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 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) 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 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: - operations continue 24 hours/day, 7 days/week, 365 days/year at the Plant (except for Tailings Basin construction activities, which are seasonal) - 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)). 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. 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. 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: - all chemicals have an additive effect - assumed all non-carcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects. - 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 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 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 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 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 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 Short-term, acute inhalation: breathing maximum 1 hour modeled air concentration of a chemical in ambient air 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 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) 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) 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 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) Plant-Site property ownership boundary	0.5	1	$3x10^{-6}$	$1x10^{-5}$
Multipathway Exposure 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 (Not a risk driver)
Arsenic Compounds	On MPCA list of Pollutant of Interest in terms of age adjustment	None (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 PPRTV documentation recommends against age adjustment for cobalt because the mutagenic mode of action has not been clearly established for cobalt (Reference (41))
Diesel Particulate Matter	Currently not evaluated as a carcinogen in the RASS.	None (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 (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 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 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 95th % 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. 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 NorthMet, Plant Site	Mercury Speciation	Comments
Scenario 1 (1)	25% elemental 50% oxidized 25% particle-bound	Conservative estimate for local deposition
Scenario 2 (1)	80% elemental 10% oxidized 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 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 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 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 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 Mine Site	X X	X X	X 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 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 -Exposure duration is 30 years for a resident and 40 years for a farmer -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

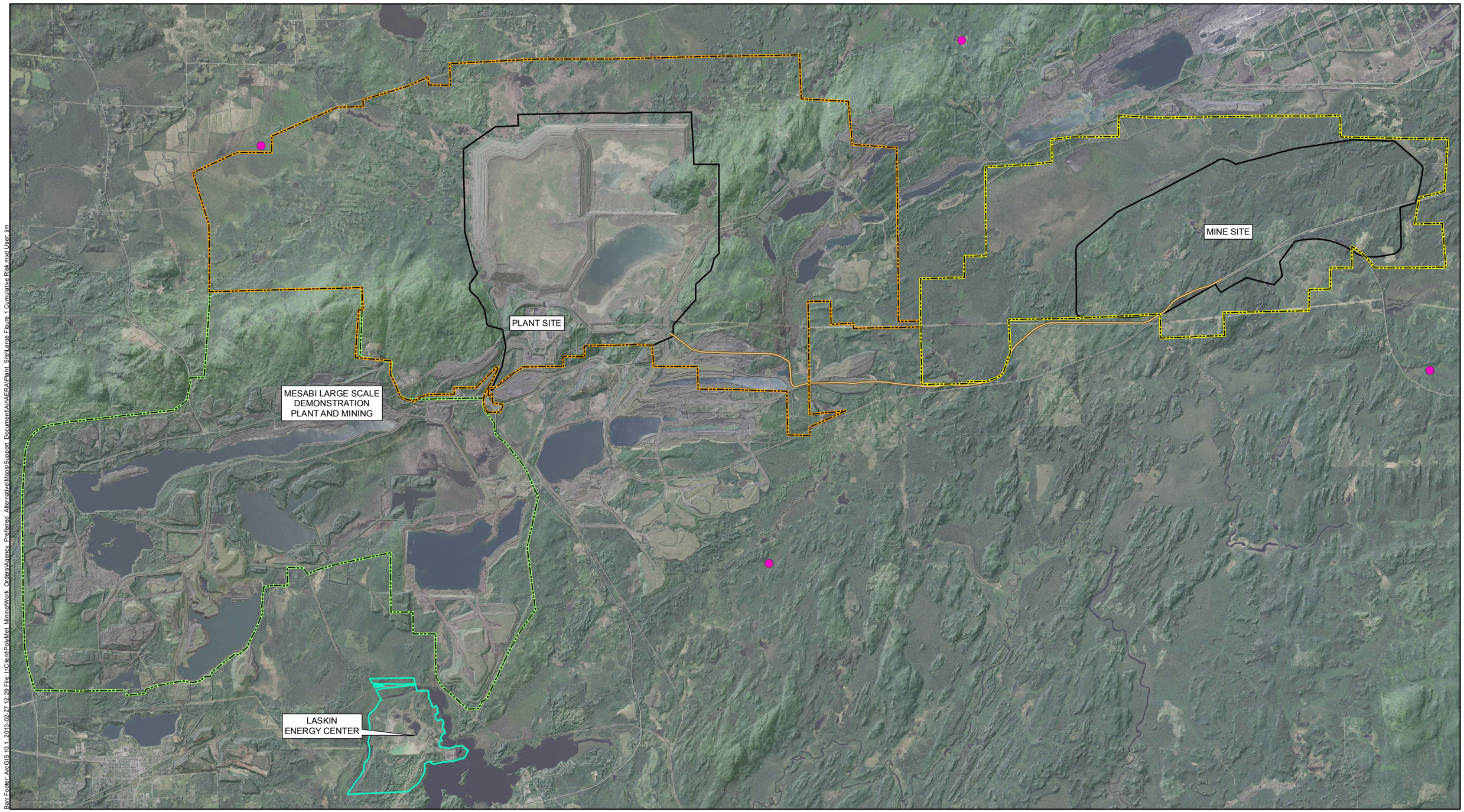
Pollutant	Time Period	Estimated Ambient Air Concentrations ($\mu g/m^3$)(2)	Minnesota Ambient Air Quality Standard ($\mu g/m^3$)	National Ambient Air Quality Standard ($\mu g/m^3$)	Ratio of Modeled Air Concentration to the Minnesota Ambient Air Standard	Ratio of Modeled Air Concentration to the Federal 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

