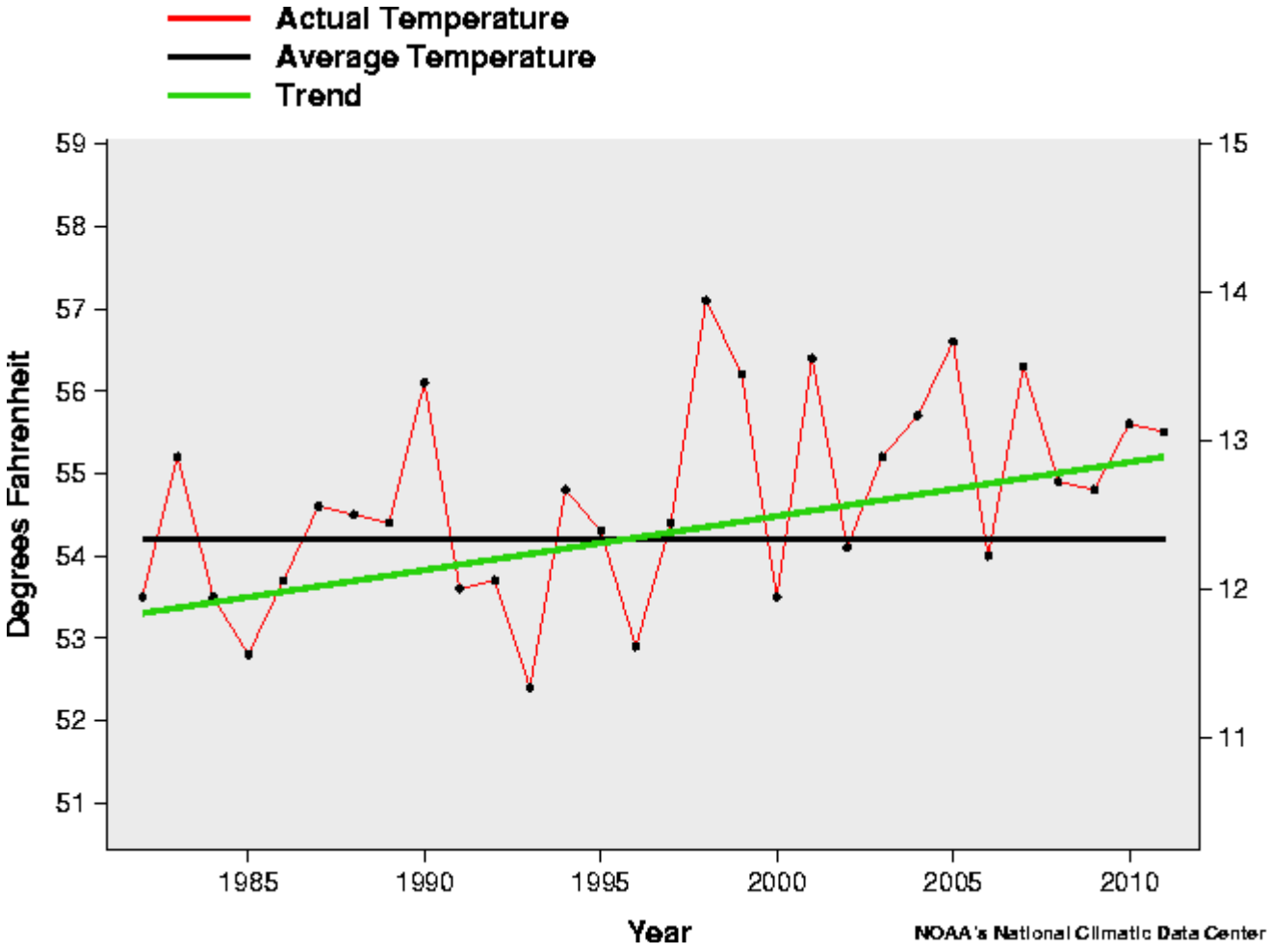
## Fall (Sep-Nov) Temperature
## Contiguous United States

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Some of the following data are preliminary and have not been quality controlled.
For official data, please contact the NCDC Climate Services and Monitoring Division at ncdc.orders@noaa.gov.

**Fall (Sep-Nov) 1982 - 2011 Data Values:**
Fall (Sep-Nov) 2011: 55.55 degF Rank: 22

**Fall (Sep-Nov) 1901 - 2000 Average = 54.23 degF**
**Fall (Sep-Nov) 1982 - 2011 Trend = 0.65 degF / Decade**




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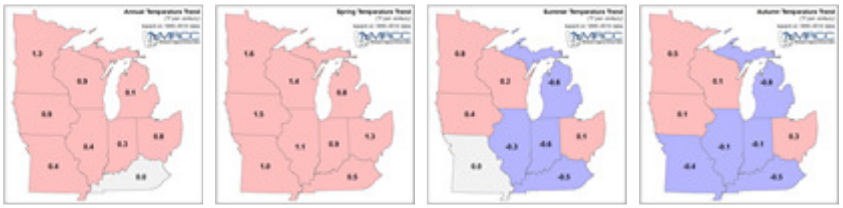



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**Climate Change & Variability in the Midwest**

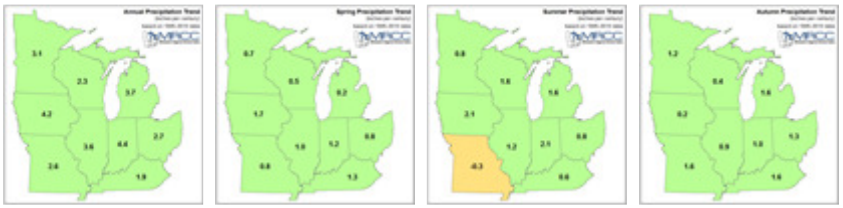
The climate of the Midwest has changed over time since the beginning records in 1895. Presented here are maps of the state average annua temperature and precipitation trends between 1895 and 2010. Tempe shown in degrees Fahrenheit change per century, and precipitation tre as inches of precipitation change per century. The monthly state aver calculate the trends came from the National Climatic Data Center. Clic see a larger version of the image.

**Temperature Trends, 1895-2010**



Annual Spring Summer Autumn

**Precipitation Trends, 1895-2010**



Annual Spring Summer Autumn

How the Trend Values Were Calculated:
The values displayed on the maps are linear trends in units per century. Mo state was averaged (temperature) or totaled (precipitation) into seasonal or Linear regressions were computed from the seasonal and annual data. The resulting regression coefficients (slopes) were multiplied by 100 to compute century which are displayed on the maps.

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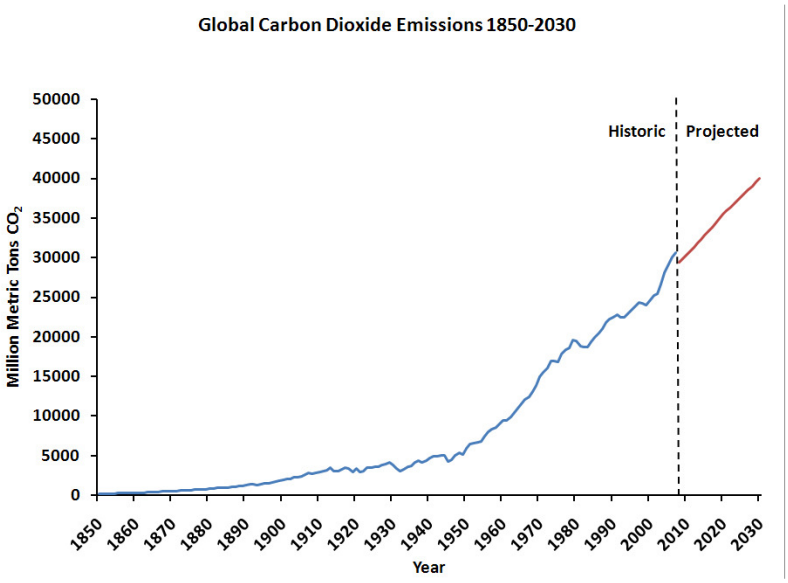
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## HISTORICAL GLOBAL CO2 EMISSIONS

Greenhouse gas emissions, largely CO2 from the combustion of fossil fuels, have risen dramatically since the start of the industrial revolution.




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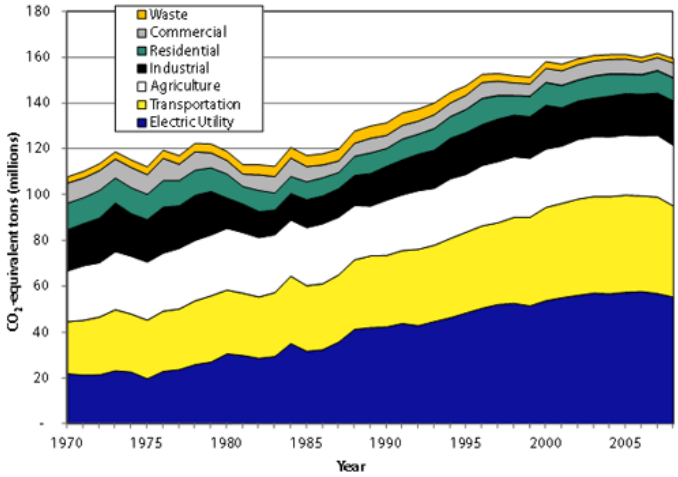
# Climate Change: Greenhouse Gas Emissions in Minnesota

Under Minnesota statute (Minn. Stat. § 216H.07, subd. 3), the Minnesota Pollution Control Agency (MPCA) is obligated to report on statewide progress toward the greenhouse gas (GHG) reduction goals enumerated in the Next Generation Energy Act (Minn. Stat. § 216H.02). The Next Generation Energy Act established the following GHG reduction goals: 15 percent reduction from 2005 levels by 2015; 30 percent reduction by 2025; and 80 percent reduction by 2050.

Emissions are estimated for all years from 1970 to 2008. Emissions are grouped in the agricultural, commercial, electric generation, industrial, residential, transportation, and waste sectors, and into major activity groups by energy use and fuel production, agricultural process, industrial process, and waste management emissions. tinyURL link : 992

## Greenhouse Gas Emissions by Economic Sector

**Greenhouse Gas Emissions from Minnesota by Economic Sector**

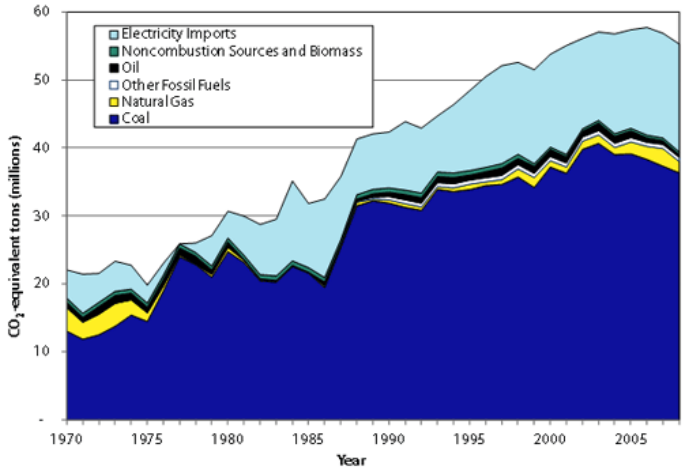



Statewide GHG emissions increased by an estimated 51.5 million CO2-equivalent tons between 1970 and 2008, to a total of 159.5 million CO2-equivalent tons, 48 percent higher than emissions in 1970. Total emissions in the baseline year, 2005, were an estimated 161.3 million CO2-equivalent tons.

Between 1970 and 2008, the majority of the growth in estimated statewide GHG emissions occurred in just two sectors: the electric power sector and the transportation sector. Emissions from transportation and electric power generation comprised roughly 41 percent of all Minnesota GHG emissions in 1970, and, by 2008, they accounted for 60 percent, more than doubling in absolute terms.

### Electric Generation Sector

**Greenhouse Gas Emissions from the Electric Generation Sector in Minnesota**

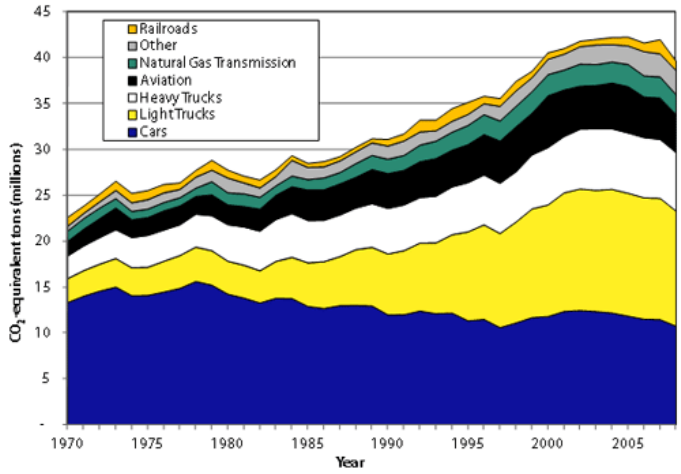



Emissions from electric generation have risen at an average annual rate of 3.5 percent between 1970 and 1988, and 1.5 percent per year between 1988 and 2008. Since 2000, emissions from electricity generation have increased about three percent, rising at an average annual rate of 0.3 percent per year.

