Environmental Information Report:

An Assessment of Stresses Facing Minnesota's Environment

Technical Support Appendices

Note to readers: These appendices refer to reports and documents indicated as clickable internet links, which were live when the report was drafted. It is likely that some of these links are no longer live and current, as the MPCA cannot maintain those belonging to other organizations. If you are interested in a particular reference and cannot access it, please contact Michael Trojan at 651/297-5219.

Minnesota Pollution Control Agency

Environmental Outcomes Division

May 2002

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Minnesota Pollution Control Agency

Environmental Outcomes Division
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Appendix A: Rationale for Scoring Overall Comparative Contribution for Stressors

We defined a stressor as a pollutant or human activity that contributes to an impact in the environment. The stressors considered in this report are generally those in which the MPCA currently plays a role or we felt may potentially play a role in the future. Thus, we didn't consider some stressors that are clearly within the purview of other agencies. This includes stressors like exotic species or indoor air quality.

Human Health Stressors

Human Health – Cancer Impact

Procedure

A group of 13 individuals gathered to discuss stressors for the *Human Health – Cancer* impact category. The group consisted of staff with expertise in air, soil, water, and risk assessment. Information for each stressor was provided to the group, followed by discussion. Each individual then scored overall relative contribution to risk for each stressor. Scores ranged from 0 to 2 (low, medium, and high, respectively). The scoring procedure was changed for subsequent groups to allow more flexibility.

Scoring

Scores are presented in Table 1. The Environmental Information Report (EIR) Group assigned final scores based on the results from Table 1 and the following procedure:

Overall Comparative Contribution

Average score of 0.00 to 0.66: Low overall comparative contribution
Average score of 0.67 to 1.33: Medium overall comparative contribution
Average score of 1.34 to 2.00: High overall comparative contribution

Table 1: Scoring results for *Human Health – Cancer*. Scores are for overall comparative contribution.

Individual	Excess UV Radiation from Stratospheric Ozone Depletion	Particles in Air	Toxic Chemicals in Food	Toxic Chemicals in Soil	Toxic Chemicals in Water	Toxic Volatile Organic Chemicals in Air
1	1	1	1	0	1	1
2	0	2	1	0	0	2
3	1	1	1	0	0	2
4	1	2	2	0	0	1
5	1	2	2	0	1	1
6	1	1	2	0	0	1
7	1	1	2	0	1	1
8	1	2	2	0	1	1
9	1	2	1	0	2	1
10	2	2	0	1	2	2
11	1	1	2	0	0.5	1

Individual	Excess UV Radiation from Stratospheric Ozone Depletion	Particles in Air	Toxic Chemicals in Food	Toxic Chemicals in Soil	Toxic Chemicals in Water	Toxic Volatile Organic Chemicals in Air
12	1	2	0	0	0	2
13	1	2	2	0	0	0
Mean	1.0	1.6	1.2	0.08	0.65	1.2

Discussion

Table 2 summarizes scoring and scoring rationale for the *Human Health – Cancer* impact category. The rationale is also summarized in the following discussion.

1. Particles in Air: The score of 1.6 for Particles in Air placed it in the high overall comparative contribution category. Scores were attributable to high exposure at concentrations of concern, suspected high cancer potency, and severe effects associated with lung cancer.
2. Toxic Chemicals in Food: The score of 1.2 for Toxic Chemicals in Food placed it in the medium overall comparative contribution category. Exposure at concentrations of concern is high. Incidence of cancer is unknown. Severity varies with chemical exposure.
3. Toxic Volatile Organic Chemicals in Air: The score of 1.2 for Toxic Volatile Organic Chemicals in Air placed it in the medium overall comparative contribution category. Exposures were considered high. Cancer incidence was considered medium. Severity of cancer varies with chemical exposure.
4. Excess UV Radiation from Stratospheric Ozone Depletion (UV): The score of 1.0 for UV radiation placed it in the medium overall comparative contribution category. Exposures are high. Cancer incidence is medium and release of the most important ozone-depleting chemicals has decreased over the past ten years. Severity of cancer varies from low to high.
5. Toxic Chemicals in Water: The score of 0.65 for Toxic Chemicals in Water placed it into the low overall comparative contribution category. Exposure is low because public water supplies are treated and private wells are unlikely to be contaminated with cancer-producing chemicals. There are concerns with pesticides and with new chemicals found in drinking supplies, such as pharmaceuticals. Cancer incidence is low. Severity varies with chemical exposure.
6. Toxic Chemicals in Soil: The score of 0.08 for Toxic Chemicals in Soil placed it in the low overall comparative contribution category. Exposure and cancer incidence is low. Severity of effects varies with chemical exposure.

Table 2: Summary of criteria used in determining overall comparative contribution for each stressor.

Stressor	Score for Overall Comparative Contribution	Exposure[1]	Cancer incidences[2]	Severity of effects
Air particles	1.6	High	High	High
Food chain	1.2	High	Unknown	Medium to high

Stressor	Score for Overall Comparative Contribution	Exposure[1]	Cancer incidences[2]	Severity of effects
Toxic Volatile Organic Chemicals in Air	1.2	High	High	Medium to high
Excess UV Radiation from Stratospheric Ozone Depletion	1.0	High	High	Low to high
Toxic Chemicals in Water	0.65	Medium to High	Low	Medium
Toxic Chemicals in Soil	0.08	Low	Low	Medium

[1] At levels of concern
[2] Relative to other stressors

Human Health – Noncancer Chronic Impact

Procedure

A group of 13 individuals gathered to discuss stressors for the *Human Health – Noncancer Chronic* impact category. The group consisted of staff with expertise in air, soil, water, and risk assessment. Information for each stressor was provided to the group, followed by discussion. Each individual then scored overall relative contribution to risk for each stressor. Scores ranged from 1 to 9 (low to high overall comparative contribution, respectively).

Scoring

Scores are presented in Table 3. The Environmental Information Report (EIR) Group assigned final scores based on the results from Table 3 and the following scoring procedure:

Overall comparative contribution

Average score of 1.0 to 3.5: Low overall comparative contribution
Average score of 3.6 to 6.5: Medium overall comparative contribution
Average score of 6.6 to 9.0: High overall comparative contribution

Table 3: Scoring results for *Human Health – Noncancer Chronic.* Scores are for overall comparative contribution.

Individual	Particles in Air	Toxic metals in air	Toxic volatile organic chemicals in air	Toxic semi-volatile chemicals in air	Odorous chemicals from biological processes	Toxic chemicals in food	Toxic chemicals in water
1	8	2	2	2	1	4	2
2	7	4	4	4	4	7	4
3	8	3	4	3	4	8	8
4	8	6	4	6	7	9	3
5	5	3	5	2	2	2	4
6	7	3	4	3	4	6	6
7	9	2	4	4	4	5	5
8	7	3	3	2	3	6	6

Individual	Particles in Air	Toxic metals in air	Toxic volatile organic chemicals in air	Toxic semi-volatile chemicals in air	Odorous chemicals from biological processes	Toxic chemicals in food	Toxic chemicals in water
9	7	3	4	2	6	8	7
10	9	3	4	3	5	7	6
11	8	2	5	2	4	7	3
12	8	1	2	2	3	5	3
13	8	2	3	3	3	6	6
Mean	7.6	2.8	3.7	2.9	3.8	6.2	4.8
Individual	**Carbon monoxide**	**Ground-level ozone**	**Mercury**	**Sulfur dioxide**	**Oxides of nitrogen**	**Noise**	**Toxic chemicals in soil**
1	1	4	3	2	2	1	1
2	1	3	7	1	1	3	3
3	2	2		2	2	4	4
4	2	2		2	2	6	2
5	5	6	7	5	4	5	2
6	1	3		2	2	5	4
7	1	3	4	1	1	4	3
8	2	3	2	1	2	4	2
9	2	3	3	4	3	3	3
10	2	7	4	4	4	4	5
11	1	5		2	2	4	3
12	3	5		1	1	3	3
13	3	4	5	2	2	5	3
Mean	1.9	3.6	2.5	2.1	2.0	3.6	2.7

Discussion

Table 4 summarizes scoring and scoring rationale for the *Human Health – Noncancer Chronic* impact category. The rationale is also summarized in the following discussion.

1. Particles in Air: The score of 7.6 for Particles in Air placed it in the high overall comparative contribution category. High scores were attributable to high exposure, documented incidences of chronic effects, and suspected severe health effects associated with high concentrations in the environment.
2. Toxic Chemicals in Food: The score of 6.2 for Toxic Chemicals in Food placed it in the medium overall comparative contribution category. Exposure at concentrations of concern is high. Incidence of chronic health effects is unknown. Severity is likely to vary with chemical exposure.
3. Toxic Chemicals in Water: The score of 4.8 for Toxic Chemicals in Water placed it in the medium overall comparative contribution category. Public water supplies ensure that a small percent of the population is exposed at concentrations of concern. People drinking from private wells, however, may be at relatively high overall comparative contribution, particularly from pesticides. There are concerns with pesticides and with estrogenic effects from new chemicals found in drinking supplies (such as pharmaceuticals).