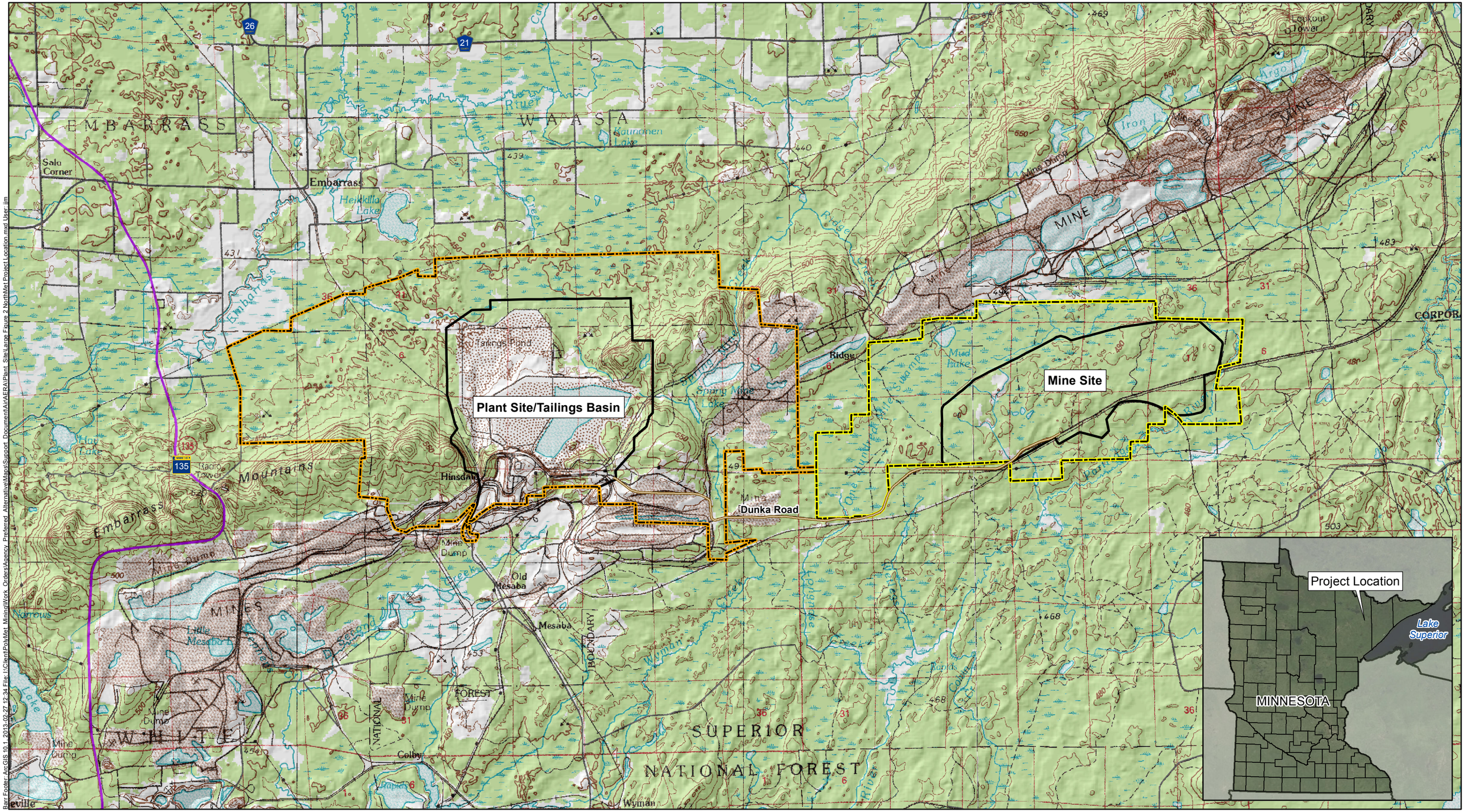
Receptors of Interest
Ambient Air Boundary - Mine Site
Ambient Air Boundary - Plant Site
Ambient Air Boundary - Mesabi Nugget
Laskin Energy Center - Approximate Boundary
Project Areas