Between 2005 and 2008, total GHG emissions from the electric sector decreased 2.1 million CO2-equivalent tons. Emissions associated with energy produced outside of the state increased by 1.4 million CO2-equivalent tons as emissions from in-state generation have decreased.

### Transportation Sector

**Greenhouse Gas Emissions from Transportation Sector in Minnesota**

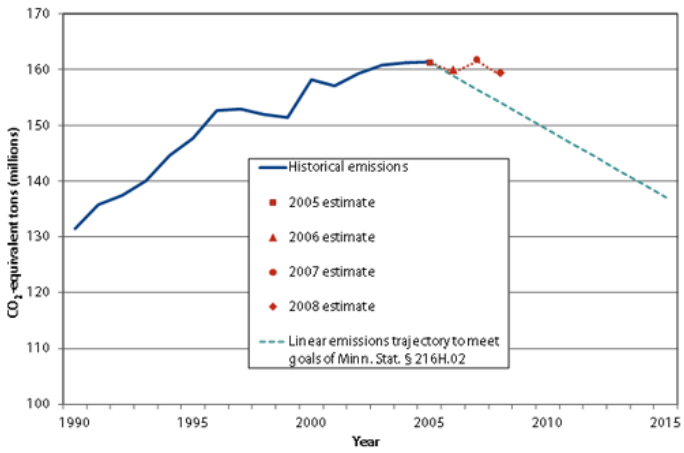



In 2008, GHG emissions from transportation were an estimated 39.7 million CO2-equivalent tons, not quite double 1970 emissions. Between 2005 and 2008, total transportation emissions decreased by 2.6 million CO2-equivalent tons.

## Progress to Meeting Next Generation Energy Act Goals

- Statewide GHG emissions totaled 161.3 million $CO_2$-equivalent tons in the baseline year, 2005, falling to 159.5 million $CO_2$-equivalent tons in 2008.

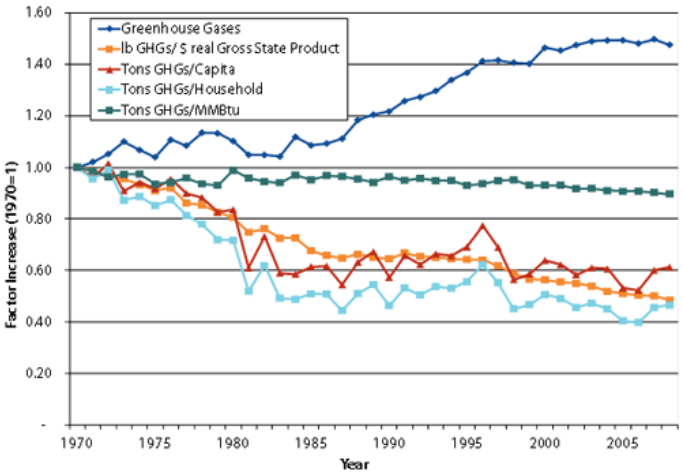
**Tracking Progress on Minnesota Greenhouse Gas Emissions**




## Indicators and Explanation of Trends

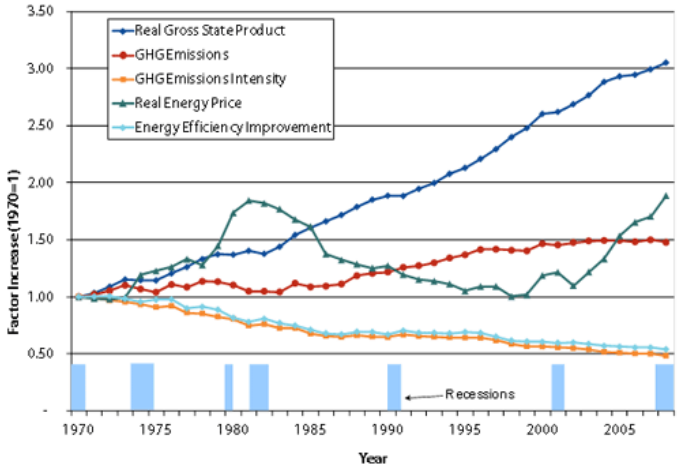
Measures of emission intensity are useful in understanding what has or has not happened and why. It is common to express emissions in relation to total population, household numbers, economic output, total energy consumption and other social and economic indicators of interest. The trend in emissions in relation to each of these indicators is shown in the figure below as a factor increase above 1970 levels of emission intensity.

**Indicators of Greenhouse Gas Emission Intensity**




The figure below summarizes the trend from 1970 to 2008 in GHG emissions as a factor increase compared to 1970 levels, along with parallel trends for state economic output (real gross state output), GHG emission intensity, energy efficiency, and real energy prices. Real energy prices peaked in 1981, remained at high levels through 1985, and then declined to the late 1990s. After 1998, real energy prices began a slow climb. Energy use efficiency declined rapidly, 1970-1985, stabilized from 1985-1998, then resumed its earlier pattern of decline. GHG emission intensity followed a similar pattern. Real economic output showed an inverse pattern, growing slowly through 1983, accelerating from 1983 to 1997, and then slowing after 1997.

**Minnesota Greenhouse Gas Emissions, Emissions Intensity, Economy, and Real Energy Prices**




## Full Report

- Greenhouse Gas Emissions in Minnesota: 1970-2008 (p-gen4-08) (January 2012). A report on statewide progress toward greenhouse gas reduction goals enumerated in the Next Generation Energy Act, including a summary of emissions by economic sector and by major activities, with long term trends and social and economic indicators.
- Greenhouse Gas Emissions in Minnesota: 1970-2006 (p-gen4-05) (June 2009). A report on statewide progress toward greenhouse gas reduction goals enumerated in the Next Generation Energy Act, including a summary of emissions by economic sector and by major activities, with long term trends and social and economic indicators.
- Data Summary for Greenhouse Gas Emissions in Minnesota: 1970-2006 (p-gen4-06). This spreadsheet contains the summarized data for all years from 1970 through 2006 that was used in the report. Keys for organizing the data into the same economic sectors and activities as in the report are included. It is important to note that the numbers in this spreadsheet and subsequent iteration of the analysis are subject to change if methods or original data are updated. (Posted October 2, 2009)

Last modified on Friday, January 13, 2012 12:42

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**Attachment X**

# Addendum 1 to Appendix A: Greenhouse Gas Emission Inventory and Energy Efficiency Analysis of the NorthMet Project Greenhouse Gas and Climate Change Evaluation v5

**NorthMet Project – Addendum 1 to Appendix A: *Greenhouse Gas Emission Inventory and Energy Efficiency Analysis* of the NorthMet Project Greenhouse Gas and Climate Change Evaluation v. 5 (June 2012)**

March 29, 2013 – version 2

## Summary

This document provides an analysis of the impacts to NorthMet Project (Project) greenhouse gas emission (GHG) estimates caused by Project design changes. Project design changes considered here are primarily associated with the implementation of engineering controls to manage water quality impacts. These changes were documented in Version 5 of the Adaptive Water Management Plan and Version 5 of the Project Description, both dated March 7, 2013 and further discussed in Version 2 of the NorthMet Project –Analysis of Air Ripple Effects document dated March 8, 2013. Six key changes were identified: Changes in timing for construction of the Category 1 Waste Rock Stockpile cover, changes in the extent of the Category 1 Waste Rock Stockpile Containment System, changes to Waste Water Treatment Facility (WWTF)/Waste Water Treatment Plant (WWTP) design and operating assumptions, changes to the design of the Flotation Tailings Basin (FTB) Containment System, potential changes to the FTB North Buttress Design and the potential need for additional lime to neutralize water in the East Pit.

This addendum also addresses two other changes that are relevant to the GHG estimates provided in Appendix A to Version 5 of the NorthMet Project Greenhouse Gas and Climate Change Evaluation Report (Greenhouse Gas Emission Inventory and Energy Efficiency Analysis). First, revised GHG estimates provided in this addendum include minor changes to mobile source (over the road trucks) emissions estimates to address blasting material hauling. Second, the analysis provided in this addendum also addresses changes to direct wetland impact acreages since June 2012 and the effect of these changes on estimated aboveground carbon loss from wetlands. The current direct wetland impact assessment is provided in Version 7 of the Wetland Data Package dated March 7, 2013.

These Project changes and their relationship to calculated Project GHG emissions are summarized in Table 1 below. The remainder of this document provides an overview of each of the Project changes as well as revised GHG emission estimates.

DRAFT

**Table 1 Project Change Description**

| Change | Brief Description | Implication for Project Greenhouse Gas Emissions |
|---|---|---|
| Category 1 Waste Rock Stockpile Cover timing | Construction of cover was to begin after closure. Construction now begins in Mine Year 14, resulting in increased activity at Mine Site while waste rock is disposed of/relocated to East Pit. Geomembrane used instead of evapotranspiration system. | No change in total Mine Site emissions during operations as construction schedule can be optimized to avoid creating a new worst case year for air quality impacts. Increase in total reclamation phase emissions due to construction required for completion of Category 1 Waste Rock Stockpile Cover in Year 21. |
| Category 1 Waste Rock Stockpile Containment System | Containment system has been extended along south side of Category 1 Waste Rock Stockpile. | No change in total Mine Site emissions during operations as no new worst case year for air quality impacts is created. Increase in total construction phase emissions. |
| WWTF/WWTP Design | Evaporators operated after cessation of mining and completion of reclamation. | Additional emissions from fuel combustion in evaporators during long term closure phase. |
| FTB Containment System | Containment system design has been changed to a trench/drain rather than wells along north and west sides. | Minor change in construction phase emissions occurring prior to beginning of Plant operations. |
| Change in rock quantity for North Buttress of FTB | Increased quantity or rock required for construction of Tailings Basin north buttress | No impact on emissions as this change does not affect worst case emission rate for Tailings Basin construction occurring after Plant operations begin. |
| Additional lime demand at the Mine Site for East Pit Neutralization | Lime will be delivered to the Mine Site by returning ore trains, slurrified at the WWTF and pumped to the East Pit | No increase in direct GHG emissions |
| Blasting material hauling | Minor changes to mobile source (over the road trucks) emissions estimates to address blasting material hauling – traffic for these vehicles was added to the emission inventory after preparation of the previous carbon footprint analysis | Minor increase in Mine Site/Plant Site mobile source emissions. |
| Direct wetland impact acreages | Minor changes to direct wetland impact acreages and types | Minor increase in wetland biomass carbon loss. |

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## Project Greenhouse Gas Emission Inventory

The Greenhouse Gas Emission Inventory and Energy Efficiency Analysis provides annual emissions estimates for activities during operations (Mine Years 1-20) at the Mine Site and Plant Site as well as estimates of total emissions associated with the construction (Mine Year 0) and reclamation/long term closure phases (20 year reclamation period and 30 years of waste water treatment with evaporators in the long term closure period) of the Project. In addition, potential emissions associated with alterations to the terrestrial carbon cycle were assessed via an evaluation of impacts to carbon storage and sequestration in wetlands and forests, emissions from stockpiled peat, and carbon flux associated with peat used in reclamation activities.

Annual Mine Site emission calculations presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis consider maximum potential annual emissions associated with operation of the WWTF Backup Generator, WWTF Propane Fired Space Heaters, mining related equipment, Ore Haul Locomotives, and other vehicle emissions during mine operation. Annual Plant Site emission calculations presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis consider maximum potential annual emissions from operation of the Autoclave Startup Boiler, Oxygen Plant Adsorber Regeneration Heater, Space Heaters, Backup Generators and Fire Pumps, Autoclave Solution Neutralization and Iron and Aluminum Precipitation Tanks, vehicle traffic, FTB and Hydrometallurgical Residue Facility construction equipment, Ore Haul Locomotives and locomotive use in the switch yard during a worst case year of plant operation. Total Project emissions for the Mine Site and Plant Site were calculated assuming maximum potential emissions for a 20-year proposed operating life.

Construction emissions were calculated for both the Mine Site and the Plant Site based on the same information as used for the operating emissions, with the exception of tailpipe emissions from vehicles used for Process Plant construction. Construction emissions included in the calculation included Plant Site point and mobile sources, Mine Site point and mobile sources as well as other miscellaneous construction sources. All construction emissions were calculated for Year 0 of the Project and included emissions from equipment used for new building construction as well as paving and grading. Emissions were estimated for a potential reclamation period of 20 years for the Plant Site and Mine Site and included emissions for mobile equipment as well as point sources at both the Mine Site and Plant Site. Additional emissions during the long term closure period, including the operation of evaporators were also added for this addendum. The assumptions for the reclamation and long term closure period used in this addendum represent an update from the previous greenhouse gas emission inventory.

DRAFT

Based on the Project changes described in Table 1 and the revised GHG emission estimates detailed in the remainder of this document, Table 2 provides a revised summary of total potential GHG emissions estimated over the lifetime of the Project.