4. Noise: The score of 3.9 for Noise placed it in the medium overall comparative contribution category. Although health effects were considered relatively minor, a large percent of the population is exposed.
5. Odorous Chemicals from Biological Processes: The score of 3.8 for Odorous Chemicals from Biological Processes placed it in the medium overall comparative contribution category. Although a small percent of the population is likely to be exposed at concentrations of concern, health effects are uncertain and individual awareness of exposure is high.
6. Ground-level Ozone: The score of 3.8 for Ground-level Ozone placed it in the medium overall comparative contribution category. A large percent of the population is exposed and the health effects were considered moderate.
7. Toxic Volatile Organic Chemicals in Air: The score of 3.7 for Toxic Volatile Organic Chemicals in Air placed it in the medium overall comparative contribution category. The potential and actual exposure was considered high. Incidence of chronic health effects and concentrations in the environment were considered medium, with concentrations varying for individual pollutants.
8. Toxic Chemicals in Soil: The score of 2.9 for Toxic Chemicals in Soil placed it in the low overall comparative contribution category. Exposure, incidence of health impacts, and severity of health impacts are low.
9. Other Criteria Pollutants in Air: Other Criteria Pollutants in Air was not a stressor scored by the expert panel. The EIR Work Group determined that the various air-related stressors could be condensed into three stressors:
   - 9.1. Particles in Air, which includes Particles in Air, Mercury, Toxic Semi-volatile Chemicals in Air, and Toxic Metals from Table 3;
   - 9.2. Toxic Volatile Organic chemicals in Air, which includes Toxic Volatile Organic Chemicals in Air from Table 3. The work group chose the score of 3.7 for Toxic Volatile Organic Chemicals in Air in assigning comparative overall comparative contribution;
   - 9.3. Other Criteria Pollutants in Air, which includes Carbon Monoxide, Sulfur Dioxide, and Oxides of Nitrogen in Air from Table 3. The average score of 2.36 for the stressors comprising Other Criteria Pollutants in Air placed it in the low overall comparative contribution category. Although a large percent of the population is exposed to criteria pollutants, the potential for exposure at concentrations of concern was considered low.
10. Excess UV Radiation from Stratospheric Ozone Depletion (UV): UV radiation was not presented as a stressor to the expert panel. In subsequent meetings, the EIR Work Group identified chronic health effects associated with UV radiation. The EIR group determined that the overall comparative contribution from UV radiation rated low relative to other stressors. This low ranking was based on the relatively minor chronic health effects from UV radiation, although a large percent of the population is exposed.

Table 4: Summary of criteria used in determining overall comparative contribution for each stressor.

Stressor	Score for Overall Comparative Contribution	Exposure[1]	Chronic incidences[2]	Severity of effects
Particles in Air	7.6	High	High	High
Toxic Chemicals in Food	6.2	Uncertain, but may be high	Unknown	Medium to high
Toxic Chemicals in Water	4.8	Medium to high	Low	Medium
Noise	3.9	High	Medium	Low
Odorous Chemicals from Biological Processes	3.8	Low	Medium	Medium
Ground-level Ozone	3.8	High	Medium	Low
Toxic Volatile Organic Chemicals in Air	3.7	Medium	Medium	Medium
Excess UV Radiation from Stratospheric Ozone Depletion	-	High	Low	Low
Toxic Chemicals in Soil	2.9	Low	Low	Low
Other Criteria Pollutants in Air	2.4	Low	Medium	Low

[1] At levels of concern
[2] Relative to other stressors

Human Health – Noncancer Acute Impact

Procedure

A group of 14 individuals gathered to discuss stressors for the *Human Health – Noncancer Acute* impact category. The group consisted of staff with expertise in air, soil, water and risk assessment. Information for each stressor was provided to the group, followed by discussion. Each individual then scored overall relative contribution to risk for each stressor. Scores ranged from 1 to 9 (low to high, respectively).

Scoring

Table 5 presents scores. The Environmental Information Report (EIR) Group assigned final scores based on the results from Table 5 and the following scoring procedure:

Overall comparative contribution

Average score of 1.0 to 3.5: Low overall comparative contribution
Average score of 3.6 to 6.5: Medium overall comparative contribution
Average score of 6.6 to 9.0: High overall comparative contribution

Table 5: Scoring results for *Human Health – Noncancer Acute.* Scores are for overall comparative contribution.

Individual	Explosive/flammable materials-high level accidental releases	Toxic chemicals-high level accidental releases	Toxic chemicals in water	Toxic chemicals in soil	Carbon monoxide	Oxides of nitrogen
1	3	3	4	1	2	3
2	5	3		3	2	1
3	5	3	4	3	3	1
4	6	3	8	2	8	7
5	7	6	6	5	8	6
6	4	3	5	1	6	1
7	9	7	3	2	2	4
8	2	3	4	1	2	1
9	4	3	6	3	4	2
10	3	2	5	2	2	4
11	3	1	5	3	1	1
12	2	3	5	2	2	2
13	4	4	3	2	2	1
14	5	3	7	4	3	2
Mean	4.4	3.4	5	2.4	3.4	2.6
Individual	**Toxic semi-volatile chemicals in air**	**Odorous chemicals from biological processes**	**Particles in air**	**Pathogens in water**	**Temperature Increase/ climate change (present)[1]**	**Temperature increase/ climate change (future)**
1	1	5	8	1	2	9
2	2	5	7	8		
3	1	4	8	6	5	9
4	2	8	8	6		
5	2	1	5	7		
6	1	6	8	5		
7	1	6	5	4		
8	1	4	8	4	1	3
9	3	3	8	4	2	5
10	2	6	7	6		
11	2	4	9	5	3	9
12	1	5	7	5		
13	1	4	8	5	2	6
14	2	5	8	5	4	9
Mean	1.6	4.7	7.4	5.4	2.7	7.1

Individual	Temperature increase/climate change (combined)	Toxic metals in air	Noise	Sulfur dioxide	Toxic volatile organic chemicals in air	Ground level ozone
1		3	1	3	2	4
2	7	2	3	1	2	4
3		1	4	1	2	6
4	2	2	6	7	3	8
5	4	3	7	8	4	9
6		1	4	1	1	4
7		1	3	3	2	4
8		1	1	1	2	5
9		2	4	1	2	7
10	7	3	3	4	7	6
11		2	3	1	2	6
12		1	7	2	2	6
13		1	3	1	2	6
14		2	6	2	5	7
Mean	5	1.8	3.9	2.6	2.7	5.9

[1] Participants discussed potential environmental impacts of climate change and agreed that there may be effects that are occurring at present, but that most of the effects from climate change would occur in the future. Consequently, participants were asked to score this stressor separately for present and future overall comparative risk. Some participants chose to look at this stressor independent of time (combined effects).

Discussion

Table 6 summarizes scoring and scoring rationale for the *Human Health – Noncancer Acute* impact category. The rationale is also summarized in the following discussion.

1. Particles in Air: The score of 7.4 for Particles in Air placed it in the high overall comparative contribution category. High scores were attributable to the high potential and actual exposure, documented incidences of acute health effects, and suspected high concentrations in the environment.
2. Temperature Increase/Climate Change: The expert panel was unclear how to score global climate change. The EIR Work Group recommended scoring on current and future impacts from climate change, and on overall perception of health impacts from climate change. The score for current impacts was 2.7 and the score for future impacts was 7.1. The low score for current effects is attributable to unnoticeable effects from climate change, at least in Minnesota. The high score for future overall comparative contribution is due to the belief that climate change will result in significantly hotter weather with an increased frequency of severe storms, both of which can have severe health impacts. Effects from climate change will be widespread. The EIR group decided to use the current and future scoring results in

the matrix. Consequently, this stressor was assigned both low and high comparative overall comparative contribution and renamed Temperature Increase/Climate Change. Acute effects from climate change include increased and severe weather.

3. Ground-level Ozone: The score of 5.9 for Ground-level Ozone placed it in the medium overall comparative contribution category. Effects from ozone primarily affect urban areas where most of Minnesota's population lives. Acute health impacts associated with ozone are moderate to severe. Children and elderly are particularly sensitive to ozone.
4. Pathogens in Water: The score of 5.4 for Pathogens in Water placed it in the medium overall comparative contribution category. Although there are relatively few reported incidences of health impacts from pathogens, the number of incidences is probably greatly under-reported. Effects are generally moderate but occasionally can be severe.
5. Toxic Chemicals in Water: The score of 5.0 placed Toxic Chemicals in Water in the medium overall comparative contribution category. Although nitrate is the only chemical of concern, we have strong evidence that a large number of people are exposed to drinking water with nitrate concentrations above the drinking water standard. Acute effects from nitrate occur only in infants, however.
6. Odorous chemicals from Biological Processes: The score of 4.7 placed Odorous Chemicals from Biological Processes in the medium overall comparative contribution category. A small percent of the population is exposed at concentrations of concern, but effects for exposed people can be severe. Health effects are uncertain and individual awareness of exposure is high.
7. Explosive/flammable Materials – High Level Accidental Releases: The score of 4.4 for Explosive/flammable Materials – High Level Accidental Releases placed it in the medium overall comparative contribution category. The number of people exposed to this stressor is very low, but health effects are severe, including death.
8. Noise: The score of 3.9 for Noise placed it in the medium overall comparative contribution category. Although health effects were considered relatively minor, a large percent of the population is exposed.
9. Toxic Chemicals – High Level Accidental Releases: The score of 3.4 for Toxic Chemicals – High Level Accidental Releases placed it in the low overall comparative contribution category. The number of people exposed to this stressor is very low. Health effects can be severe, but are generally not as severe as for Explosive/flammable Materials – High Level Accidental Releases
10. Toxic Volatile Organic Chemicals in Air: The score of 2.7 for Toxic Volatile Organic Chemicals in Air placed it in the low overall comparative contribution category. Exposure may be high, although generally not at concentrations that result in acute health effects. Health effects are not severe.
11. Other Criteria Pollutants in Air: Other Criteria Pollutants in Air was not a stressor scored by the expert panel. The EIR Work Group determined that the various air-related stressors could be condensed into three stressors:
    - 11.1. Particles in Air, which includes Particles in Air, Toxic Semi-Volatile Chemicals in Air, and Toxic Metals from Table 5;
    - 11.2. Toxic Volatile Organic chemicals in Air, which includes Toxic Volatile Organic Chemicals in Air from Table 5;