N

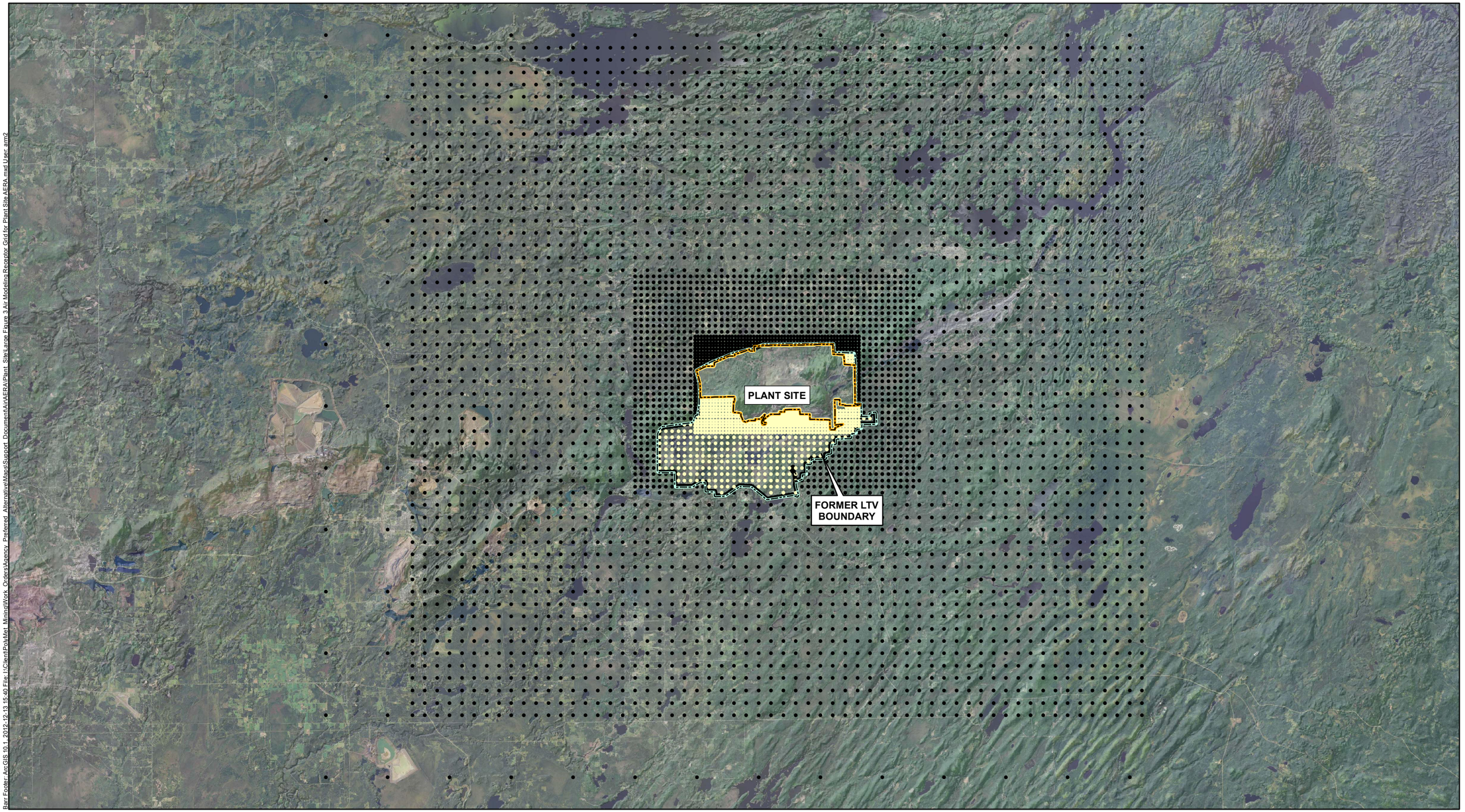
1 0.5 0 1

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



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