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**Table 2 Total Potential GHG Emissions Estimated over the Lifetime of the Project**

| | As presented in v. 5 of the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis | | | Revised Estimate | | |
|---|---|---|---|---|---|---|
| **Source** | **Maximum Total Potential Direct Emissions ($CO_2$-e, m.t.)** | **Maximum Total Potential Indirect Emissions ($CO_2$-e, m.t.)** | **Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t./yr)** | **Maximum Total Potential Direct Emissions ($CO_2$-e, m.t.)** | **Maximum Total Potential Indirect Emissions ($CO_2$-e, m.t.)** | **Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t./yr)** |
| Mine Site [1] (mining equipment and vehicles, ore hauling) | 793,734 | | | 793,734 | | |
| Plant Site [1] (ore crushing, concentrating, metal recovery) | 2,933,103 | | | 2.933,181 | | |
| Construction Phase Emissions [2] | 92,885 | | | 94,186 | | |
| Reclamation/ Long Term Closure Phase Emissions [3] | 438,988 | | | 1,549,688 **[5]** | | |
| Subtotal | 4,258,710 | 10,220,000 **[4]** | 14,478,710 | 5,370,789 | 10,220,000 **[4]** | 15,590,789 |
| Terrestrial carbon loss (aboveground wetland carbon stock, aboveground forest carbon stock, 20 years of emissions from stockpiled peat, emissions from peat used in reclamation) | 199,591 | | 199,591 | 199,963 | | 199,963 |

Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year.
[1] Based on maximum annual emissions occurring for 20 year proposed operating life of Project
[2] Includes Phase 1 (flotation concentrate production only) and Phase 2 (Hydrometallurgical Plant) Construction
[3] Based on 20 year reclamation period for Plant Site Mine Site and an additional 30 years of active wastewater treatment during long term closure including the operation of evaporator/crystallizers for updated emissions (previous calculations assumed 20 year operation at the Plant Site and 60 year operation at the Mine Site.
[4] Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by a manufacturing company represent the manufacturer's indirect emissions. Electrical load for the Project is estimated to be approximately 59.5 megawatts. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. See Attachment B for calculation details. Based on maximum annual emissions occurring for 20 year proposed operating life of Project.
[5] Increase = 1,549,688 – 438,988 = 1,110,700 = 584,060 (evaporators) + 525,726 (non-evaporator WWTF/WWTP) + 915 (Category 1 Stockpile Cover – Mine Year 21)

DRAFT

## Category 1 Waste Rock Stockpile Cover Timing

Project design changes will require installation of a geomembrane cover on the Category 1 Waste Rock Stockpile to reduce the load going to the WWTF. The reclamation plan in place when the Air Emission Inventory for the Mine Site was prepared called for the construction of the cover to begin after closure. The revised schedule indicates that construction will begin in Mine Year 14 and continue through the end of mining operations at Mine Year 20. The cover will be completed during Mine Year 21 (i.e. after mining has ceased

While this change in construction timing shifts activity so that it will occur during operations, the change does not affect GHG emission estimates for the Mine Site during operations provided in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis because these estimates were based on maximum potential to emit during a "worst case" year. Analysis provided in Version 1 of the NorthMet Project –Analysis of Air Ripple Effects document dated January 23, 2013 demonstrates that the construction schedule for the Category 1 Waste Rock Stockpile Cover can be optimized to avoid creating a new worst case year for air quality impacts. Thus, no adjustment to the maximum potential to emit estimates for GHG emissions provided in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis is needed.

The Greenhouse Gas Emission Inventory and Energy Efficiency Analysis also provided an estimate of total GHG emissions for the reclamation phase of the Project. The changes in Waste Rock Stockpile Cover construction timing will require construction activities to continue through Year 21. Total Project reclamation phase emissions in Table 2, show the adjusted reclamation phase emissions, accounting for Category 1 Waste Rock Stockpile Cover construction emissions calculated for Year 21. These construction activities are expected to contribute a total of 915 metric tons of $CO_2$ equivalent (m.t.$CO_2$-e) to total Project reclamation phase emissions, an increase of 0.2% over the total Project reclamation/long term closure phase emissions presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis. ).

In addition to changes in construction timing, adjustments to the Category 1 Waste Rock Stockpile design include a switch from an evapotranspiration cover to a geomembrane cover. As a result planned reclamation activities will involve establishment of herbaceous cover on the Category 1 Waste Rock Stockpile. Section 10.4 of the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis discusses carbon flux associated with peat use in reclamation areas and considers carbon flux profiles for

cover types including red pine woodland, aspen woodland, and herbaceous cover. While red pine woodland and aspen woodland both showed net carbon gains over time, modeling of herbaceous cover indicate a net loss of 10% of the ecosystem's stored carbon over a 50-year period. The Greenhouse Gas Emission Inventory and Energy Efficiency Analysis Based assumed that of the approximately 145 mega grams (Mg) of stored carbon per hectare (ha) of reclaimed area approximately 5 Mg/ha would be lost during the first five years after reclamation as the site transitioned from herbaceous cover to woody cover. Given that the cover on the Category 1 Waste Rock Stockpile is now expected to remain as herbaceous cover, this change would equate to a carbon loss of approximately an additional 10 Mg/ha from the reclaimed areas of the Category 1 Waste Rock Stockpile over a 50 year period. At approximately 550 acres of reclaimed area for the Category 1 Waste Rock Stockpile, this equates to the release of just over 8,000 additional m.t.$CO_2$-e, contributing a less than 5% increase in total emissions from Project disturbance to terrestrial ecosystems.

## Category 1 Waste Rock Stockpile Containment System

Project design Changes will require the Category 1 Waste Rock Stockpile Containment System to be extended along the south and southwest sides of the stockpile footprint. Approximately 50% of the construction will be completed prior to mining operations commencing. The remaining containment system construction is distributed over Mine Years 2 through 5, specifically, Mine Years 2, 3 and 5.

While this change in containment system design includes construction that will occur during operations, the change does not affect GHG emission estimates for the Mine Site during operations provided in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis because these estimates were based on maximum potential to emit during a "worst case" year. Analysis provided in Version 1 of the NorthMet Project –Analysis of Air Ripple Effects document dated January 23, 2013 demonstrates that the containment system construction will have minimal effect on total emissions and it is very unlikely to result in a new worst case emission scenario during operations. Thus, no adjustment to the maximum potential to emit estimates for GHG emissions during operations provided in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis is needed.

The Greenhouse Gas Emission Inventory and Energy Efficiency Analysis also provided an estimate of total GHG emissions for the construction phase of the Project. Approximately 50% of the construction for Category 1 Waste Rock Stockpile Containment System will be completed during the construction phase prior to the commencement of mining operations. Total Project construction emissions in Table 2 show

the adjusted construction emissions, accounting for construction of the Category 1 Waste Rock Stockpile Containment System. These construction activities are expected to contribute a total of 497 m.t.$CO_2$-e to total Project construction emissions, an increase of 0.5% over the total Project construction phase emissions presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis.

## WWTF/WWTP Design

Once the reclamation phase is complete, two reverse osmosis waste water treatment plants with evaporators will be installed to treat brine for long term closure. The estimated total water flow to the evaporators is about 60 gallons per minute. Assuming the water fed to the evaporators is 70 degrees Fahrenheit and 20% evaporator inefficiency, the amount of thermal energy needed to operate the evaporators is equal to about 40 million Btu/hour. Based on relative brine generation rates, the heat input for the Mine Site evaporator will be 8 million Btu/hour and the heat input for the Plant Site evaporator will be 32 million Btu/hour. Emission calculations are based on the Plant Site evaporator burning natural gas and the Mine Site evaporator burning propane.

This increased energy usage will increase GHG emissions during the long term closure phase of the Project relative to the emission totals reported in the Greenhouse Gas Emission Inventory and Energy and Efficiency Analysis. Total Project reclamation and long term closure phase emissions in Table 2 show the adjusted emissions, accounting for operation of the two reverse osmosis waste water treatment plants. The increased energy usage associated with the waste water treatment plant evaporators is expected to contribute a total of 584,060 m.t.$CO_2$-e to total Project long term closure phase emissions. The majority of the balance of the increase shown in Table 2 for the Reclamation/Long Term Closure phase is due to changes in the assumptions for operation of the other emission sources associated with the WWTF and WWTP, such as heaters and backup generators. The previous calculations assumed 20 year operation at the Plant Site (WWTP) and 60 year operation at the Mine Site (WWTF). The calculations completed for this addendum assume a total of 50 years of operation for both (20 years reclamation, 30 years long term closure). The resulting increase is a total of 525,726 m.t.$CO_2$-e.

Total updated emissions for the reclamation and long term closure periods show an increase of a factor of about 2.5 over the total Project reclamation and long term closure phase emissions presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis. To provide further perspective, this emission increase corresponds to 8% of the previously reported total Project carbon footprint. These calculations assume a reclamation period with a duration of 20 years for the Plant Site and Mine Site and

an operating duration of 30 years for the evaporators during the long term closure period. This assumption is based on an expectation that a transition to non-mechanical treatment will be possible within 70 years of the commencement of mining operations. The annual emission rate during the long term closure period, with the evaporators, is 38,763 metric tons of $CO_2e$ per year. This value can be used to assess the carbon footprint based on other assumptions for the duration of evaporator operation.

Total potential point source GHG emissions during the long term closure period are estimated as about 42,000 short tons of $CO_2$-e per year. This is below the Prevention of Significant Deterioration (PSD) major source level of 100,000 short tons of $CO_2e$ per year, so the Project will not be major for PSD purposes during the long term closure phase. PolyMet will evaluate the need for a permit or permit amendment prior to the installation of the evaporators and commence construction in accordance with applicable state and federal permitting rules.

## Flotation Tailings Basin Containment System

The previously proposed interception well installation has been replaced with a trench/drain system that will be installed along the north and west sides of the FTB. This will lead to additional construction activity, which could increase air emissions. The containment system will be installed prior to the commencement of ore processing at the Plant Site, so any associated air emissions can be considered part of the construction phase of the Project. Total Project construction phase emissions in Table 2 show the adjusted emissions, accounting for additional construction activity associated with the FTB Containment System. These construction activities are expected to contribute a total of 804 m.t.$CO_2$-e to total Project construction emissions, an increase of about 1% over the total Project construction phase emissions presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis.

## Rock Quantity for North Buttress of Flotation Tailings Basin

The quantity of buttress rock placed at the North Buttress at the FTB may be increased to address geotechnical concerns. This potential change has not yet been incorporated into the proposed project, but an increased quantity of buttress rock has been assumed in the water modeling and the same assumptions were used to assess potential changes to air impacts.

As noted in Table 1, this change is not expected to impact calculated GHG emissions as the change does not affect worst case emission rate for FTB construction. The number of trucks assumed to operate as part of the FTB construction in the GHG calculations is sufficient to accommodate the transport of the

additional rock to the North Buttress. Therefore, there is no increase in GHG emissions associated with the potential increased quantity of buttress rock.

## East Pit Lime Addition

The water modeling assumes a circumneutral pH in the East Pit pore water during the backfilling and stockpile relocation phase (Mine Years 11 through 20). Some of the required alkalinity will be provided by waste streams from the WWTF. When additional alkalinity is needed, lime slurry will be added to the East Pit. The estimated lime demand is about 15 tons per day, which could be supplied by a single railcar (approximately 100-ton payload) delivered approximately once per week. The lime containing railcar would be transported to the Mine Site by a returning ore train, so no additional truck or train traffic will occur. Lime would be delivered by common carrier to the Plant Site in a covered hopper car or other appropriate railcar type. The loaded car would be coupled to the returning ore train for transport to the Mine Site, with no handling of the lime at the Plant Site.

The lime will be transferred pneumatically from the railcar to the lime silo at the Mine Site WWTF. The mix tank at the WWTF will be used to slurrify the lime. The slurry will be mixed with additional water and pumped from the WWTF to the East Pit, so there are no additional emissions resulting from this activity. Equipment already included in the project design will be used to adjust the pH in the East Pit and the slurry would be pumped along with water already reporting to the East Pit, so any change in project electricity usage, and therefore indirect GHG emissions would be minimal.

## Blasting Material Hauling

GHG estimates provided in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis did not account for hauling of blasting material. In order to account for emissions from vehicles used for blasting material hauling, minor changes to mobile source (over the road trucks) emissions estimates were made. These changes are reflected in updated Plant Site emission estimates provided in Table 2 (all over the road truck traffic is arbitrarily assigned to the Plant Site). This additional haul truck traffic is expected to contribute a total of 78 m.t. $CO_2$-e to total Plant Site emissions. This amounts to an increase of less than 0.1% in total Project operation phase emissions over the total Project operation phase emissions presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis.