11.3. Other Criteria Pollutants in Air, which include Carbon Monoxide, Sulfur Dioxide, and Oxides of Nitrogen from Table 5. The work group averaged the scores for these other categories. The resultant score of 2.2 placed Other Criteria Pollutants in Air in the low overall comparative contribution category. Exposure at concentrations that represent a potnetial health concern are low, as is the severity of health impacts.

12. Toxic Chemicals in Soil: The score of 2.4 for Toxic Chemicals in Soil placed it in the low overall comparative contribution category. Exposure and severity of health effects are low.

Table 6: Summary of criteria used in determining overall comparative contribution for each stressor.

Stressor	**Score for Overall Comparative Contribution**	**Exposure[1]**	**Acute incidences[2]**	**Severity of effects**
Particles in Air	7.4	High	High	High
Temperature Increase/Climate Change	2.7; 7.1	High	Unknown	High
Ground-level Ozone	5.9	High	Medium	Medium
Pathogens in Water	5.4	Medium	Medium	Medium
Toxic Chemicals in Water	5.0	High	Low	High
Odorous Chemicals from Biological Processes	4.7	Low	High	Medium
Explosive/flammable materials – high level accidental releases	4.4	Low	Low	High
Noise	3.9	High	Medium	Low
Toxic chemicals – high level accidental releases	3.4	Low	Low	High
Toxic Volatile Organic Chemicals in Air	2.7	Medium	Low	Medium
Toxic Chemicals in Soil	2.4	Low	Low	Low
Other Criteria Pollutants in Air	2.2	Low	Low	Medium

[1] At levels of concern

[2] Relative to other stressors

Ecosystem Impacts

The procedure for scoring and assigning overall comparative contribution was similar between Human Health and Ecosystem Impact stressors, but the manner in which the expert panels were informed about environmental impacts differed. For Ecosystem Impacts, there was less published information about actual exposures, effects, and chemical concentrations. There was more informal information sharing and discussion among the expert panel.

Ecosystem Impacts – Aquatic Organisms

Procedure

A group of 14 individuals gathered to discuss stressors for the *Ecosystem Impacts – Aquatic Organisms* impact. The group consisted of staff with expertise in surface water and aquatic biology. Information for each stressor was provided to the group, followed by discussion. Each individual the scored overall relative contribution to risk for each stressor. Scores ranged from 1 to 9 (low 1.0 to 3.5, medium 3.5 to 6.5, and high 6.5 to 9.0).

Scoring

Scores are presented in Table 7. The Environmental Information Report (EIR) Group assigned final scores based on results from Table 7 and the following scoring procedure:

Overall comparative contribution

Average score of 1.0 to 3.5: Low overall comparative contribution
Average score of 3.6 to 6.5: Medium overall comparative contribution
Average score of 6.6 to 9.0: High overall comparative contribution

Table 7: Scoring results for *Ecosystem Impacts – Aquatic Organisms.* Scores are for overall comparative contribution.

Individual	**Transported sediment**	**Phosphorus**	**Nitrogen**	**Habitat/ hydrologic modification**	**Oxygen-demanding pollutants**	**Ammonia**	**Toxic organic compounds**
1	6	8	7	8	6	4	7
2	8	7	5	7	5	5	6
3	6	7	7	9	5	5	6
4	7	4	4	7	5	3	3
5	7	6	4	7	5	2	2
6	8	6	6	7	8	2	8
7	9	7	4	9	8	2	3
8	9	8	6	5	6	6	9
9	8	8	6	9	5	3	4
10	7	8	7	3	8	5	3
11	7	8	6	8	5	3	3
12	6	7	6	7	6	3	7
13	9	7	7	7	8	4	6
14	7	8	5	8	5	2	6
Mean	7.4	7.1	5.7	7.2	6.1	3.5	5.2

Table 7 continued

Individual	Toxic metals	Acid deposition	Temp-erature increase	Excess UV radiation from stratospheric ozone depletion	Dissolved solids	Mercury
1	6	5	4	5	6	6
2	5	3	2		2	2
3	3	2	3	6	6	6
4			5	4	4	2
5	3	1	4	1	3	1
6	4	3	5	5	5	3
7	2	2	5	2	2	3
8	6	3	3	6	3	4
9	3	2	3	2	2	1
10	5	1	2	2	3	3
11	3	2	5	5	6	2
12	5	1	1	3	3	1
13	5	3	2	1	2	1
14	3	2	3	2	2	2
Mean	4.1	2.2	3.2	3.4	3.5	2.6

<u>Discussion</u>

Table 8 summarizes scoring and rationale for the *Ecosystem Impacts – Aquatic Organisms* impact category. The rationale is summarized below.

1. Transported Sediment: The score of 7.4 for Transported Sediment placed it in the high-overall comparative contribution category. Transported sediment is a widespread problem that has immediate and severe effects on aquatic organisms.
2. Habitat/Hydrologic Modification: The score of 7.2 for Habitat/Hydrologic Modification placed it in the high-overall comparative contribution category. Habitat effects occur statewide from a variety of stressors, such as urban development, lakeshore development, and agriculture. Other factors considered in ranking habitat modification high were the severe effects on aquatic organisms and irreversibility of most effects.
3. Phosphorus: The score of 7.1 for Phosphorus placed it in the high-overall comparative contribution category. Phosphorus effects are well documented. Although effects do not occur statewide, nutrient enrichment has severe and slowly reversible effects on aquatic organisms.
4. Oxygen-demanding Pollutants: The score of 6.1 for Oxygen-demanding Pollutants placed it in the medium overall comparative contribution category. Effects from oxygen-demanding pollutants, although severe, have lessened significantly in the past 30 years.
5. Nitrogen: The score of 5.7 for Nitrogen placed it in the medium overall comparative contribution category. Nitrogen, like phosphorus, can have significant impacts on aquatic organisms. Generally, however, phosphorus is more limiting than nitrogen as a nutrient.
6. Toxic Organic Chemicals: The score of 5.2 for Toxic Organic Chemicals placed it in the medium overall comparative contribution category. Impacts from organic chemicals on aquatic organisms are not well understood. While effects on aquatic

organisms have not been extensively documented, the expert panel felt that effects were likely to be greater than indicated by existing documentation.

7. Toxic Metals: The score of 4.1 for Toxic Metals placed it in the medium overall comparative contribution category. Impacts to aquatic ecosystems from toxic metals have not been well documented. The expert panel felt the effects were not likely to be as severe as for organic chemicals. Mercury was included with toxic metals, but its effect on food chain biomagnification is not a factor for aquatic organisms.
8. Ammonia: The score of 3.5 placed it in the low overall comparative contribution category. While ammonia is highly toxic to aquatic organisms, effects are localized.
9. Dissolved Solids: The score of 3.5 for Dissolved Solids placed it in the low overall comparative contribution category. The primary concern with dissolved solids was chloride, which is not highly toxic. Dissolved solid concentrations are elevated in many aquatic ecosystems, however, particularly in urban areas.
10. Excess UV Radiation from Stratospheric Ozone Depletion: The score of 3.4 for UV Radiation placed it in the low overall comparative contribution category. The expert panel was uncertain about UV radiation affects on aquatic ecosystems. The group felt that effects would occur statewide but would not be severe.
11. Temperature Increase/Climate Change: The score of 3.2 for Temperature Increase/Climate Change placed it in the low overall comparative contribution category. At the time of scoring, temperature increase referred only to increases in temperature associated with thermal discharges from power plants and warming of surface water in urban and developing areas. The EIR group later included effects of global warming on temperature increase. Current effects from global climate change were considered small, but future impacts could be severe. Consequently, the EIR group added a high ranking to this stressor and renamed it Temperature Increase/Climate Change. The stressor includes a low and high ranking to indicate differences between short-term and long-term impacts.
12. Acid Deposition: The score of 2.2 for Acid Deposition placed it in the low overall comparative contribution category. Effects from acid deposition in Minnesota have been limited because most aquatic systems are sufficiently buffered.
13. Mercury: The score of 2.6 for Mercury placed it into a low contribution category. The EIR Group considered the effects of mercury on aquatic organisms to be minor since the primary issue with mercury is biomagnification, and this is an issue for terrestrial organisms only. Since mercury was considered less important than other toxic metals, it was combined with the stressor Toxic Metals.