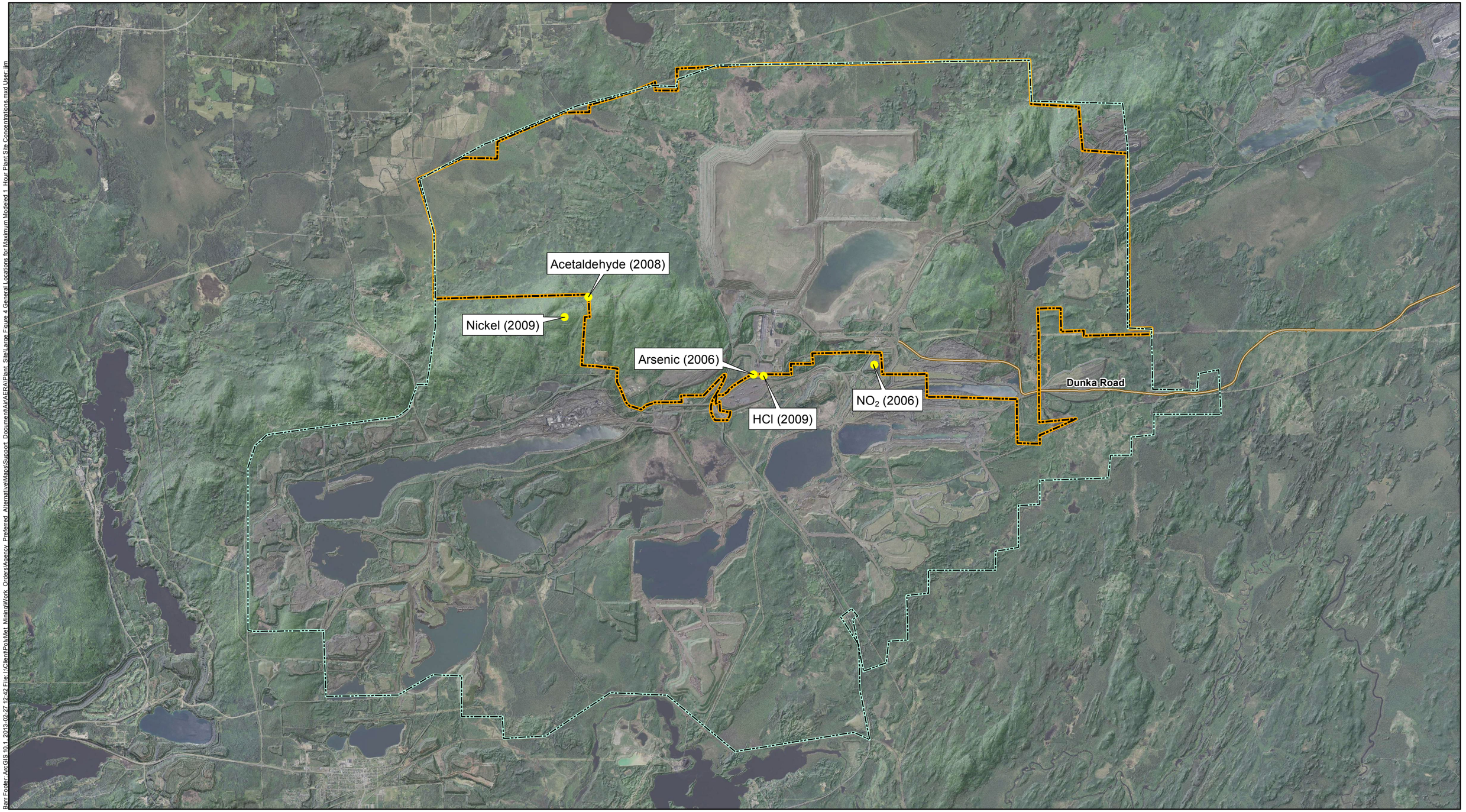
Note: All receptors shown are evaluated for Plant Site AERA Inhalation Risk.
Only those in black are evaluated for Plant Site AERA Multipathway Risk.