## Direct Wetland Impact Acreage

As discussed above, the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis provided an analysis of potential emissions associated with alterations to the terrestrial carbon cycle. The analysis

included an assessment of carbon lost as a result of the Project's direct impacts to aboveground carbon storage in wetlands. Total carbon emissions associated with direct wetland impacts were calculated by assigning aboveground carbon storage values from the literature to each major wetland ecosystem type and then assuming that all aboveground carbon stored in directly impacted wetlands would be emitted as a one-time release of $CO_2$. Based on Project design changes, adjustments have been to total acreages of the different wetland types directly impacted by the Project since June 2012. Therefore, an update to estimated carbon loss from directly impacted wetlands has been completed. Changes to total impact acreages and wetland types are reflected in updated terrestrial carbon loss estimates provided in Table 2. Revised direct wetland impact values increase total emissions from aboveground wetland carbon stock from 199,591 m.t. $CO_2$-e to 199,963 m.t. $CO_2$-e resulting in an increase of less than 1% in total terrestrial carbon loss emissions relative to the total Project terrestrial carbon loss presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis.

DRAFT

**Attachment Y**

**Addendum 2 to Appendix A of the Greenhouse Gas and Climate Change Evaluation v5**

# NorthMet Project
# Addendum 2 to Appendix A: Greenhouse Gas Emission Inventory and Energy Efficiency Analysis of the NorthMet Project Greenhouse Gas and Climate Change Evaluation v. 5 (June 2012)

## January 13, 2015 – version 1

## 1.0 Summary

This document updates the estimated total potential greenhouse gas (GHG) emissions over the lifetime of the NorthMet Project (Project) from those reported in Addendum 1 to Appendix A of Greenhouse Gas Emission Inventory and Energy Efficiency Analysis of the NorthMet Project Greenhouse Gas and Climate Change Evaluation v. 5 (June 2012). The updated emissions in this document reflect the Project configuration proposed for the Final Environmental Impact Statement (FEIS). Compared to the Project described in the Supplemental Draft Environmental Impact Statement (SDEIS), the following changes are proposed for the FEIS:

- The Semi Autogenous Grinding (SAG) Mill
- The Coal Ash Landfill Relocation
- The Flotation Tailings Basin (FTB) Containment System: East Dam Extension
- Changes at the Waste Water Treatment Plant at the Plant Site (WWTP)
- Tailings Basin Cement Deep Soil Mixing

These changes were documented in Version 8 of the Project Description, submitted in December 2014. Additional information on how the first four changes listed above would affect air quality impacts was included in NorthMet FEIS Changes and Potential Air Quality Impacts (version 2) submitted in December of 2014. FTB Cement Deep Soil Mixing will be completed during the construction phase of the project. Because impacts would be greater during the Project operating phase, impacts from criteria and toxic pollutants associated with the FTB Cement Deep Soil Mixing were not evaluated.

These Project changes and their relationship to calculated Project GHG emissions are summarized in Table 1 below. The remainder of this document provides an overview of each of the Project changes as well as revised GHG emission estimates.

**Table 1 Project Change Description**

| Change | Brief Description | Implication for Project Greenhouse Gas Emissions |
|---|---|---|
| SAG Mill | Incorporation of semi-autogenous grinding (SAG) mill and a new Ball mill into the Beneficiation Plant flowsheet and removal of 4 of the 7 Fine Crushing Lines and related equipment. | Small reduction in total Beneficiation Plant heating demand resulting in a small decrease in direct greenhouse gas emissions. Lower electrical demand for the SAG Mill configuration will reduce indirect GHG emissions relative to the SDEIS configuration. |
| Coal Ash Landfill Relocation | A Coal Ash Landfill, located within the final footprint of the Flotation Tailings Basin will be excavated and the coal ash transferred to the lined Hydrometallurgical Residue Facility. | Small increase in greenhouse gas emissions from diesel fuel combustion in construction equipment. |
| WWTP | Increased maximum water treatment rate and usage of water treatment chemicals | Increased direct emissions of $CO_2$ from chemical usage and increased indirect emissions from additional electricity usage. |
| FTB Containment System: East Dam Extension | Containment system will be extended during Mine Year 6 to include the East Dam. | Small increase in greenhouse gas emission from additional fuel usage in construction equipment. Small increase in potential quantity of peat stockpiled at the Tailings Basin and associated potential $CO_2$ emissions. |
| Cement Deep Soil Mixing | Cement will be mixed with fine taconite tailings in place in the Flotation Tailings basin during the Project construction phase. | Additional GHG emission from diesel powered equipment and power generation for portable cement plant |

# 2.0 Project Greenhouse Gas Emission Inventory

The Greenhouse Gas Emission Inventory and Energy Efficiency Analysis estimates total emissions associated with the construction at the Mine Site and Plant Site(Mine Year 0), and annual emissions for activities during operations (Mine Years 1-20), reclamation, and long-term closure. In addition, potential emissions associated with alterations to the terrestrial carbon cycle were assessed via an evaluation of impacts to carbon storage and sequestration in wetlands and forests, emissions from stockpiled peat, and carbon flux associated with peat used in reclamation activities.

Annual Mine Site emission calculations presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis consider maximum potential annual emissions associated with operation of the WWTF Backup Generator, WWTF Propane Fired Space Heaters, mining related equipment, Ore Haul Locomotives, and other vehicles emissions during mine operation. Annual Plant Site emission calculations presented in the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis consider maximum potential

annual emissions from operation of the Autoclave Startup Boiler, Oxygen Plant Adsorber Regeneration Heater, Space Heaters, Backup Generators and Fire Pumps, Autoclave Solution Neutralization and Iron and Aluminum Precipitation Tanks, vehicle traffic, FTB and Hydrometallurgical Residue Facility construction equipment, Ore Haul Locomotives and locomotive use in the switch yard during a worst case year of plant operation. Total Project emissions for the Mine Site and Plant Site were calculated assuming maximum potential emissions for a 20-year proposed operating life.

Construction emissions were calculated for both the Mine Site and the Plant Site based on the same information as used for the operating emissions, with the exception of tailpipe emissions from vehicles used for Process Plant construction. Construction emissions included in the calculation included Plant Site point and mobile sources, Mine Site point and mobile sources as well as other miscellaneous construction sources. All construction emissions were calculated for Year 0 of the Project and included emissions from equipment used for new building construction as well as paving and grading. Emissions were estimated for a potential reclamation period of 20 years for the Plant Site and Mine Site and included emissions for mobile equipment as well as point sources at both the Mine Site and Plant Site. Additional emissions during the long-term closure period, including the operation of evaporators, were also included.

Based on the Project changes described in Table 1 and the revised GHG emission estimates detailed in the remainder of this document, Table 2 provides a revised summary of total potential GHG emissions estimated over the lifetime of the Project. Calculations assumed 20 a year reclamation period and 30 years of waste water treatment with evaporators in the long-term closure period of the Project. Emissions associated with varying lengths of reclamation or long-term closure can be assessed by using annual values for emissions during reclamation and long term closure, provided in Table 2.

**Table 2 Total Potential GHG Emissions Estimated over the Lifetime of the Project**

| | As presented in Addendum 1 to Appendix A of v. 5 of the Greenhouse Gas Emission Inventory and Energy Efficiency Analysis | | | Revised Estimate[5] | | |
|---|---|---|---|---|---|---|
| **Source** | **Maximum Total Potential Direct Emissions ($CO_2$-e, m.t.)** | **Maximum Total Potential Indirect Emissions ($CO_2$-e, m.t.)** | **Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t./yr)** | **Maximum Total Potential Direct Emissions ($CO_2$-e, m.t.)** | **Maximum Total Potential Indirect Emissions ($CO_2$-e, m.t.)** | **Maximum Potential Total (direct + indirect) Emissions [3] ($CO_2$-e, m.t./yr)** |
| Mine Site [1]<br>(mining equipment and vehicles, ore hauling) | 793,734 | | | 793,659 | | |
| Plant Site [1]<br>(ore crushing, concentrating, metal recovery) | 2,933,181 | | | 2,905,866 | | |
| Construction Phase Emissions [2] | 94,186 | | | 94,386 | | |
| Reclamation/ Long Term Closure Phase Emissions [3] | 1,549,688 | | | 1,548,061 | | |
| Subtotal | 5,370,789 | 10,220,000 [4] | 15,590,789 | 5,341,972 | 10,080,000 [4] | 15,421,972 |
| Terrestrial carbon loss (aboveground wetland carbon stock, aboveground forest carbon stock, 20 years of emissions from stockpiled peat, emissions from peat used in reclamation) | 199,963 | | 199,963 | 201,002 | | 201,002 |

Units = $CO_2$-e, m.t./yr = GHG emissions as $CO_2$-equivalents, in metric tons per year.

[1] Based on maximum annual emissions occurring for 20 year proposed operating life of Project

[2] Includes Phase 1 (flotation concentrate production only) and Phase 2 (Hydrometallurgical Plant) Construction

[3] Updated emission estimates are based on a 20 year reclamation period for the Plant Site and Mine Site and an additional 30 years of active wastewater treatment during long-term closure including the operation of evaporator/crystallizers. (Previous calculations assumed 20 years of active wastewater treatment during long-term closure at the Plant Site and 60 years at the Mine Site). Annual emissions during reclamation and long-term closure are 19.283 tons $CO_2e$ and 38,747 tons $CO_2e$ respectively. These values can be used to estimate the total carbon footprint for other assumed durations of reclamation and long-term closure.

[4] Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by a manufacturing company represent the manufacturer's indirect emissions. Electrical load for the Project is estimated to be approximately 58.7 megawatts, with the updates for the SAG Mill and WWTP. The electricity to be used by the Project is planned to be generated by Minnesota Power. The emission factor used in the calculation of potential indirect emissions is from the MPCA General Guidance for Carbon Footprint Development in Environmental Review and is based on the Environmental Disclosure information filed annually by the electric utilities. Based on maximum annual emissions occurring for 20 year proposed operating life of Project.

[5] Revised estimates use updated EPA global warming potential values in addition to other adjustments.

# 3.0 SAG Mill

PolyMet proposes to install a SAG Mill and an associated Ball Mill in the Concentrator Building at the Plant Site. This proposed change affects the Crusher/Concentrator operation (i.e. the beneficiation process). The SAG Mill and the Ball Mill will replace the existing Rod and Ball Mills as well as the Tertiary and Quaternary Crushers in the Fine Crusher Building in the process flow sheet. Additional conveyors and transfer points relative to the design evaluated in the supplemental draft environmental impact statement (SDEIS) will be needed to deliver the ore to the SAG Mill, but an overall reduction in ventilation air will result. The SAG Mill and Ball Mill are wet processes, so there will be no particulate emissions from them or need for associated particulate emission control devices. New material handling operations upstream of the SAG Mill will have the potential for particulate emissions and will be vented to the same type of cartridge filter dust collector as has been proposed previously for many of the Crusher/Concentrator emissions units.

In order to maintain operational flexibility and allow options for process optimization, PolyMet will maintain three of the seven fine crushing lines in the SAG Mill configuration along with the portion of the Coarse Ore Bin that feeds these crushers. Specifically, the East 1, West 1, and West 2 Fine Crushing Lines (EU 015, 018, and 019) will continue to be included in the Emission Inventory and air permit application and any future modeling. The 2A Tripper Car and West Coarse Ore Bin will also be included (EU 403 and EU 136).

## 3.1 Space Heating

The heating demand in the Coarse Crusher Building and Drive House #1 would be unchanged from the SDEIS. The heating demand in the Fine Crusher Building will be reduced because of the proposal to include only three of the seven existing fine crushing lines in the emission inventory as spare equipment and/or for use in optimizing SAG Mill performance. The reduced work areas of the Fine Crusher Building would require heating under the proposed configuration and as necessary barriers, insulation, or other engineered means would be installed. The Concentrator Building demand is based on the SDEIS modeled value of 34.08 MMBtu/hr plus the increase for the SAG Mill Configuration of 2.874 MMBtu/hr as determined by the Project mechanical design consultant, KFI (34.08 MMBtu/hr + 2.874 MMBtu/hr = 36.95 MMBtu/hr). The overall reduction in heating demand as compared to the modeled values for the SDEIS is 3.5 MMBtu/hr, resulting in a reduction in direct potential GHG emissions of 1809.1 tpy carbon dioxide equivalents ($CO_2$-e).

## 3.2 Electricity Usage

The Beneficiation Plant, with incorporation of the SAG Mill and new Ball Mill, is more electrically efficient that the SDEIS flowsheet. Therefore, there would be an associated reduction in electrical demand of 1.5 MW. This results in a reduction in indirect emissions.

# 4.0 Coal Ash Landfill Relocation

The Coal Ash Landfill (Landfill) is located on the east side of the former LTV Steel Mining Company (LTVSMC) Tailings Basin Cell 1E. The Coal Ash Landfill was operated by LTVSMC to accept coal ash from

LTV's Taconite Harbor facility and coal contaminated soil from the LTVSMC abandoned coal yard. The Landfill was closed per the "Closure Plan for the Tailings Basin Coal Ash Disposal Area" (Plan) prepared by Wenck Associates for LTVSMC in May 2000, and filed with the Minnesota Pollution Control Agency (MPCA). The Landfill ceased accepting coal ash on approximately August 1, 2000.

The current footprint of the Landfill lies within the future footprint of an area to be inundated by NorthMet Project flotation tailings. To mitigate potential environmental risks, PolyMet proposes to relocate the Landfill to an appropriate storage facility. The Hydrometallurgical Residue Facility (HRF) is part of the planned NorthMet Project and is an appropriate storage facility. This double-lined facility is currently planned to be constructed and commissioned prior to the time period at which the Landfill should be relocated.