Table 8: Summary of criteria used in determining overall comparative contribution for each stressor.

Stressor	**Score for Overall Comparative Contribution**	**Exposure**[1]	**Incidences**[2]	**Severity of effects**
Transported sediment	7.4	High	High	High
Habitat/hydrologic modification	7.2	High	High	High
Phosphorus	7.1	Medium	High	High
Oxygen-demanding pollutants	6.1	Low	Medium	High

Stressor	Score for Overall Comparative Contribution	Exposure[1]	Incidences[2]	Severity of effects
Nitrogen	5.7	Medium	Medium	Medium
Toxic organic chemicals	5.2	Unknown	Unknown	High
Toxic metals	4.1	Unknown	Unknown	Medium
Ammonia	3.5	Low	Low	High
Dissolved solids	3.5	Medium	Low	Low
Excess UV Radiation from Stratospheric Ozone Depletion	3.4	High	Medium	Low
Temperature increase	3.2	High	Unknown	High
Acid deposition	2.2	Low	Low	High

[1] At levels of concern
[2] Relative to other stressors

Ecosystem Impacts – Terrestrial Organisms

Procedure

A group of 13 individuals gathered to discuss stressors for the *Ecosystem Impacts – Terrestrial Organisms* impact category. The group consisted of staff with expertise in surface water, aquatic biology, terrestrial biology, and climate. Information for each stressor was provided to the group, followed by discussion. Each individual then scored overall relative contribution to risk (Overall comparative contribution Score). Scores ranged from 1 to 9 (low 1 to 3.5, medium 3.5 to 6.5, and high 6.5 to 9.0).

Scoring

Scores are presented in Table 9. The Environmental Information Report (EIR) Group assigned final scores based on the results from Table 9 and the following scoring procedure:

Overall comparative contribution

Average score of 1.0 to 3.5: Low overall comparative contribution
Average score of 3.6 to 6.5: Medium overall comparative contribution
Average score of 6.6 to 9.0: High overall comparative contribution

Table 9: Scoring results for *Ecosystem Impacts – Terrestrial Organisms.* Scores are for overall comparative contribution.

Individual	Habitat/ hydrologic modification	Toxic organic chemicals	Toxic metals	Mercury	Acid deposition	Excess UV radiation from stratospheric ozone depletion	Climate change	Nitrogen	Ground-level ozone
1	9	5	5	3	4	3	7	7	6
2	8	5	2	2	2	5	8	5	5
3	9	4	1	2	2	4	8	6	5
4	9	6	2	2	2	2	4		3
5	9	8	3	3	3	4	9	5	3

Individual	Habitat/ hydrologic modification	Toxic organic chemicals	Toxic metals	Mercury	Acid deposition	Excess UV radiation from stratospheric ozone depletion	Climate change	Nitrogen	Ground-level ozone
6	9	6	3	3	3	3			3
7	9	7	3	4	2	3	9	3	3
8	9	7	3	4	2	3	8	5	3
9	8	6	3	2	3	4	7	6	5
10	9	7	3	5	2	2	9	7	6
11	9	7	1	5	2	2	6	6	4
12	9	5	1	2	2	4	3	5	4
13	9	7	3	4	2	4	9	7	5
Mean	8.8	6.2	2.5	3.2	2.4	3.3	7.3	5.6	4.2

Discussion

Table 10 summarizes scoring and scoring rationale for the *Ecosystem Impacts – Terrestrial Organisms*. The rationale is also summarized in the following discussion.

1. Habitat Modification: The score of 8.8 for Habitat Modification placed it in the high-overall comparative contribution category. Habitat effects occur statewide from a variety of stressors, such as urban development and agriculture. Other factors considered in ranking Habitat Modification high were the severe effects on terrestrial organisms and irreversibility of most effects.
2. Toxic Organic Chemicals: The score of 6.2 for Toxic Organic Chemicals placed it in the medium-overall comparative contribution category. Impacts from organic chemicals occur statewide and toxic impacts on terrestrial organisms can be seen at low concentrations. Another contributing factor to the comparative contribution was uncertainty of effects from organic chemicals, since there is little monitoring and many new chemicals (e.g. pharmaceuticals) are being detected in the environment.
3. Nitrogen: The score of 5.6 for Nitrogen placed it in the medium-overall comparative contribution category. The expert panel acknowledged that humans have dramatically altered the nitrogen cycle, but were less certain of how this alteration has impacted terrestrial organisms.
4. Ground-level Ozone: The score of 4.2 for Ground-level Ozone placed it in the medium-overall comparative contribution category. Ground-level ozone is likely to have the same effects on terrestrial organisms as on humans. Ozone is an important chemical of concern in urban areas. Effects in other areas are less significant.
5. Excess UV from Stratospheric Ozone Depletion: The score of 3.3 for UV Radiation placed it in the low-overall comparative contribution category. UV radiation exposure occurs statewide, but effects are uncertain. The most important ozone-depleting chemicals are banned.
6. Toxic Metals: The score of 2.5 for Toxic Metals placed it in the low-overall comparative contribution category. Except for mercury, effects from metals occur only in localized areas. Mercury affects terrestrial ecosystems statewide. Although biomagnification of mercury occurs in some terrestrial species, few actual effects have been observed.

7. Acid Deposition: The score of 2.4 for Acid Deposition placed it in the low-overall comparative contribution category. Actual effects from acid deposition in Minnesota have been limited because most terrestrial systems are sufficiently buffered.
8. Temperature Increase/Climate Change: Temperature Increase/Climate Change had a high contribution based on the mean score of 7.3. In considering the importance of climate change to habitat modification, the group struggled with the time frame over which effects of climate change were being considered. The expert panel felt the comparative contribution in the short-term was low, while long-term impacts are severe. The problem of time frame was the main reason we employed two circles to indicate high and low comparative contribution. The stressor was renamed Temperature Increase/Climate Change to maintain consistency with other uses of this stressor in the EIR.
9. Mercury: Mercury had a low contribution based on a mean score of 3.2. In subsequent meetings, the EIR Group decided to combine mercury with Toxic Metals. Mercury is the most important of the toxic metals. Since the contribution for mercury did not differ from toxic metals, the two stressors were combined into a single stressor.

Table 10: Summary of criteria used in determining overall comparative contribution for each stressor.

Stressor	Score for Overall Comparative Contribution	Exposure[1]	Chronic incidences[2]	Severity of effects
Habitat/ modification	8.8	High	High	High
Toxic organic chemicals	6.2	Medium	Medium	High
Nitrogen	5.6	High	Unknown	Unknown
Ground-level ozone	4.2	Medium	Medium	Low
Excess UV radiation from stratospheric ozone depletion	3.3	High	Low	Low
Toxic metals	2.5	Low	Low	Medium
Acid deposition	2.4	Low	Low	High

[1] At levels of concern
[2] Relative to other stressors

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Appendix B: Documentation for Stressors

Note to readers: This appendix and others refer to reports and documents indicated as clickable internet links, which were live when the report was drafted. It is likely that some of these links are no longer live and current, as the MPCA cannot maintain those belonging to other organizations. If you are interested in a particular reference and cannot access it, please contact Michael Trojan at 651/297-5219.

Information in this Appendix was collected by the EIR Team with assistance from MPCA technical staff. Information was provided to the expert panels that scored stressors for each impact category.

Table 1 summarizes the 56 stressor-impact combinations. The table indicates the page where the support documentation can be found. We do not discuss Quality of Life-Aesthetics because there was no scoring for these stressors. The Quality of Life-Aesthetic stressors include Odorous Chemicals from Biological Processes, Habitat Modification, Phosphorus, Transported Sediment, Noise, Particles in Air, Ground-level Ozone, and Oxygen-demanding Pollutants.

Information is provided for the following four questions for the Ecosystem Impact categories.

1. What are the primary chemicals of concern for this stressor?
2. What concentrations of these chemicals and health benchmark exceedances are we seeing?
3. What effects on aquatic organisms are associated with excess exposure to these chemicals?
4. How persistent/reversible is this stressor?

Information is provided for the following questions for the Human Health Impact categories.

1. What health effects are associated with excess exposure to these chemicals?
2. How many people are exposed to concentrations exceeding health benchmarks?
3. How many incidences of the diseases/ailments of concern result from exposures above criteria?
4. How persistent/reversible is this stressor?