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

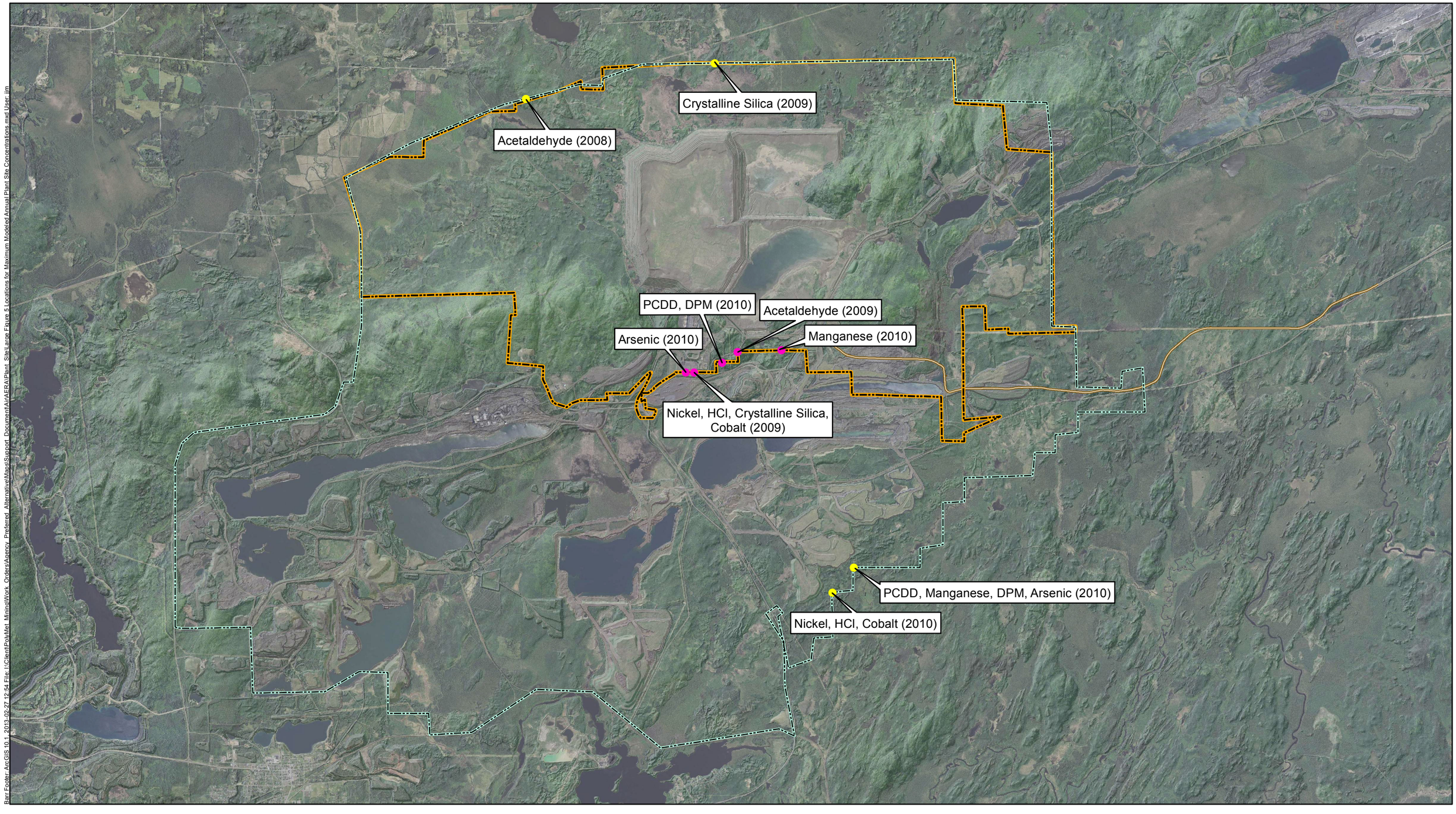
- Maximum 1-Hour Inhalation Concentration Receptors
- Ambient Air Boundary - LTVSMC (Multipathway Risk)
- Ambient Air Boundary - Plant Site (Inhalation Risk)