Currently it is estimated the transport of the landfilled material could be accomplished using five to six, sixty-ton capacity mining haul trucks to move the material over an approximate two and one-half mile haul (one-way). The materials would be removed from the landfill using a tracked excavator or front end loader. Other equipment utilized would consist of a grader, dozer, and water truck. It is expected to take approximately fifty shifts (8-hour shifts) to move this material. This effort would require no new roads as existing tailings basin roads would be utilized. Some economies could be realized by using other road grading and watering equipment likely in use for other tailings basin construction activities at that time.

Additional GHG emissions will occur as a result of diesel fuel consumption in the equipment used for this activity. The estimated total GHG emissions are 5841.8 tons $CO_2$-e or an increase of about 0.2% in the Plant Site emissions over the 20 year project life.

# 5.0 Flotation Tailings Basin (FTB) Containment System: East Dam Extension

The East Dam segment of the FTB Containment System will have the same design as the system constructed along the north and west sides of the Tailings Basin, with a cutoff wall and collection trench with slotted drain pipe. Potential air emission sources include: cutoff wall and trench excavation, hauling and placement of fill, and tailpipe emissions from construction equipment. The installation of the East Dam segment of the FTB Containment System is expected to occur during Mine Year 6. Construction is expected to last approximately five months.

The quantity of fill required for construction has been estimated as approximately 1,400 cubic yards of aggregate and 6,400 cubic yards of common borrow (silty sand and gravel). This is equivalent to about 14,000 tons of fill material. Assuming trucks with a 60-ton payload would be used to haul this material, as for FTB dam construction, this corresponds to approximately 230 truck trips to haul the required fill.

Additional GHG emissions would result from diesel fuel combustion in the construction equipment. The estimated total emissions are 244.4 tons of $CO_2$-e.

The quantity of peat excavated during installation of the containment system at the East Dam has been estimated as approximately 24,000 cubic yards. This will increase the surface area of the peat stockpile at the Tailings Basin by one acre (rounded to the nearest acre) compared to the carbon footprint calculation assumptions used for the SDEIS. The increase in annual peat emission based on the high end emission rate of 3,500 $g/m^2/yr$ is 52 metric tons of $CO_2e$ per year.

# 6.0 Waste Water Treatment Plant (WWTP)

Changes in plans for stream augmentation have resulted in the need for additional water treatment at the WWTP. Additionally, a number of process improvements have been incorporated into the WWTP design in the time since the emission calculations were last updated (Plant Site Air Emission Inventory ver. 7, February 2013). The updated Emission Inventory prepared for the FEIS incorporates the additional design details and accounts for the increased water volume needing treatment.

## 6.1 Summary of Potential WWTP Changes for the FEIS

### 6.1.1 Use of Carbon Dioxide for pH adjustment

Carbon dioxide ($CO_2$) will be the primary means of pH reduction for the Vibratory Shear Enhanced Process (VSEP) treatment unit in the WWTP. The estimated usage for $CO_2$ is about 650 tons per year (tpy) and the efficiency of the process is estimated as 95% to 99% (i.e. only 1 to 5% of the $CO_2$ used would be potentially vented to the air) as described in the $CO_2$ emissions section below. Hydrochloric acid will continue to be an option for pH adjustment for the primary membranes.

### 6.1.2 Waste Hauled by Rail

The SDEIS emission inventory includes truck traffic to transport solids from the WWTP to Hydrometallurgical Residue facility (HRF) and concentrate from the WWTP to the Mine Site Waste Water Treatment Facility (WWTF). The current plan, developed late in the SDEIS process, is to haul all VSEP concentrate to the WWTF via railcars attached to ore trains returning to the Mine Site. Solids are not produced by the latest WWTP design. An emission reduction could be obtained by eliminating the truck traffic, but for the FEIS emission inventory, the truck traffic has been left in to allow maximum overall flexibility.

### 6.1.3 Space Heating Switched to Electric

PolyMet may use electric space heaters in the WWTP rather than the natural gas fired space heaters included in the SDEIS emissions inventory. This would result in a direct emission reduction. Emissions from natural gas fired space heaters in the SDEIS emission inventory are 4,250 tpy $CO_2$. However, there would be a corresponding increase in electricity usage for electric heaters and therefore indirect greenhouse gas emissions. For the FEIS emission inventory, the natural gas space heaters have been included to allow maximum flexibility going forward.

### 6.1.4 Calcite Usage

The current WWTP information shows a maximum of 730 tpy calcite usage. Some fraction of the carbon in the calcite could be released to the atmosphere as $CO_2$ – see $CO_2$ emissions section below. Calcite usage was not included in the SDEIS emission inventory.

### 6.1.5 Emergency Generator

A 500 electrical kilowatt emergency generator was included in the SDEIS emission inventory to keep critical systems at the WWTP operating during power failure. This generator is also anticipated to be large enough to power critical systems for the Project as described in the FEIS and remains unchanged in the FEIS emission inventory.

### 6.1.6 $CO_2$ Emissions

The total $CO_2$ emissions from the wastewater treatment process, from $CO_2$ and calcite usage, were determined through modeling of the degasifier, which would be the point in the WWTP where any $CO_2$ would be emitted. The results were that less than 150 lb/day of $CO_2$ will be emitted from the process.

### 6.1.7 Changes in Electricity Usage

Increased water flow rates to the WWTP will result in additional electricity consumption. The estimated increase is 6,000,000 kW hours per year or an annual average demand of about 0.7 MW.

### 6.1.8 Operation During Reclamation/Long Term Closure

As noted above, a 20 year reclamation period and 30 years of waste water treatment with evaporators in the long term closure period were assumed in the carbon footprint calculations. These are the same assumptions used in the SDEIS carbon footprint calculations and they are based on an expectation that a transition to non-mechanical treatment will be possible within 70 years of the commencement of mining operations. The annual emission rate during the long term closure period, with the evaporators, is 38,752 metric tons of $CO_2e$ per year. This value can be used to assess the carbon footprint based on other assumptions for the duration of evaporator operation.

## 7.0 Cement Deep Soil Mixing

During the Project construction phase, cement will be added to fine taconite tailings in place at the existing Tailings Basin. Cement will be delivered by rail or truck and pneumatically conveyed to silos. After mixing in a portable cement plant, the cement will be conveyed to two cement deep soil mixing machines mounted on backhoe loaders. Up to two front-end loaders and trucks for hauling material will also be operated. The portable cement plant will require electrical power. The deep soil mixing process is expected to take about 43 days plus time for setup and demobilization.

This estimate of greenhouse gas emissions assumes that a cement plant with an integrated diesel generator would be used. A cement plant requiring an electrical power hookup could also be used which

would reduce direct emissions, but increase indirect emissions. The total estimated GHG emissions for this operation are about 200 tons of $CO_2$-e.

Detailed planning and design has not been completed to date for this operation, so while the description above and the GHG emission are representative of the anticipated activities associated with this operation, the emissions estimate should be viewed as an approximation. However, the estimated emissions are very small compared to the total Project carbon footprint, so any uncertainty will have little effect on the Project totals.

**Attachment Z**

**Climate Change Report Scope**

**April 1, 2011 Barr Engineering Company Memo w/ Emission Factor Comparison Table**
**November 9, 2011 Email from Suzanne Baumann (MPCA)**
**Comment Spreadsheet**

# Memorandum

**To:** NorthMet Air IAP Group

**From:** Louise Segroves and Pat Sheehy

**Subject:** Overview of CEQ Draft NEPA Guidance on Climate Change and Greenhouse Gas Emissions and Comparison to NorthMet DEIS Carbon Footprint Assessment and Climate Change Evaluation

**Date:** April 1, 2011

**c:** Jim Scott and Kevin Pylka, PolyMet

On February 18, 2010 the Whitehouse Council on Environmental Quality (CEQ) issued draft NEPA guidance on consideration of the effects of climate change and greenhouse gas emissions. This memo provides a brief overview of the CEQ guidance and an assessment of the extent to which analysis completed for the Draft Environmental Impact Statement (DEIS) for the NorthMet Project on climate change and greenhouse gas (GHG) issues meets the objectives outlined in the draft CEQ guidance. This memo also includes a brief description of the outcome of discussions of the CEQ guidance in the NorthMet Air Impact Assessment Planning (IAP) group where appropriate.

The carbon footprint assessment and climate change evaluation completed to aid in the development of the DEIS was developed with input from the Minnesota Department of Natural Resources (MDNR) and the Minnesota Pollution Control Agency (MPCA). A report, consistent with Minnesota state agency guidance, was submitted in June of 2009 (reference 1). That report will be updated to reflect project changes and changes in the regulatory environment. The update is to be submitted to support preparation of a Supplemental Draft Environmental Impact Statement (SDEIS). The update will also provide the opportunity to incorporate any changes necessary to make the analysis consistent with the federal guidance.

This memo is being submitted by PolyMet and Barr to provide information to the lead agencies for the SDEIS to aid in their decision making related to the scope of the updated carbon footprint analysis.

## Summary of CEQ Guidance

Overall, the CEQ guidance calls for an evaluation of two items:

1. Impact of agency action on the environment through the mechanism of GHG emissions
2. Impact of changing climate on agency action

The guidance offers some specific indications of how to complete an evaluation:

1) Impact of agency action on the environment through the mechanism of GHG emissions
   a) When to evaluate GHG Emissions?
      i) GHG emission should be evaluated where this would provide "meaningful" information to decision makers.
      ii) As a guide, a threshold of 25,000 metric tons of $CO_2$-equivalents/year (direct emissions) can be used.
      iii) Below this threshold, consideration of long term emissions may be warranted.
   b) How to evaluate GHG emissions?
      i) Quantify annual and cumulative direct and indirect emissions for all phases and elements of the proposed action and alternatives. Emissions should be evaluated within limits based on "feasibility and practicality".
      ii) Discuss measures to reduce emissions including energy conservation and mitigation opportunities for reasonable alternatives.
      iii) Qualitatively address the link between GHG emissions and climate change. Do not link individual project emissions with specific climate change impacts.
2) Impact of changing climate on agency action
      i) Using the sensitivity, location and timeframe of the proposed action as a guide, identify observed and projected effects of climate change on the action.
      ii) Discuss effects of the proposed action/alternatives and the nexus of those effects with projected climate change.
      iii) Identify climate change impacts that affect the design of the proposed action and alternatives.
      iv) In some cases it may be necessary to address adaptation to the affects of climate change.

## Comparison to NorthMet DEIS Carbon Footprint Assessment and Climate Change Evaluation

In the opinion of PolyMet and Barr Engineering the overall objectives identified by the CEQ guidance are generally consistent with the objectives identified in guidance followed for the NorthMet Project carbon footprint analysis and climate change evaluation completed for the DEIS in 2009. Table 1 below provides a summary comparing the elements of the analyses in the 2009 report to the guidance from the CEQ and it lists proposed changes for the updated report where warranted. Key areas where the approach used for the 2009 Report may differ from the outline of the draft CEQ guidance are highlighted in this table. These key areas are summarized below:

Scope of the carbon footprint development:

- CEQ guidance includes "all phases and elements of the proposed action" in the direct emissions considered for the project. The CEQ guidance does not explain exactly what this means, but it could be interpreted to mean that construction and closure phases should be included in the analysis. For the most part, the quantitative assessment of GHG emission in the June 2009 report focused on the operation phase of the project. However, emissions and reductions in sequestration due to land usage changes were evaluated for the total amount of impacted land (i.e. construction and operation phases). A quantitative assessment of all direct and indirect GHG emission during the construction and closure phases of the project would be difficult to conduct, but it would be appropriate to add a qualitative discussion of the affects of these phases on the overall project carbon footprint to the updated report and possibly the SDEIS. This item is highlighted in green in Table 1, as a consensus within the IAP group could not be reached regarding whether a quantitative assessment of construction emissions would provide meaningful information for decision making. Input from the co-lead agencies will be requested to aid in identifying an appropriate interpretation of the CEQ guidance and resolution for this item. The recommended appropriate level of treatment will be presented in the updated carbon footprint report.

- GHG emission calculations were completed for the June 2009 report using multiple references and guidance documents including: World Resources Institute Greenhouse Gas Protocol Standard (WRI), The Climate Registry's General Reporting Protocol (TCR), MPCA's General Guidance for Carbon Footprint Development in Environmental Review (MPCA), Intergovernmental Panel

on Climate Change recommendations (IPCC), EPA guidance and the professional judgment of the report preparers. The CEQ guidance calls for the use of EPA GHG Mandatory Reporting Rule (MRR) methodologies as a primary resource for calculating emissions. The NorthMet inventory includes most potential greenhouse gas sources that are quantifiable as a practical matter, so using MRR methodologies would not add additional sources to the inventory. Also, established procedures were used in the calculations where available, or procedures were developed based on scientific principles, such that using the specific calculations procedures in the MRR would not be expected to produce a significantly different result. Attachment A provides a comparison of the emission factors referenced in the CEQ guidance to those used in the 2009 report for stationary combustion sources. $CO_2$ emission factors differ by less than 5%. There are some larger differences for $N_2O$ and $CH_4$ factors, but these gasses combined make of less than one percent of the total GHG emissions as $CO_2$ - equivalents in the 2009 report. PolyMet and Barr will propose what we conclude are the most appropriate emission factors when the updated NorthMet emission inventory is submitted along with a justification for the factors selected. Emission factors can be adjusted as requested by the co-lead agencies, but we do not believe that it is necessary to perform multiple, parallel sets of calculations and such an approach may make the calculations more confusing. We understand that there is consensus on this approach in the Air IAP Group.