Section	Impact	Stressor	Page
2.1	Ecosystem impacts-terrestrial organisms	Habitat modification	40
2.2	Ecosystem impacts-terrestrial organisms	Temperature increase/climate change	42
2.3	Ecosystem impacts-terrestrial organisms	Toxic organic chemicals	43
2.4	Ecosystem impacts-terrestrial organisms	Nitrogen	43
2.5	Ecosystem impacts-terrestrial organisms	Ground-level ozone	44
2.6	Ecosystem impacts-terrestrial organisms	Toxic metals	46
2.7	Ecosystem impacts-terrestrial organisms	Acid deposition	47
2.8	Ecosystem impacts-terrestrial organisms	Excess UV radiation from stratospheric ozone depletion	49
3.1	Human health impacts-cancer	Particles in air	50
3.2	Human health impacts-cancer	Toxic volatile organic chemicals in air	51
3.3	Human health impacts-cancer	Toxic chemicals in food	54
3.4	Human health impacts-cancer	Excess UV radiation from stratospheric ozone depletion	55
3.5	Human health impacts-cancer	Toxic chemicals in water	57
3.6	Human health impacts-cancer	Toxic chemicals in soil	60
4.1	Human health impacts-noncancer acute	Particles in air	62
4.2	Human health impacts-noncancer acute	Temperature increase/climate change	63
4.3	Human health impacts-noncancer acute	Ground-level ozone	64
4.4	Human health impacts-noncancer acute	Pathogens in water	64
4.5	Human health impacts-noncancer acute	Odorous chemicals from biological processes	66
4.6	Human health impacts-noncancer acute	Toxic chemicals in water	67
4.7	Human health impacts-noncancer acute	Explosive/flammable materials - high level accidental releases	68
4.8	Human health impacts-noncancer acute	Noise	68
4.9	Human health impacts-noncancer acute	Toxic chemicals – high level accidental releases	69
4.10	Human health impacts-noncancer acute	Toxic volatile organic chemicals in air	70
4.11	Human health impacts-noncancer acute	Other criteria pollutants in air	72
4.12	Human health impacts-noncancer acute	Toxic chemicals in soil	76
5.1	Human health impacts-noncancer chronic	Particles in air	77
5.2	Human health impacts-noncancer chronic	Toxic chemicals in food	78
5.3	Human health impacts-noncancer chronic	Toxic chemicals in water	80
5.4	Human health impacts-noncancer chronic	Noise	81
5.5	Human health impacts-noncancer chronic	Odorous chemicals from biological processes	82
5.6	Human health impacts-noncancer chronic	Toxic volatile organic chemicals in air	83
5.7	Human health impacts-noncancer chronic	Ground-level ozone	85
5.8	Human health impacts-noncancer chronic	Excess UV radiation from stratospheric ozone depletion	85
5.9	Human health impacts-noncancer chronic	Toxic chemicals in soil	87
5.10	Human health impacts-noncancer chronic	Other criteria pollutants in air	87

1. Ecosystem Impacts-Aquatic Organisms

1.1. Habitat Modification

What are the primary chemicals of concern for this stressor?

There are no chemicals associated with habitat modification. Activities that result in habitat modification and that can have negative effects on aquatic ecosystems include drainage, channelization, development (urban, suburban, and lake-shore), crop production, and dredging (http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_10.shtml; http://www.adem.state.al.us/EnviroProtect/WatershedMan/watman/mgtplan/pdf/partIIhy.pdf; http://www.wri.org/wri/biodiv/b03-gbs.html).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Benchmarks do not exist for habitat modification. Defining critical habitat requirements is also difficult, primarily due to inadequate data for many important species. This data includes characterization of many habitat-species interactions that are necessary for successful growth, reproduction, and survival of rare and endangered organisms (http://www.nps.gov/noca/Ltem/AH_Text.htm; http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_10.shtml). Extent and rates of modification are perhaps the best way to evaluate the occurrence of this stressor. Minnesota has about 5 million acres of drained land and 27,000 miles of constructed ditches (http://www.extension.umn.edu/extensionnews/1998/JO1207.html). About half of Minnesota's 18.6 million wetland acres have been drained http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch4-4.pdf). Drainage activity has tapered off in the last two decades, although some drainage activity is taking place in the state's growing urbanization areas, including preparing for streets, roads, airports, and residential and industrial development (http://www.house.leg.state.mn.us/hrd/pubs/drainage.pdf). In addition to ditching, extensive channelization of streams has occurred in western and southern Minnesota (http://news.mpr.org/features/200204/01_losurem_drainage/). The population of Minnesota expanded by 406,599 people between 1990 and 1998. Suburban and outlying communities of Minnesota's metropolitan areas sustained the most rapid population growth (http://www.mnplan.state.mn.us/pdf/2000/demog/estimate.pdf). There are nearly 150,000 highway miles in Minnesota, and the number of vehicle miles driven per person has increased from 6992 in 1980 to more than 10,000 in 2000 (http://projects.dot.state.mn.us/seh/212/back.html; http://www.mnplan.state.mn.us/mm/indicator.html?Id=57&G=39). Further increases are likely over the next 20 years, leading to additional construction of highways. Highways result in drainage of wetlands, habitat fragmentation, and transport of chemicals and exotic species (http://www.defenders.org/habitat/highways/new/ecology.html; http://www.wildlandscpr.org/resourcelibrary/reports/wade_report2.html).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Habitat modification typically leads to decreases or elimination in populations or species. This may occur directly through loss of habitat or by changes in ecosystem functioning. These changes lead to a gradual decrease in ecosystem health (Kaiser et al.; http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_10.shtml;

http://www.epa.state.oh.us/dsw/watershed/causetbl.htm; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch4-4.pdf; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch4-4.pdf). There are few long-term studies that show impacts of habitat modification on aquatic organisms, although decreases in waterfowl populations over the last half to quarter century are one example (http://midwest.fws.gov/NAWMP/minnesota.html; http://www.ducks.org/conservation/greatplains.asp).

How persistent/reversible is this stressor?

There is general agreement that impacts from habitat modification are slowly reversible or irreversible. Reestablishment of habitat is difficult and may take considerable time, if it can be done at all. Since the primary effect of habitat modification is reduction of or elimination of species or populations, even restoration of habitat may not lead to restoration or full recovery of the aquatic ecosystem (http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_10.shtml).

1.2. Transported Sediment

What are the primary chemicals of concern for this stressor?

There are no specific chemicals for this stressor. Suspended sediments in waterways may include silt and clay, organic and inorganic matter and living or dead microorganisms, including phytoplankton (http://www.wrc.wa.gov.au/swanavon/environ_issues/sediments_waterways.html). Chemicals may be associated with sediment, however, particularly chemicals that are strongly adsorbed to soil particles. This includes most metals, PAHs, dioxins, and pesticides (http://h2osparc.wq.ncsu.edu/info/sediment.html; http://depts.washington.edu/cuwrm/research/tssturb.pdf).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Turbidity, suspended sediment concentrations, and Secchi disk transparency measurements are common ways of measuring levels of suspended sediment in aquatic systems. Although suspended solids are responsible for environmental impacts, it is difficult to measure suspended solid concentration. Turbidity can often be related to suspended solid concentration (http://depts.washington.edu/cuwrm/research/tssturb.pdf; http://www.epa.nsw.gov.au/soe/97/ch3/11_1.htm; http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf). Recommended levels to prevent impairment of aquatic ecosystems include less than 50 NTU (turbidity) for an instantaneous measurement, less than 25 NTUs for a 10 day average, and a seasonal change less than 10 percent http://www.vic.waterwatch.org.au/fortheteacher/manual/sect4d.htm; http://webpages.charter.net/kwingerden/erhs/aquarium/EnvEffects; http://www.lpe.nt.gov.au/care/waterwatch/data/interp.htm; http://www.epa.nsw.gov.au/soe/97/ch3/11_2.htm). For Minnesota streams and rivers, turbidity standards are 10 NTU for Class 2A waters and 25 NTU for Class 2Bd, B, C, D waters. There were 46 stream and river locations on the 1998 TMDL List for turbidity.

Many of these are rivers in southern Minnesota, particularly the Minnesota and Mississippi Rivers (http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf).

What effects on aquatic organisms are associated with excess exposure to these chemicals?
The environmental effects of high concentrations of suspended sediments in waterways are diverse. They include:

- reduced light penetration and consequent reduced primary production (photosynthesis);
- interference with the feeding mechanisms of filter feeding organisms and aquatic species that rely on vision for feeding;
- smothering of sessile organisms and/or change in the nature of the substrate as particulate matter settles out, in some cases severely degrading the ecology of aquatic systems;
- organic material, for example animal manure, can also cause other problems as it decays, such as decreasing the amount of oxygen available to sustain aquatic life;
- degradation of water quality (eutrophication) from adsorbed nutrients, especially phosphorus;
- retardation of seedling emergence where water resources are used for irrigation, because of high silt and clay contents; and
- the accumulation of a sediment film on plant leaves can inhibit photosynthesis and growth.

(http://www.wrc.wa.gov.au/swanavon/environ_issues/sediments_waterways.html; http://h2osparc.wq.ncsu.edu/info/sediment.html; http://wwwdiaiwc.cr.usgs.gov/projects/ia072.html; http://webpages.charter.net/kwingerden/erhs/aquarium/turbidit.htm#EnvEffects; http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf).