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*

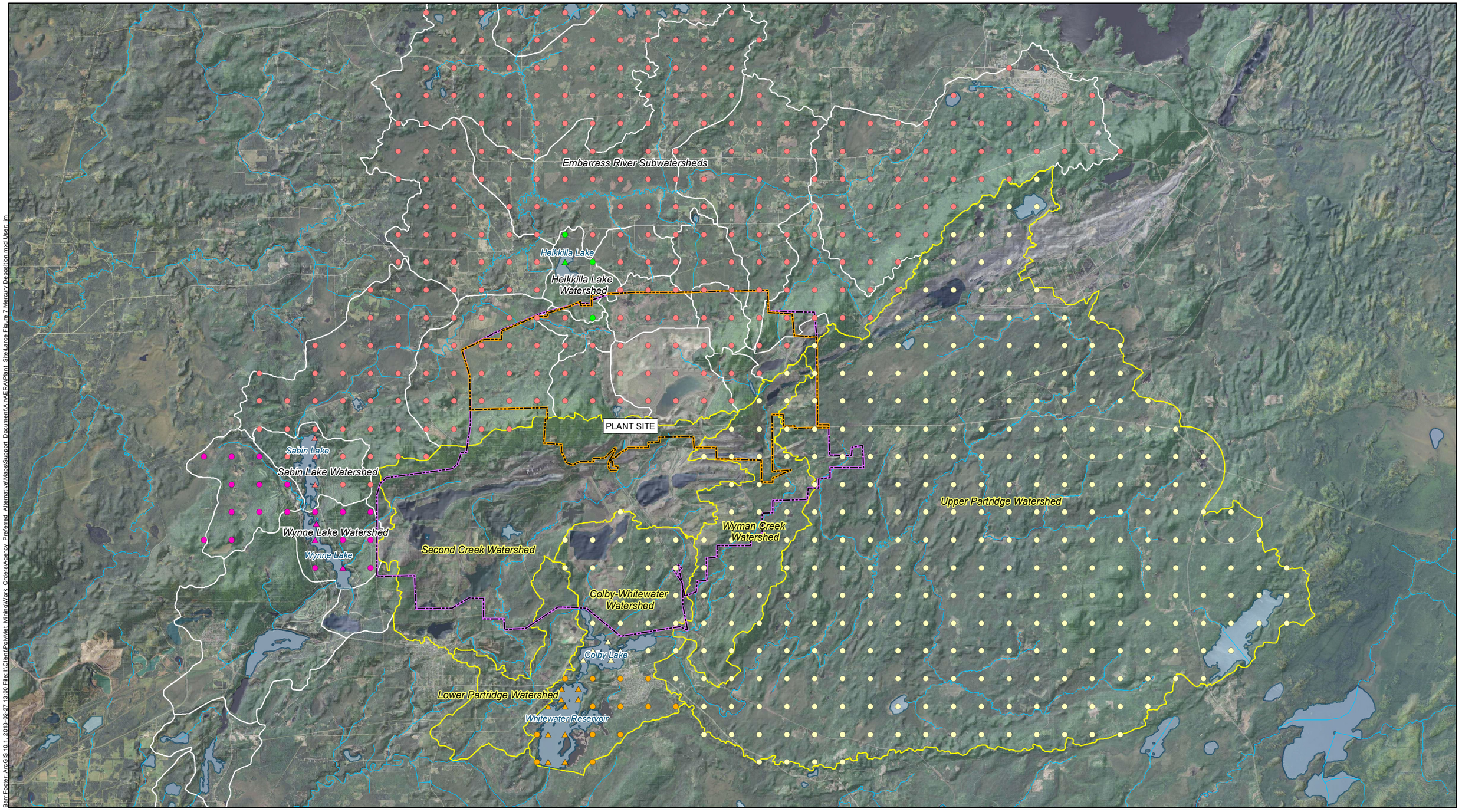
- Barren Land (Rock/Sand/Clay)
- Cultivated Crops
- Forest
- Developed
- Developed Open Space
- Wetlands
- Grassland/Herbaceous
- Open Water
- Pasture/Hay
- Shrub/Scrub

*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 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). 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

Attachment H

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