- In addition to annual emissions, the CEQ guidance recommends quantifying emissions over the life of the project. This calculation can be added to the updated report, with a minimal amount of effort, if the lead agencies feel it would be useful.

Consideration of current or projected effects of climate change on proposals for agency action

- CEQ guidance identifies the need for an evaluation of climate change impacts that may affect the design of the proposed action and alternatives. The 2009 NorthMet report does not directly address this issue, therefore, the proposed path forward is to incorporate text with a qualitative discussion of the potential affect of climate change on the project and a reference to any specific impact assessments where the potential effects of climate change were considered (one potential example would be water management strategies to address the potential for extreme precipitation events). The co-lead agencies will determine for which impact analyses potential climate affects should be considered and the level of detail needed in those analyses to aid in the preparation of

the SDEIS. It is the opinion of PolyMet and Barr that the NorthMet project would not be nearly as subject to the affects of climate changes as the example in the guidance of a project that would be especially vulnerable, which is the long term development of transportation infrastructure on a coastal barrier island (pg. 7, third full paragraph). The NorthMet project design is intended to be able to adaptively account for longer term variations such as climate change effects.

- CEQ guidance includes a discussion of adaptation to the affects of climate change. The 2009 NorthMet report does not directly address this issue. A discussion of this topic could be added to the updated report and/or the SDEIS as needed. The co-lead agencies will be determining if any additional consideration of climate change affects is needed for specific impact analyses to aid in the preparation of the SDEIS.

# Table 1 Comparison of CEQ and MPCA/DNR Guidance

| | 2009 DEIS Report (MDNR/MPCA guidance) | CEQ Guidance | Suggested Action/Rationale |
|---|---|---|---|
| | **General** | **General** | |
| Threshold | Assessment required for projects that must obtain both an air emissions permit and complete environmental review, so analysis is required for NorthMet. | "Meaningful emissions": > 25,000 Mton $CO_2$-e/yr per EPA GHG MRR or with notable long term emissions. NorthMet emissions > 25,000 Mton $CO_2$-e/yr. | No change: Facility emissions are > 25,000 Mton $CO_2$-e/yr, so decision to evaluate is consistent with CEQ guidance. |
| Significance | No assessment of whether or not the GHG emissions from the project or the potential contribution to climate change is "significant" | CEQ guidance specifically avoids setting significance thresholds for GHGs/climate change. Guidance indicates that evaluation of significance should be based on categorization of action in agency NEPA procedures and action-specific analysis of the context and intensity of the environmental impacts; guideline of 25,000 Mton CO2-e/yr $CO_2$-e is referenced as "meaningful" as noted above and is not, according to CEQ guidance, intended to be a measure of significance. | No change: No action is being suggested at this time as an appropriate framework for assessing significance has not been identified. However, we are open to input from lead agencies if they have developed a procedure for the evaluation of significance based on categorization of action in agency NEPA procedures and action-specific analysis of the context and intensity of the environmental impacts |
| | **Carbon Footprint development: operation emissions** | **Consideration of the effects of a proposed agency action on GHG emissions** | |
| Greenhouse Gases Considered | CO2, CH4, N2O HFCs, PFCs, SF6 | CO2, CH4, N2O HFCs, PFCs, SF6 | No change: 2009 report approach matches CEQ guidance. |
| Direct Emissions considered: | See detailed breakdown below | Annual direct emissions, cumulative emissions over the life of the project, all phases and elements of the proposed action, note emissions under EPA GHG MRR | 1) Emission factors can be adjusted as requested by the lead agencies. However, we would like to reach a consensus in identifying one set of appropriate emission factors as we believe that developing multiple sets of calculations with different emission factors will cause confusion.<br>2)Provide an assessment of cumulative emissions over the life of the project: This is consistent with CEQ guidance<br>3) Include a qualitative discussion of construction and closure emissions: The CEQ guidance does not provide a clear path forward, but could be interpreted to mean that construction and closure phases should be included in the analysis. A qualitative assessment is proposed because the specifics that would be needed for a reliable quantitative assessment (equipment types, exact fuel usage, energy usage, etc.) are difficult to accurately project. Furthermore these emissions are likely to be small in comparison to operation emissions, so a qualitative discussion of the affects of these phases on the overall project carbon footprint to the updated report and possibly the SDEIS is appropriate. The air IAP group was not able to reach consensus on this topic, so the co-lead agencies will be asked to provide input. |
| Combustion | Onsite stationary and mobile sources during operation | | |
| Process | Onsite process emissions during operation | | |
| Terrestrial | Onsite emissions and changes to sequestration capacity from disturbance of vegetation and soils (including excavation, drainage, vegetation removal etc.) throughout construction and operation | | |
| Indirect Emissions Considered | Indirect emissions associated with purchased electricity | Bounded by "limits of feasibility" | No change: Indirect emissions associated with purchased electricity arguably represent "limits of feasibility" for this project. Emission calculation for power generation will be updated to reflect latest data available on the website referenced by MPCA. |
| Guidance Documents | TCR, WRI, IPCC, MPCA, NCASI, EPA, CCAR, professional Judgment | EPA GHG MRR, EO 13514 5(a) and 9(b) (federal facilities), DOE technical guidelines 1605(b) (terrestrial) | See comparison in Attachment A. Differences for $CO_2$, which accounts for >99% of total $CO_2$-e, are less than 5%. Where $N_20$ factors differ significantly, the values in the 2009 report tend to be higher. There is consensus in the Air IAP group that a single emission inventory for GHG is preferable. PolyMet and Barr will propose emission factors in the updated NorthMet emission inventory along with a technical and/or regulatory rationale for the emission factors selected. |
| | **Energy and Efficiency Analysis** | **Consideration of the effects of a proposed agency action on GHG emissions** | |
| GHG reduction/mitigation considerations | Evaluation of process choices to reduce emissions | Discuss measures to reduce GHG emissions including consideration of "reasonable alternatives". Evaluate GHG emission associated with Energy use and mitigation opportunities to compare between reasonable alternatives. | No change: 2009 report approach matches intent of CEQ guidance. |
| | Evaluation of equipment choices to reduce emissions | | |
| | Evaluation of energy provider | | |
| | Evaluation of fuel alternatives | | |
| | Mitigation options beyond energy efficiency | | |
| | **Effects of a proposed action on Climate Change** | **Effects of a proposed action on Climate Change** | |
| Approach to address project impacts on climate change | Generally, at the individual project level, it is not currently useful for the analysis to attempt to link specific climatological changes or the environmental impacts thereof to the particular project or emissions as such direct linkage is difficult to isolate and to understand | | No change: 2009 report approach matches CEQ guidance. |
| | Overview of climate change science/background | Qualitatively discuss the link between GHG emissions and climate change | No change: 2009 report approach matches CEQ guidance. |
| | Overview of climate change/GHG policy/regulatory framework | | No change: 2009 report approach matches CEQ guidance. *NOTE: An additional section (beyond scope of CEQ guidance) will be added associated with the regulatory developments in GHG permitting (e.g. PSD and Title V) along with references to other relevant project reports concerning regulatory applicability and any additional analysis required by permitting regulations (e.g. BACT controls if applicable).* |

## Table 1 Comparison of CEQ and MPCA/DNR Guidance (Continued)

| | 2009 DEIS Report (MDNR/MPCA guidance) | CEQ Guidance | Suggested Action/Rationale |
|---|---|---|---|
| | **Climate Change Evaluation** | **Consideration of current or projected effects of climate change on proposals for agency action** | |
| Applicability and extent of analysis | Determined via agency input | Determined using NEPA's "rule of reason" | No change: 2009 report approach seems to match spirit of CEQ guidance. |
| Overview of climate change considerations | Overview of projected climate change | Describe the observed and projected effects of climate change as part of the current and future state of the proposed action's affected environment (globalchange.gov) | No change: 2009 report approach seems to match CEQ guidance. |
| Climate change impacts on project and project related resources | Overlapping Impacts on Resources: climate change and project impacts | Discuss aspects of the environment affected by the proposed action and the nexus of those effects with projected climate change | No change: 2009 report approach seems to match spirit of CEQ guidance. |
| | | Relationship of climate change effects to proposed action and alternatives design (particularly projects designed for long term utility and located in areas that are considered vulnerable to specific effects of climate change) | Proposed approach would incorporate text with a qualitative discussion of the potential affect of climate change on the project and a reference to any specific impact assessments where the potential effects of climate change were considered (e.g. water management strategies to address the potential for extreme precipitation events). [1] |
| | | Adaptation to the affects of climate change if important and adoption of a monitoring program | |

[1] The co-lead agencies will determine for which analyses potential climate affects should be considered and the level of detail needed in those analyses to aid in the preparation of the SDEIS.

## References

Reference 1 Barr Engineering Company. NorthMet Project Greenhouse Gas and Climate Change Evaluation Report. June 2009.

Attachment A
NorthMet Project
Comparison of Emission Factors from 2009 Report to EPA Mandatory Reporting Rule (MRR)
24-Mar-11

Combustion Sources

| | In Report Units | | | Conversion Factor | | | In MRR Units | | | | | Comparison |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollutant | 2009 Report Factor | Units | Source | High Heat Value | Units | Source | Report Factor | Units | MRR Factor | Units | Source [2] | % Difference |
| Natural Gas | | | | | | | | | | | | |
| CO2 | 53171 | kg/MMCf | [100] | 1011 | MMBtu/MMscf | MPCA | 52.59 | kg/MMBtu | 53.02 | kg/MMBtu | Table C-1 | 0.8% |
| N2O | 0.92 | kg/MMCf | [101] | 1011 | MMBtu/MMscf | MPCA | 0.001 | kg/MMBtu | 1.0E-04 | kg/MMBtu | Table C-2 | -810.0% |
| CH4 | 0.92 | kg/MMCf | [101] | 1011 | MMBtu/MMscf | MPCA | 0.001 | kg/MMBtu | 1.0E-03 | kg/MMBtu | Table C-2 | 9.0% |
| No. 2 Oil (generators) | | | | | | | | | | | | |
| CO2 | 72.37 | kg/MMBtu | [102] | NA | NA | NA | 72.37 | kg/MMBtu | 73.96 | kg/MMBtu | Table C-1 | 2.1% |
| N2O | NA | NA | NA | NA | NA | NA | NA | NA | 6.0E-04 | kg/MMBtu | Table C-2 | NA |
| CH4 | NA | NA | NA | NA | NA | NA | NA | NA | 3.0E-03 | kg/MMBtu | Table C-2 | NA |
| No. 6 Oil (heaters) [1] | | | | | | | | | | | | |
| CO2 | 10034 | kg/Mgal | [105] | 140 | MMBtu/Mgal | AP-42 | 71.67 | kg/MMBtu | 73.96 | kg/MMBtu | Table C-1 | 3.1% |
| N2O | 0.042 | kg/Mgal | [109] | 140 | MMBtu/Mgal | AP-42 | 0.0003 | kg/MMBtu | 6.0E-04 | kg/MMBtu | Table C-2 | 50.0% |
| CH4 | 0.42 | kg/Mgal | [104] | 140 | MMBtu/Mgal | AP-42 | 0.0030 | kg/MMBtu | 3.0E-03 | kg/MMBtu | Table C-2 | 0.0% |
| Propane | | | | | | | | | | | | |
| CO2 | 5740 | kg/Mgal | [106] | 91.5 | MMBtu/Mgal | AP-42 | 62.73 | kg/MMBtu | 61.46 | kg/MMBtu | Table C-1 | -2.1% |
| N2O | 0.37 | kg/Mgal | [106] | 91.5 | MMBtu/Mgal | AP-42 | 0.0040 | kg/MMBtu | 6.0E-04 | kg/MMBtu | Table C-2 | -574.0% |
| CH4 | 0.08 | kg/Mgal | [106] | 91.5 | MMBtu/Mgal | AP-42 | 0.0009 | kg/MMBtu | 3.0E-03 | kg/MMBtu | Table C-2 | 70.9% |

[1] The residual oil fired heaters are no longer part of the proposed project.
[2] From 40 CFR Part 98 Subpart C
[100] MPCA General Guidance for Carbon Footprint Development in Environmental Review, Table 4, Natural Gas
[101] Emission factors from Table 12.7 of The Climate Registry's General Reporting Protocol, May 2008. Converted from g/MMBtu to kg/MMCF by multiplying by the AP-42 factor of 1020 MMBtu/MMscf for natural gas and 1000 g/kg.
[102] Emission factors taken from MPCA General Guidance for Carbon Footprint Development in Environmental Review, Table 4, Diesel Fuel. Converted from lb/MMBtu to kg/MMBtu by multiplying by a factor of 0.45359.
[105] Emission factor taken from MPCA General Guidance for Carbon Footprint Development in Environmental Review, Table 4, Fuel Oil no. 1-2.
[109] Emission factors from The Climate Registry's General Reporting Protocol Table 12.7, Residual Fuel Oil Boilers. Converted to kg/Mgal using 140 MMBtu/Mgal and 1000 g/kg.
[104] Emission factors from Table 12.7 of The Climate Registry's General Reporting Protocol, May 2008. Converted from g/MMBtu to kg/Mgal by multiplying by the AP-42 factor of 140 MMBtu/Mgal for distillate oil and 1000 g/kg.
[106] Emission factors taken from the Climate Registry General Reporting Protocol (Version 1.1) Table 12.1.