How persistent/reversible is this stressor?
If sources of sediment are reduced, water clarity can improve relatively quickly as a result of settling, transport, and dilution. There are many management practices that will reduce erosion, including use of silt fences, contouring, conservation tillage, establishment of vegetation, limiting loss from drains (particularly in urban areas), and installation of stormwater detention basins. In some cases, sedimentation of water bodies is significant enough to require dredging to remove the sediment source, but dredging in many cases is more harmful to aquatic ecosystems than the suspended sediment (http://www.wes.army.mil/el/dots/pdfs/eedp06-11.pdf; http://www.ukmarinesac.org.uk/activities/ports/ph5_2.htm). If chemicals adsorbed to sediments are toxic, they can be persistent in aquatic ecosystems (see Sections 1.3, 1.7, and 1.8) (http://www.wrc.wa.gov.au/swanavon/environ_issues/sediments_waterways.html).

1.3. Phosphorus
What are the primary chemicals of concern for this stressor?
Phosphorus.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Total phosphorus for whole lakes should be maintained below 20 µg/L to avoid the production of nuisance algae and below 10 µg/L to avoid aesthetic degradation. In moving waters, the total phosphorus level should remain below 30 µg/L. Minnesota utilizes a phosphorus criteria of 15 ug/L for cold water fisheries and a criteria of 30 or 40 ug/L, depending on ecoregion, for assessing full use support of surface water. A value less than 90 ug/L but exceeding the full use criteria is considered to support partial use. Phosphorus concentrations have decreased in the past years at 78 percent of monitored stream sites, with increasing trends at only 1 percent of the monitored stream sites. Lakes also show a trend of improving water quality at most monitored sites. Approximately 65 percent of sampled streams and lakes are fully supporting of aquatic life standards (http://www.pca.state.mn.us/publications/reports/305bfinalreport-2000.pdf; http://www.mnplan.state.mn.us/mm/indicator.html?Id=64&G=40). There were 32 stream or river sampling points listed on the 1998 TMDL list for low oxygen. This doesn't necessarily reflect excess phosphorus (http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Phosphorus can pollute surface waters and cause excessive algae and plant growth. When algae blooms exhaust the supply of phosphorus, they die and start to decompose. During decomposition, dissolved oxygen is removed from the water by microorganisms that break down the organic material. The lack of dissolved oxygen makes it difficult for aquatic organisms to survive. Significant fish kills can result. Algae blooms and excessive weed growth can have negative effects on aquatic ecosystems. Blue-green algae contain toxins that can affect the liver and nervous system of organisms. Livestock and wildlife have died from consuming water that contains toxins from blue-green algae (http://www.nwri.ca/sande/artificialstreams.html; http://www.agric.gov.ab.ca/agdex/500/576-2.html; http://www.pca.state.mn.us/water/phosphorus.html).

How persistent/reversible is this stressor?

Phosphorus is typically the limiting nutrient in aquatic ecosystems and is therefore rapidly taken up by organisms. Phosphorus cycling varies with different aquatic ecosystems. Sediments rich in organic matter, iron, aluminum, and calcium may provide a sink for large quantities of phosphorus. This phosphorus, however, can be released, and the rate of release or attenuation may not keep pace with the rate of addition in impacted waters. Phosphorus cycling occurs annually for plants and over a much shorter period of time for other aquatic organisms. Consequently, the persistence and reversibility of degradation from phosphorus varies with each aquatic ecosystem (http://edis.ifas.ufl.edu/SS302; http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-11/6-10-4.asp).

1.4. Temperature Increase/Climate Change

What are the primary chemicals of concern for this stressor?

The main anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tropospheric ozone (O_3), and several chlorofluorocarbon (CFC) refrigerants. There are many less important greenhouse gases, including carbon tetrachloride (CCl_4) and sulfur hexafluoride (SF_6). These chemicals absorb infrared light and heat in the atmosphere and warm the surrounding air. Resultant thermal emissions cause surface temperatures to increase.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Health benchmarks (related to climate change) do not exist for these chemicals. It is the effect of increased concentrations of these chemicals in the atmosphere that cause negative impacts, not necessarily direct exposure to the chemicals themselves. Atmospheric concentrations of CO_2 (33%), CH_4 (142%), N_2O (13%), and O_3 (100%) have increased drastically over pre-industrial levels. Man-made chemicals, such as CFCs, were not present at all in the atmosphere prior to industrialization, but some are now measured at hundreds of parts per trillion.

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Although we can predict a range of possible temperature increases, efforts to assess the specific consequences of climate change are not complete. Estimates of general impact trends are available. Ecosystems in northern states that are adapted to cooler temperatures may be very sensitive to any ambient warming. One possible outcome is a reduction in habitat for cold-water fish. Aquatic species may also be impacted if climate change increases the effects of other stresses on species health. For example, warmer weather may increase eutrophication. Extreme events, such as flooding or severe droughts, would also negatively impact aquatic species.

How persistent/reversible is this stressor?

Greenhouse gases have atmospheric lifetimes ranging from 5 to 50,000 years, depending on the chemical and atmospheric removal processes. The most common greenhouse gas, carbon dioxide, persists in the atmosphere for 500 years. The duration of the warming effect from these pollutants in the atmosphere depends on the timing and effectiveness of control strategies designed to reduce the emissions of these chemicals. If, for example, emission levels increased at current rates until 2100 and then were linearly phased out, temperatures would still not return to current levels (and certainly not pre-industrial levels) for more than 500 years, and possibly much longer.

References:

- Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix H: Global Climate Change.* http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html.
- http://www.pca.state.mn.us/hot/globalwarming.html

1.5. Nitrogen

What are the primary chemicals of concern from this stressor?

Nitrate (NO3), and to a lesser extent, its reduced form, nitrite (NO2)

What concentrations of these chemicals and benchmark exceedances are we seeing?

Minnesota is a major contributor to environmental releases of nitrogen. We are the sixth largest user of nitrogen fertilizers in the United States. Over 600,000 tons of nitrogen fertilizer are applied annually in the state, roughly 5.5 percent of the national total (http://www.pca.state.mn.us/programs/indicators/iom-0901.html). The heavily-agriculturalized Minnesota River Basin is a large contributor of nitrate-nitrogen to the Mississippi River (and hence, the Gulf of Mexico) with >1,000 kilograms per square kilometer per year contributed. (http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.135-00.fig6.gif)

What effects on aquatic and terrestrial organisms are associated with excess exposure to nitrogen?

Nitrogen is an essential element for all life, although in excessive amounts, it can be toxic to various forms of life. Nitrogen contributes to eutrophication of lakes, rivers, and oceans; contamination of ground water which may then interact with surface water; development of "dead zones" in oceans and seas because of hypoxia; acidification or other modification of terrestrial and aquatic ecosystems; and global warming. Ingestion of nitrate in excess of 10 mg/l in a water supply can cause methemoglobinemia (blue-baby disease), which affects humans six months of age or younger and may affect young farm animals. (http://www.pca.state.mn.us/programs/indicators/iom-0901.html)

How persistent/reversible is this stressor?

Nitrate is the primary oxidized form of nitrogen in water. It is soluble (dissolves) in water and may be found in high concentrations if a source of nitrogen and oxygen is present. Most nitrate which enters water comes from anthropogenic (human-derived) sources such as atmospheric deposition of nitrous oxides associated with the combustion of coal and gas, land application of animal manure at farms, and application of fertilizers to agricultural crops and urban yards. Nitrate in shallow ground water can interact with surface water, contributing to problems for terrestrial and aquatic organisms. In well-oxygenated water, various forms of nitrogen such as nitrogen gas, ammonia and nitrite are usually converted quickly to nitrate. However, in the absence of oxygen (reducing conditions) ammonia can be a concern if there are sources of ammonia available to a water supply. Nitrate and ammonia can occur together in reducing waters when a source of nitrogen is nearby, such as a leaking waste lagoon, a poorly-managed feedlot, or a failed septic system. (http://www.pca.state.mn.us/water/groundwater/pubs/nitrate.pdf)

1.6. Oxygen-demanding Pollutants

What are the primary chemicals of concern for this stressor?

Organic matter, which serves as a food source for microorganisms. During consumption of organic matter, microorganisms utilize oxygen, which can eventually become depleted. Although organic matter is directly linked to oxygen depletion, nutrient enrichment may stimulate microbiological growth in waters where organic matter is not limiting. Phosphorus and, to a lesser extent nitrogen, are the primary nutrients of concern. These are discussed separately in Sections 1.3 (Phosphorus) and 1.5 (Nitrogen). It is important to note that organic matter, as discussed in this section, includes chemical compounds that are readily available as a food source to microorganisms. Thus, many toxic organic chemicals (Section 1.7), such as dioxins, PCBs, and many pesticides, would not be included in this discussion (http://sevilleta.unm.edu/collaboration/igert/research/carbon/).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Dissolved oxygen (DO) is required for essentially all aquatic organisms to live. DO is not a toxicant, and in general, the more DO in the water, up to about 110 percent of saturation, the better, as far as aquatic organisms are concerned. Most fish, excluding roughfish, are negatively impacted at dissolved oxygen concentrations less than 5 mg/L. Roughfish typically require 2 to 3 mg/L to thrive, but some roughfish can survive at concentrations of 1 mg/L or less (http://www.bae.ncsu.edu/programs/extension/wqg/volunteer/man_ch3.htm; http://wupcenter.mtu.edu/education/stream/pHecologydatainfo.htm; http://www.me.cc.va.us/dept/ietech/water_wastewater/distance_learning/courses/ENV110/LESSON_12.html). Dissolved oxygen standards differ depending on the use class of the water:

- Class 2A. Not less than 7 mg/L as a daily minimum
- Class 2Bd, 2B, 2C. Not less than 5 mg/L as a daily minimum
- Class 2D. Maintain background
- Class 7. Not less than 1 mg/L as a daily average, provided that measurable concentrations are present at all times.