## Lisa A. Ungar

**From:** Baumann, Suzanne (MPCA) <Suzanne.Baumann@state.mn.us>
**Sent:** Wednesday, November 09, 2011 2:01 PM
**To:** Pat Sheehy
**Subject:** FW: Reviewed responses to comments: PolyMet Climate Change Scope

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**From:** Joy Wiecks [mailto:JoyWiecks@FDLREZ.COM]
**Sent:** Wednesday, November 09, 2011 12:17 PM
**To:** Baumann, Suzanne (MPCA)
**Subject:** RE: Reviewed responses to comments: PolyMet Climate Change Scope

Hi Suzanne,

I think the response addresses our concerns sufficiently that we can move ahead.

-Joy

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**From:** Baumann, Suzanne (MPCA) [mailto:Suzanne.Baumann@state.mn.us]
**Sent:** Tuesday, November 08, 2011 8:46 AM
**To:** Joy Wiecks; Alexander Jackson; Nancy Schuldt
**Cc:** 'Pat Sheehy'
**Subject:** FW: Reviewed responses to comments: PolyMet Climate Change Scope

Joy, Alex and Nancy:

Just a follow up regarding my message below. Please let me know ASAP whether your comment has been addressed sufficiently by Barr/PolyMet's response.

Thanks,
Suzanne

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**From:** Baumann, Suzanne (MPCA)
**Sent:** Wednesday, October 26, 2011 4:50 PM
**To:** "Joy Wiecks'; 'nancyschuldt@FDLREZ.COM'; 'Alexander Jackson'
**Cc:** 'Thomas A Hale'; Johnson, Bill H (DNR); Arkley, Stuart (DNR); 'Kevin Pylka'; 'Deb McGovern'; Baumann, Suzanne (MPCA); Foss, Ann (MPCA); 'Pat Sheehy'; 'Danny Kringel'; 'jscott@polymetmining.com'; Westlake.Kenneth@epamail.epa.gov; 'manoyan.simon@epa.gov'; 'Kevin Pylka'; 'Pat Sheehy'; 'Yvette'; 'Joy Wiecks (joywiecks@fdlrez.com)'; cain.alexis@epamail.epa.gov; 'Deb McGovern'; Foss, Ann (MPCA); Arkley, Stuart (DNR); Johnson, Bill H (DNR); Seelen, Sarah (MPCA); Ciborowski, Peter (MPCA); "Joy Wiecks'; 'Alexander Jackson'; 'Louise I. Segroves'; Hulting.Melissa@epamail.epa.gov; Ciborowski, Peter (MPCA); Hulting.Melissa@epamail.epa.gov; Nash.Carlton@epamail.epa.gov
**Subject:** Reviewed responses to comments: PolyMet Climate Change Scope

Joy, Alex and Nancy:

This message is a follow up to the commenter's review of the response to comments received to date on the **PolyMet Climate Change Report Scope.** I am seeking your feedback regarding the resolution of the final comment on the document.

As a reminder, your comment to Barr/PolyMet's response was:

> The Luyssaert document was provided as an example of how to quantify carbon sequestration, and was not intended to be used literally. The fact remains that the project as proposed will disturb peat lands plus 250-300 acres of upland, mature forest. The oldest forest contains 40-80 year old trees, and the loss of carbon sequestration from these trees needs to be quantified. Also, only a small bit of the wetlands lost are to be mitigated on-site, and not for another 20 years, resulting in the loss of 20 years of sequestration. Likewise, the Cagampan and Stack document is not intended to be used as a template, but as an example of how a more holistic accounting could be accomplished to include broad estimates and calculations for different biomes.

In turn, earlier today Barr/PolyMet provided the following response and asked me to share it with you:

> After reviewing the final responses, in my opinion, we have sufficient agreement on the scope of the Climate Change Report to proceed with preparation of the report. Please note that we intend to quantify changes to carbon sequestration capacity and carbon loss due to land use changes. This was done for the construction and operation phases of the project in the report prepared for the Draft Environmental Impact Statement. As requested, the assessment of carbon footprint will be extended to the closure phase of the project, so that the net effect of any additional carbon loss or changes to sequestration capacity during this phase will be evaluated. The references provided by the commenters along with other published literature and scientific principles as appropriate will be considered in this analysis.

**If possible, please let me know by the end of the day on Friday, November 4, 2011, whether your comment has been addressed sufficiently by Barr/PolyMet's response above.** If so, the next step will be for Barr/PolyMet to generate the report scoped per this workplan.

As always, please give me a call if you have any questions or concerns.

Thanks,
Suzanne

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**From:** Baumann, Suzanne (MPCA)
**Sent:** Monday, October 17, 2011 4:38 PM
**To:** Baumann, Suzanne (MPCA); 'Pat Sheehy'
**Cc:** 'Thomas A Hale'; Johnson, Bill H (DNR); Arkley, Stuart (DNR); 'Kevin Pylka'; 'Deb McGovern'; Foss, Ann (MPCA); 'Danny Kringel'; 'jscott@polymetmining.com'; Westlake.Kenneth@epamail.epa.gov; 'manoyan.simon@epa.gov'; 'Kevin Pylka'; 'Pat Sheehy'; 'Yvette'; 'Joy Wiecks (joywiecks@fdlrez.com)'; cain.alexis@epamail.epa.gov; 'Deb McGovern'; Foss, Ann (MPCA); Arkley, Stuart (DNR); Johnson, Bill H (DNR); Seelen, Sarah (MPCA); Ciborowski, Peter (MPCA); ''Joy Wiecks'; 'Alexander Jackson'; 'Louise I. Segroves'; Hulting.Melissa@epamail.epa.gov; Ciborowski, Peter (MPCA); Hulting.Melissa@epamail.epa.gov; Nash.Carlton@epamail.epa.gov
**Subject:** Reviewed responses to comments: PolyMet Climate Change Scope

Pat:

Attached are the amended commenter's review of the response to comments received to date on the **PolyMet Climate Change Report Scope.** This version contains Fond du Lac's responses.

Please let me know if it would be useful to set up a call to discuss any of the responses in detail.

Thanks,
Suzanne

**From:** Baumann, Suzanne (MPCA)
**Sent:** Friday, October 07, 2011 10:38 AM
**To:** 'Pat Sheehy'
**Cc:** 'Thomas A Hale'; Johnson, Bill H (DNR); Arkley, Stuart (DNR); 'Kevin Pylka'; 'Deb McGovern'; Foss, Ann (MPCA); 'Danny Kringel'; 'jscott@polymetmining.com'; 'Westlake.Kenneth@epamail.epa.gov'; 'manoyan.simon@epa.gov'; Baumann, Suzanne (MPCA); 'Kevin Pylka'; 'Pat Sheehy'; 'Yvette'; 'Joy Wiecks (joywiecks@fdlrez.com)'; 'cain.alexis@epamail.epa.gov'; 'Deb McGovern'; Foss, Ann (MPCA); Arkley, Stuart (DNR); Johnson, Bill H (DNR); Seelen, Sarah (MPCA); Ciborowski, Peter (MPCA); "Joy Wiecks'; 'Alexander Jackson'; 'Louise I. Segroves'; 'Hulting.Melissa@epamail.epa.gov'; Ciborowski, Peter (MPCA); 'Hulting.Melissa@epamail.epa.gov'; 'Nash.Carlton@epamail.epa.gov'
**Subject:** Reviewed responses to comments: PolyMet Climate Change Scope

Pat:

Attached are the commenter's review of the response to comments received to date on the **PolyMet Climate Change Report Scope**. In summary, EPA felt that their comments were adequately addressed. As you heard on the call yesterday, Fond du Lac is planning on submitting responses as well. I will incorporate those as soon as I receive them.

As always give me a call to discuss if you wish.

Thanks,
Suzanne

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**From:** Baumann, Suzanne (MPCA)
**Sent:** Tuesday, September 20, 2011 4:08 PM
**To:** Baumann, Suzanne (MPCA); 'Kevin Pylka'; 'Pat Sheehy'; 'Yvette'; 'Joy Wiecks (joywiecks@fdlrez.com)'; 'Deb McGovern'; Foss, Ann (MPCA); Arkley, Stuart (DNR); Johnson, Bill H (DNR); Seelen, Sarah (MPCA); Ciborowski, Peter (MPCA); "Joy Wiecks'; 'Alexander Jackson'; 'Louise I. Segroves'; Hulting.Melissa@epamail.epa.gov; Ciborowski, Peter (MPCA); Hulting.Melissa@epamail.epa.gov; 'nash.carlton@epamail.com'
**Cc:** 'Thomas A Hale'; Johnson, Bill H (DNR); Arkley, Stuart (DNR); 'Kevin Pylka'; 'Pat Sheehy'; 'Deb McGovern'; Foss, Ann (MPCA); 'Danny Kringel'; 'jscott@polymetmining.com'; Westlake.Kenneth@epamail.epa.gov; 'manoyan.simon@epa.gov'
**Subject:** Please review responses to comments: PolyMet Climate Change Scope

All:

Attached for your review are Barr/PolyMet's response to comments on **PolyMet Climate Change Report Scope.** Also, Barr/PolyMet incorporated the discussion from the conference call on 9/1/11 into the responses. Commenters on the document were Joy and Alex from Fond du Lac and Melissa Hulting from EPA.

**So, please review PolyMet/Barr's responses to your comments by the end of the day on Tuesday, October 4, 2011**. I've added a column to the attached spreadsheet to insert your comments into.

In particular, please let me know if:

1) the response adequately addresses your comment,
2) the response is technically correct, but need to be reworded, or
3) the response does not adequately address your comment, why, and if it would be useful to meet to discuss.

As always, thank you for your continued cooperation! If there is something that I can do to assist, please let me know.

Thanks,
Suzanne

**From:** Baumann, Suzanne (MPCA)
**Sent:** Wednesday, August 10, 2011 4:35 PM
**To:** Baumann, Suzanne (MPCA); 'Kevin Pylka'; 'Pat Sheehy'; 'Yvette'; 'Joy Wiecks (joywiecks@fdlrez.com)'; 'Deb McGovern'; Foss, Ann (MPCA); Arkley, Stuart (DNR); Johnson, Bill H (DNR); Seelen, Sarah (MPCA); Ciborowski, Peter (MPCA); ''Joy Wiecks'; 'Alexander Jackson'; 'Louise I. Segroves'; Hulting.Melissa@epamail.epa.gov; Ciborowski, Peter (MPCA); Hulting.Melissa@epamail.epa.gov
**Cc:** 'Thomas A Hale'; Johnson, Bill H (DNR); Arkley, Stuart (DNR); 'Kevin Pylka'; 'Pat Sheehy'; 'Deb McGovern'; Foss, Ann (MPCA); 'Danny Kringel'; 'jscott@polymetmining.com'; Westlake.Kenneth@epamail.epa.gov; 'manoyan.simon@epa.gov'
**Subject:** Amended Compiled Comments: PolyMet Climate Change Scope

All:

Attached are amended compiled comments on the proposed **PolyMet Climate Change Report Scope.** Thank you to everyone who provided comments!

As a reminder, in early March 2011 PolyMet/Barr proposed the scope of its planned updated carbon footprint analysis for the SDEIS. The Air IAP greenhouse gas subteam met to discuss the proposal, the document was revised by PolyMet/Barr, and redistributed to the group for comments. Comments were received by Fond du Lac on the document. The MPCA and DNR did not have comments on the revised document.

Since that time, EPA was asked to review the document to ensure that the proposal will meet national environmental review requirements. Please note that because the CEQ guidance still draft, EPA's comments represent its interpretation on how the current draft CEQ guidance should be applied.

The attached, amended comments include all comments received on the proposed PolyMet Climate Change Report Scope to date.

As always, please let me know if you have any questions or concerns.

Suzanne

**POLYMET SDEIS COMPILED COMMENTS**

Report Name: **Overview of CEQ Draft NEPA Guidance on Climate Change and Greenhouse Gas Emissions and Comparison to NorthMet DEIS Carbon Footprint Assessment and Climate Change Evaluation,** April 1, 2011
Date Compiled: April 28, 2011
Compiled by: Suzanne Baumann
Comments by: Fond du Lac

| Comment ID | Initials | Chapter | Page | Para/Sentence | Comment | PolyMet/Barr Response | Commenters Review of Response |
|---|---|---|---|---|---|---|---|
| 00001 | Fond du Lac | | | | FdL believes that quantitative analyses of all direct and indirect emissions of GHG's from the construction and closure phases of the project should be conducted. These are important parts of the whole and we feel that a GHG analysis of the project would not address "cumulative emissions over the life of the project, all phases and elements of the proposed action" without them. Furthermore, the types of equipment needed for these phases of the project are probably already in the project's business plan or can be estimated from use in other projects. Estimates can be made as long as the underlying assumptions are explained. Even if the specific type of equipment isn't known, an order of magnitude assessment can still be made. | Construction and closure emissions can be included in the final report, with the caveat that these emissions will be an estimate with more limited accuracy than the calculated emissions for operation. Assumptions required to complete the calculations along with a qualitative discussion of potential sources of error will be included in the updated report. Please note that emissions from terrestrial sources and changes in sequestration capacity calculated in the previous report included the construction phase of the project and that additional emissions not previously evaluated for the construction and closure phases are expected to be small compared to emissions within the scope of the previous report. | OK. |
| 00002 | Fond du Lac | | | | FdL offers the attached, updated, peer-reviewed information on the amount of carbon sequestration lost by the destruction of peat bogs. This information is more up-to-date with the current state-of-the-science than the information used in the original analysis, and paints a clearer picture of the contribution of this project to global climate change. It is important to recognize that while peat slowly accumulates and sequesters substantial amounts of carbon, it rapidly releases carbon to the atmosphere when it is disturbed (i.e., excavated or drained). This carbon release from peat has been quantified, and should be accounted for in the inventory of emissions related to project construction. | We have reviewed the references provided, but we do not think that they indicate the need to alter the analysis conducted in the previous report. However, the inclusion of post closure emissions may result in the need for additional assessment for which referenced documents may be considered. A brief discussion of the individual references is provided below; a more detailed assessment can be provided upon request. Luyssaert et al. (2008) - we were not sure how this reference relates to peat bogs, it seems to discuss old growth forest. In our opinion, the timber located within the project boundary is not old growth forest and this reference is not relevant. If we have misunderstood the purpose of providing this reference, please let us know. Bridgham et al. (2006) - we were already aware of this publication and in fact referenced it in the previous report (see NorthMet Project Greenhouse Gas and Climate Change Evaluation Report, June 2009, Appendix A, page 56). Cagampan and Stack (2008) - we do not agree that this document reflects peer-reviewed information; it appears to be simply a literature revue conducted by a graduate student. Disregarding that, the most relevant paper cited, in our opinion, is Cleary, J., Roulet, N.T., Moore, T.R. 2005. "Greenhouse Gas Emissions from Canadian Peat Extraction, 1990-2000: A Life-cycle Analysis". Ambio 34:456-461 (Cleary et al). This paper estimates a rate of carbon loss from drained and disturbed peat bogs of 278 gram carbon per meter squared per year. The 2009 NorthMet report assumed a value of 500 g $C/m^2$/year, for disturbed but not excavated wetlands, almost twice as high. Cleary et al also discuss emissions from peat decomposition during end use of the material. The information in this reference may be used, possibly along with other references, in the estimation of post closure emissions, which will be added to the updated report. | The Luyssaert document was provided as an example of how to quantify carbon sequestration, and was not intended to be used literally. The fact remains that the project as proposed will disturb peat lands plus 250-300 acres of upland, mature forest. The oldest forest contains 40-80 year old trees, and the loss of carbon sequestration from these trees needs to be quantified. Also, only a small bit of the wetlands lost are to be mitigated on-site, and not for another 20 years, resulting in the loss of 20 years of sequestration. Likewise, the Cagampan and Stack document is not intended to be used as a template, but as an example of how a more holistic accounting could be accomplished to include broad estimates and calculations for different biomes. |
| 00003 | Fond du Lac | | | | Please include a section that summarizes comments made on the original GHG analysis from the DEIS and how the SDEIS has been changed to incorporate those comments. | In our opinion, a global decision should be made by the lead agencies and/or the air workgroup on whether or not this type of analysis should be included with the impact assessment reports (it has not been included other reports to date). PolyMet and Barr only have the summary of DEIS comments prepared by ERM and it is not solely the responsibility of the project proposer to respond to comments on the DEIS. In some cases, regulatory agencies have considered the DEIS public comments in their comments on draft documents. Our inclination is that this may be a better approach in that it allows for the agencies to determine which specific comments merit changes in the impact assessment. | OK. |
| 00004 | Fond du Lac | | | | Please list any GHG sources that were not analyzed due to not being "quantifiable as a practical matter" so that the lead agencies can decide if any of these need to be included. | Based on the CEQ guidance sources of GHG emissions that are meaningful to a reasoned decision have been identified and will be calculated for the FEIS. At this time we have not identified any specific sources within the scope of the analysis, for which emissions are not "quantifiable as a practical manner", but if any such sources are identified they will be listed in the report. | OK. |

| Comment ID | Initials | Chapter | Page | Para/Sentence | Comment | PolyMet/Barr Response | Commenters Review of Response |
|---|---|---|---|---|---|---|---|
| 00005 | Fond du Lac | | | | FdL believes that quantifying emissions over the life of the project (in addition to annual emissions) would be useful, as per page 4, an encourages the lead agencies to request this information. | Construction and closure emissions can be included in the final report, with the caveat that these emissions will be an estimate with more limited accuracy than the calculated emissions for operation. See response to comment 00001 for additional information. | OK. |
| 00006 | Fond du Lac | | | | FdL air staff is unable to comment on the adequacy of the analyses being performed for other areas of the project where climate change affects may come into play. We urge co-leads to seek input from the workgroups studying the impacts of the project to other media, specifically water and wetlands. | As indicated in the Overview of CEQ Draft NEPA Guidance on Climate Change and Greenhouse Gas Emissions and Comparison to NorthMet DEIS Carbon Footprint Assessment and Climate Change Evaluation Memo, dated April 1, 2011, impacts of climate change on other resource areas critical to the project will be addressed by the workgroups associated with these resource areas. The updated report will note if other work groups are addressing the affects of climate change at the time of publication, but the scoping, undertaking and reporting of any additional analysis will be handled by the other workgroups and documented in other reports. | Agreed. |
| 00007 | Fond du Lac | | | | A warmer climate will lead to increases in ozone concentration. Since the EPA will be releasing stricter ozone standards in the future, this should be mentioned as a potential issue. | This topic will be mentioned as a potential issue in the final report including information on the latest developments for the ozone NAAQS. | Agreed. |
| 00008 | Fond du Lac | | | | FdL disagrees that having multiple sets of emission factors will be confusing. Emission factors could simply be footnoted to indicate from what source they were obtained. | As noted by the EPA commenter in comments 00012 and 00013, changing the emission factors would not change the results significantly and therefore would not change any conclusions drawn during this process, and the emission factors used in the previous report are reputable and comparable to the emission factors used in the GHG Reporting Rule. Therefore, the existing emission factors will be carried forward into the final inventory. Please note that emission factors for stationary source GHG emissions and the heavy mining and Tailings Basin construction equipment have been included in the Plant Site, Mine Site, and mobile source emissions inventories submitted to date. Our intention is to use the same emission factors for all analyses, with emission calculations for additional sources (e.g. terrestrial emission sources) included with the carbon footprint analysis. | OK. |
| 00009 | Fond du Lac | | | | The "Approach to address project impacts on climate change" and "Climate change impacts on project and project related values" items in Table 1 should be re-evaluated, as needed, in light of the updated peat bog information. | Please see response to comment 00002. | See our reply to comment 00002. |
| 00010 | Fond du Lac | | | | From Attachment A, the most credible and/or appropriate emission factors should be used, as decided by the co-leads. | As noted in the response to comment 8, the emission factors for stationary and some mobile sources have been included in the emission inventories submitted to date which have been made available for review and comment. The additional calculations needed for the carbon footprint analysis will be available for review and comment when the updated report is submitted. | OK. |
| 00011 | EPA | | | | Per the proposed CEQ guidance, the items that need to be included are:<br>1. GHG emissions over the life of the project<br>2. The impact of a changing climate on the project, including project design and environmental impacts.<br><br>These items are both addressed in a good level of detail. The guidance also directs agencies to discuss measures to reduce GHG emissions, including reasonable alternatives, and "qualitatively discuss the link between such GHG emissions and climate change". These are also both addressed in the climate change report. | Noted. | OK |
| 00012 | EPA | | | | Although the CEQ guidance suggests the use of calculations from the GHG Reporting Rule (formerly the Mandatory Reporting Rule), the sources used for the report are reputable and comparable to those used in the Rule. | Noted. | OK |
| 00013 | EPA | | | | Contrary to the memo from Barr Engineering, I do not think revising the estimates using different emission factors would be "confusing", but then again, I don't think changing the emission factors would change the results significantly and therefore would not change any conclusions drawn during this process. | Please see response to comment 00008. Our understanding was that is was generally agreed that having a single set of emission calculations used for all analyses was viewed as preferable by the air workgroup. As noted by the commenter, the choice of emissions factor among reasonable alternatives, is unlikely to significantly affect the results. | OK |

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| 00014 | EPA | | | | I don't think the calculation/section that relates the CO2 emissions from the project to an increase of 0.00002 to 0.0001 ppm in the atmosphere is reliable or required. The calculation is based on a ratio of historic anthropogenic emissions of GHGs to the corresponding increase in atmospheric GHGs, and then multiplies that ratio by the GHG emissions from the project. As far as I can tell, the ratio used does not take into account the fact that much of past anthropogenic emissions have been absorbed into sinks (particularly the ocean) and are not necessarily reflected in the atmospheric concentration of CO2. In addition, the CEQ guidance does not require such a quantitative estimate of the impact of the emissions. The emissions from the project are deemed significant since they are above 25,000 metric tons CO2E per year (the level provided in the guidance and the same threshold as used by the EPA GHG Reporting Program); I think it is acceptable to leave it at that. | The section relating GHG emissions from the project to a change in atmospheric GHG concentrations will be removed from the updated report. | OK |
| 00015 | EPA | | | | As to whether emissions from construction and closure phases should be included, per the guidance ("over the life of the project"), it would seem that they should be included. That being said, I would think that the emissions during the years of operation would outweigh the emissions from the construction and closure phases. | Construction and closure emissions can be included in the final report, with the caveat that these emissions will be an estimate with more limited accuracy than the calculated emissions for operation. See response to comment 00001 for additional information. | OK |
| 00016 | EPA | | | | In addition, the EIS should describe how clean diesel strategies could be used during construction and operation of the facility. | A discussion of clean diesel strategies that would potentially reduce GHG emissions and be relevant to construction and operation of the facility will be added to the updated report. | OK |
| 00017 | EPA | | | | Based on the estimated direct GHG emissions from this project of 235,648 metric tons of CO2E per year, this facility would be subject to GHG BACT via the NSR permitting process. It is my understanding from Suzanne Baumann at MPCA that they intend to take limits to become synthetic minor for both criteria pollutants and GHGs (though I will be curious to see the inventory upon which PSD applicability is based). The EIS should describe how they plan to restrict emissions to qualify as synthetic minor. In early July, I spoke with Jennifer Darrow here at R5 in permitting, who informed me that at that time there was not yet a draft air permit. | Please note that the latest inventory indicates potential CO2e emissions of about 190,000 tpy, but projected actual emissions of less than 70,000 tpy. Much of the project fuel consumption is for space heating and backup power. This results in a significant difference between potential and projected actual fuel combustion and GHG emissions and therefore with appropriate permit limits, the project can be permitted as a synthetic minor facility. PolyMet and MPCA are currently discussing additional information to be added to the emission inventory to provide support that the project can be permitted as a synthetic minor. | OK |
| 00018 | EPA | | | | Finally, the background information on climate change and GHG policy and regulation is definitely out of date given developments in the last 2 years. | The policy section will be updated to reflect the many developments that have occurred since the previous publication of the report. | OK |
| 00019 | EPA | | | | I think to comply with the proposed CEQ guidance that construction and closure emissions would have to be included and the policy section would have to be updated. The section relating GHG emissions from the project to a change in atmospheric GHG concentrations is not required by the CEQ guidance and could be removed—I'm not sure the approach given in the report is sound, nor needed. The proposed revised scope for the climate change report laid out in the memo from Barr regarding the CEQ guidance is, in general, acceptable. | Construction and closure emissions can be included in the final report, with the caveat that these emissions will be an estimate with more limited accuracy than the calculated emissions for operation. The policy section will be updated to reflect the many developments that have occurred since the previous publication of the report. The section relating GHG emissions from the project to a change in atmospheric GHG concentrations will be removed from the report. | OK |
| 00020 | EPA | | | | Finally, while the estimated GHG emissions from this project are sizable (and above the threshold deemed "significant" by the CEQ guidance), it seems that any concerns to the environment locally will be more focused on water quality impacts (which were also the focus of EPA's 2/18/10 comments on the draft EIS). | Noted. | OK |