(http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf). There were 31 sampling locations on Minnesota streams and rivers that were listed on the 1998 TMDL list for low oxygen concentrations. Most of the locations occurred in the Mississippi and Minnesota River basins, although there were some locations in the Red River and Rainy River basins (http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Insufficient oxygen results in death of organisms. The make-up of aquatic ecosystems can change as oxygen levels become lower (http://www.grida.no/climate/ipcc/regional/213.htm; http://www.poultry.org/environment.htm; http://mbgnet.mobot.org/fresh/pollute.htm; http://www.sturgeongeneral.org/html/data/books/discover_your_estuary.html#organic_pollutants). For example, trout require oxygen concentrations of about 6 mg/L to survive and 7 mg/L to spawn. Carp can survive to dissolved oxygen concentrations of 1 mg/L, although they suffer at concentrations below 3 mg/L http://web.utk.edu/~rstrange/wfs550/html-con-pages/I-oxygen-in-blood.html).

How persistent/reversible is this stressor?

Most surface waters are sufficiently mixed so that oxygen is constantly reintroduced near the water surface. Deeper mixing is required to introduce oxygen to deeper depths. As organic matter is utilized, a water body can be quickly re-oxygenated and the stress on the ecosystem and organisms will be relieved. If organisms die, however, the ecosystem may not recover or may take many years to recover.

1.7. Toxic Organic Chemicals

What are the primary chemicals of concern for this stressor?

A large number of organic chemicals impact aquatic organisms. These include pesticides from agricultural and urban use; PAHs, dioxins, VOCs, and furans from area source combustion and industry; petroleum from spills; and a variety of chemicals in municipal and industrial wastewater, including endocrine-disrupting chemicals.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Few data sets allow us to assess general concentrations of toxic organic chemicals in the environment. There are numerous local and regional studies (http://www.science.mcmaster.ca/Biology/Harbour/WQORGAN/ORG10.HTM; http://www.ns.ec.gc.ca/epb/envfacts/pah.html; http://www.epa.gov/glnpo/rptcong/chap6.html), but these are typically skewed toward high concentrations of organic chemicals since most are conducted in areas experiencing problems with the aquatic environment. There is sufficient data to indicate the widespread occurrence of organic chemicals in aquatic ecosystems, however. Examples include the occurrence of chlorinated pesticides and PCBs in aquatic sediments (http://water.wr.usgs.gov/pnsp/pest.rep/sed.html), the widespread occurrence of atrazine in rivers of southern Minnesota (http://water.usgs.gov/pubs/circ/circ1210/), and the occurrence of toxaphene in the Great Lakes (http://es.epa.gov/ncer_abstracts/grants/96/air/swackh.html). It is difficult to assess the extent to which benchmarks are exceeded because there are few benchmarks for aquatic ecosystems and monitoring typically occurs only in areas where benchmarks are approached or exceeded (i.e. problem or potential problem areas).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Effects on aquatic organism vary widely from population kills to more subtle effects associated with prolonged exposure and buildup of these chemicals in tissue. Documented effects include narcotic toxicity (http://www.iras.uu.nl/research/projects_envtox_and_chem/et02.html), reproductive failure (http://research.esd.ornl.gov/CRERP/DOCS/ER_8.HTM), and endocrine disruption in aquatic animals (http://endocrine.ei.jrc.it/gedri/pack_edri.AgentsOrg?p_ageorg=Phthalates), and toxic

effects on aquatic plants
(http://www.epa.gov/oppfead1/cb/csb_page/updates/atrazasses.htm).

How persistent/reversible is this stressor?

Many organic chemicals are very persistent, particularly PAHs and halogenated chemicals such as PCBs, insecticides, and dioxins (http://water.usgs.gov/pubs/circ/circ1133/pesticides.html; http://www.oehha.ca.gov/air/hot_spots/pdf/apeng.pdf). Unless exposure to these chemicals is reduced, such as through sediment burial, the stressor effects only slowly decrease. Many other chemicals, including most herbicides, nonhalogenated chemicals, and some insecticides (e.g. carbamates and organophosphate) have relatively short half-lives (http://ace.orst.edu/info/extoxnet/tibs/movement.htm). Studies of ecosystem recovery following disturbance indicate that recovery can be slow and complex. Often, a particular element of the ecosystem, such as a nutrient or vegetation, will limit recovery and lead to a relatively long period of recovery (http://biology.usgs.gov/s+t/SNT/noframe/np105.htm; http://www.gsenet.org/library/08for/aciddepo.htm; http://www.ornl.gov/ORNLReview/rev27-3/text/envmain.htm).

1.8. Toxic Metals

What are the primary chemicals of concern for this stressor?

A large number of metals and metal-like chemicals (metalloids) can adversely impact aquatic organisms. The most important metals and metalloids are aluminum, copper, cadmium, chromium, lead, arsenic, boron, zinc, silver, mercury, and nickel.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Concentrations of metals and metalloids, with the exception of mercury, are typically below aquatic health benchmarks in 'ambient' aquatic ecosystems. There is limited data for trace metal concentrations in surface water. Bed sediment and tissue studies are the primary means which trace elements and hydrophobic organic compounds are assessed because concentrations of these constituents are generally greater in sediments and fish tissues than in water (http://mn.water.usgs.gov/umis/sw_bed.html). Some sediment benchmarks have been derived by various agencies and these may be applied to regulated sites in Minnesota. 'Typical' background concentrations of most metals are below benchmarks, although there a wide variety of benchmarks that could be applied (http://www.pca.state.mn.us/water/sediments/links-assessment.html#guidelines; (http://www.pca.state.mn.us/water/sediments/index.html; http://www.pca.state.mn.us/water/pubs/sediment.pdf; http://www.umesc.usgs.gov/data_library/sediment_contaminants/sediment_contaminant_page.html; http://mn.usgs.gov/redn/abs/meb8.html). In addition to sediment and tissue sampling, biological communities are studied to determine ecosystem health (http://mn.water.usgs.gov/umis/bio_objective.html). The benchmark in this case may be a reference site or condition that can be compared to the site of interest. Results of these studies, however, are difficult to relate to the presence of toxic metals. There are several locations in Minnesota where sediments are impacted, including the St. Louis and Mississippi Rivers (http://www.pca.state.mn.us/water/sediments/index.html). There are 27 mercury-impacted water bodies on Minnesota's proposed TMDL list http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf). These largely occur in northeastern Minnesota, in addition to locations along the Mississippi River and the Minnesota River. The most commonly used benchmarks for surface water are Aquatic Life Standards, which include both acute and chronic benchmarks for a variety of waters.

What effects on aquatic organisms are associated with excess exposure to these chemicals?

There is a large amount of material in the literature regarding effects of toxic metals on aquatic ecosystems (http://www.cciw.ca/nwri/aeprb/psefp.html; http://www.dartmouth.edu/~toxmetal/RSCRaq.htm; http://www.dartmouth.edu/~toxmetal/RSCRaq.htm; http://www.biology.sdu.dk/gb/research_groups/ecotox/gruppe.html#tracemetal). Effects on aquatic organisms vary with each chemical and range from toxicity to changes in reproduction, nutrient cycling, physiology, and so on. Some toxic metals accumulate through the food chain and are biomagnified, while others have immediate toxic effects.

How persistent/reversible is this stressor?

Most metals do not readily partition into either the water or air phase and therefore partition into the sediment (solid) phase. Although metals in the solid phase are typically much less bioavailable than metals in the water column, they persist indefinitely in sediments. Thus, they may re-enter the water column as a result of disturbance of the sediments, because of natural cycling that occurs, because of changes in geochemistry, and so on. Assessing the persistence of metals is therefore complex. Without disturbance, cycling, or some other factor that release metals from sediments, typical sedimentation half-lives for metals range from about 10 days to ½ year (http://www.trentu.ca/academic/aminss/envmodel/CEMC200104.pdf).

1.9. Ammonia

What are the primary chemicals of concern for this stressor?

Ammonia.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Direct toxic effects are the basis for the un-ionized ammonia chronic standards shown below:

- Class 2A. 0.016 mg/L un-ionized ammonia
- Class 2Bd, B, C, D. 0.04 mg/L un-ionized ammonia

The fraction of total ammonia in the un-ionized ammonia in water is dependent on ambient pH and temperature (http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf; http://www.thekrib.com/Chemistry/ammonia-toxicity.html; http://www.cryotech.com/urea.html). There were 14 sampling locations on Minnesota streams and rivers that were listed on the 1998 TMDL list for ammonia concentrations.

The locations were scattered throughout southern and western Minnesota, with several sites located on the Minnesota River (http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Ammonia in the un-ionized form (NH3) is toxic to aquatic life. When water column concentrations of un-ionized ammonia exceed water quality standards, sensitive species, and particularly the sensitive early life stages of fish (post-hatch fry) will show sublethal adverse effects. At higher concentrations, mortality can occur. Ammonia can have an indirect impact on aquatic life as well because the bacteria that oxidize ammonia to nitrite and nitrate require significant oxygen resources. Too much ammonia in the water, such as might occur after a spill of wastewater, can reduce oxygen levels to the point that fish kills occur. (http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf; http://ohioline.osu.edu/b896/b896_2.html).

How persistent/reversible is this stressor?

Ammonia is typically oxidized quickly in aerated waters. This reaction, however, can lead to oxygen depletion. Ammonia also readily volatilizes, so that mixing can lead to a reduction of ammonia. Plants can utilize ammonia and are less sensitive to ammonia than animals. In stagnant, anaerobic waters, ammonia can persist at concentrations that are toxic to fish (http://www.cryotech.com/urea.html; http://www.discoverycube.org/programs/nitrates.htm; http://www.mhbriverwatch.dst.mn.us/river_watch/plan.html).

1.10. Dissolved Solids

What are the primary chemicals of concern for this stressor?

Dissolved solids may include suspended solids that may or may not pass through a filter. Some dissolved solids come from organic sources such as leaves, silt, plankton, and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter, and fertilizers and pesticides used on lawns and farms. Some dissolved solids come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron, phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge. Salts containing chloride are the primary chemicals of concern (http://www.leo.lehigh.edu/envirosci/watershed/wq/wqbackground/tdsbg.html).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

There is limited information available about concentrations of dissolved solids that will adversely affect aquatic organisms. Concentrations of several thousand mg/L are lethal to organisms (http://www.nevadaaudubon.org/pospaper2.htm). Clean water has low amounts of dissolved solids. Clear water is water that contains less than 50 ppm dissolved solids. Concentrations exceeding 500 ppm for any monthly average is unacceptable. Instantaneous concentrations should not be over 750 ppm (http://www.ems.psu.edu/HAMS/param.html; http://www.lcra.org/lands/wrp/edu/vm_wqindicators.htm#TDS). The only monitoring stations where dissolved solids are measured are located on the Mississippi River. At 36 monitored sites, only one site was considered not sustaining its intended use for aquatic life based on high concentrations of dissolved solids. Decreasing trends in concentration were observed at 54 percent of sampled sites, with no trend at 41 percent of sampled sites. The standard for chloride is 230 mg/L (http://www.pca.state.mn.us/water/basins/305briver.html#map; http://www.pca.state.mn.us/publications/tmdl-guidancemanual.pdf).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

A constant level of minerals in the water is necessary for aquatic life. Changes in the amounts of dissolved solids can be harmful because the density of total dissolved solids determines the flow of water in and out of an organism's cells. Concentration of total dissolved solids that are too high or too low may limit growth and lead to death. High concentrations of total dissolved solids may reduce water clarity, which contributes to a decrease in photosynthesis and leads to an increase in water temperature. Many aquatic organisms cannot survive in high temperatures. It is possible for dissolved ions to affect the pH of a water body, which in turn may influence the overall health of many aquatic species. If TDS levels are high, especially due to dissolved salts, many forms of aquatic life are affected (http://www.leo.lehigh.edu/envirosci/watershed/wq/wqbackground/tdsbg.html; http://www.lcra.org/lands/wrp/edu/vm_wqindicators.htm; http://bcn.boulder.co.us/basin/natural/wqterms.html#ts; http://www.cotf.edu/ete/modules/waterq3/WQassess4g.html; http://www.earthforce.org/green/solids/main.cfm).

How persistent/reversible is this stressor?

Dissolved solid concentrations are primarily decreased through dilution. Consequently, if a source for dissolved solids exists, high concentrations of dissolved solids will persist.

1.11. Acid deposition

What are the primary chemicals of concern for this stressor?

Sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are the primary chemicals of concern for acid deposition (http://www.epa.gov/airmarkets/acidrain/#what; http://www.ems.psu.edu/info/explore/AcidRain.html).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

In 1986, Minnesota became the first state to set an acid deposition standard to protect sensitive aquatic and terrestrial ecosystems. The standard limited the amount of sulfate in precipitation to an annual load of 11 kilograms per hectare (kg/ha), or about 10 pounds per acre. Sulfate deposition is monitored under the National Atmospheric Deposition Program (NADP). Representative deposition data show a general decline since the 1970s. Emissions of SO_2 in Minnesota decreased until the middle 1990's when increased coal consumption by electric utilities caused overall emission levels to increase. Nationally, emissions have continued to decrease due to implementation of the federal acid rain program in a utility sector that is relatively dirty compared with Minnesota electric utilities. Although emissions have increased, monitored levels have decreased most likely because the increased emissions have been at relatively remote power plants with high stacks that disperse emissions effectively. Monitors are located in populated areas. Monitored levels remain comfortably below standards with little future risk of violating standards unless sulfur emissions from coal combustion increase dramatically (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf). Nitrogen oxides are regulated differently. The Acid Rain Program reduces NO_x emissions by designating an emission rate for each source. However, total national emissions of NO_x have not declined, although NO_x emission rates from individual plants have declined, because electricity production and vehicle use have increased. In 1990, Congress created the Acid Rain Program under Title IV of the 1990 Clean Air Act Amendments (CAAA). CAAA required significant reductions of SO_2 and NO_x emissions from electric utilities. By 2010, utilities would need to lower their emissions by about half (8.5 million tons) compared to 1980 levels. They would also need to reduce their NO_x emissions by 2 million tons below what they would have been without the Acid Rain Program (beginning in 2000)(http://www.pca.state.mn.us/publications/aq1-11.pdf). Monitored NO_2 levels are currently about one third of the annual NO_2 standard. Although NO_x emissions have increased and may increase further due to increased vehicle travel increased fuel combustion, it is unlikely that these increases will pose a threat to the annual NO_2 standard (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf).

What effects on aquatic organisms are associated with excess exposure to these chemicals?

Acid deposition causes acidification of lakes and streams (http://www.epa.gov/airmarkets/acidrain/effects/index.html). Acid directly interferes with the ability of fish to take in oxygen, salt, and other nutrients needed to stay alive. Acidic conditions in the water cause mucus to form in the gills of fish, and prevents them from absorbing oxygen from the surrounding waters. With a few exceptions, adult fish are unable to survive in waters with a pH below 4.8. However, fish eggs and baby fish are unable to survive pH values below 5.5. If reproduction is not possible, a given fish population will eventually die off even if the pH is not low enough to kill the adult fish. An indirect effect of acid deposition on aquatic life is the presence of the aluminum ion (Al^{++}). Al^{++} burns the gills of the fish and accumulates in their organs. Although the fish may be able to survive a pH of 5.9, this pH is strong enough to release aluminum ions, and this will eventually kill the fish (http://www.ems.psu.edu/info/explore/AcidRain.html). Acid deposition may also affect the interactions between living organisms and the chemistry of their aquatic habitats. As the water pH approaches 6.0, crustaceans, insects, and some plankton species begin to disappear. As pH approaches 5.0, major changes in the makeup of the plankton community occur, less desirable species of mosses and plankton may begin to invade, and the progressive loss of some fish populations is likely, with the more highly valued species being generally the least tolerant of acidity. Below pH of 5.0, the water is largely devoid of fish, the bottom is covered with undecayed material, and the nearshore areas may be dominated by mosses (http://www.ns.ec.gc.ca/msc/as/acidfaq.html).

How persistent/reversible is this stressor?
A UW-Madison study in Wisconsin found that while lake chemistry corrected itself naturally and quickly, biological changes took much longer to bounce back. It took about 18 years for the northern Wisconsin lake to return to its natural condition after its pH levels were dramatically altered beginning in 1984. From 1984 to 1990, the test basin was taken from an original pH of 6.1 down in two-year intervals to 5.6, 5.2 and 4.7. Then it was allowed to recover without intervention. The biological changes lagged behind the chemistry, taking several years longer to reach its previous balance. Other studies of northeast U.S. lakes have found little improvement in pH levels (http://www.news.wisc.edu/view.html?get=5150).

1.12. Excess UV from Stratospheric Ozone Depletion

What are the primary chemicals of concern for this stressor?

Chlorofluorocarbons, hydochlorofluorocarbons, 1,1,1-trichloroethane, methyl bromide, carbon tetrachloride, methylene chloride, halons, and hydrobromofluorocarbons.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Ozone is naturally found in a thin layer in the stratosphere (a layer 15-30 kilometers above the earth's surface). This layer normally absorbs a portion of ultraviolet light called UVB and prevents it from reaching the earth.

Ozone is very reactive and is constantly being formed and destroyed in the stratosphere. The total amount normally remains relatively stable. However, halogens such as chlorine and bromine can act as catalysts in the destruction of ozone, resulting in the net effect that ozone is destroyed faster than it is naturally created.

The chemicals of concern such as CFCs are very stable, so they are able to reach the stratosphere after being released. Once they reach the stratosphere, they are broken down by UV radiation and chlorine and bromine is released. The chlorine and bromine then catalyze the destruction of ozone and result in a net loss of stratospheric ozone. Therefore, less UVB radiation is absorbed and more reaches the earth.

Different chemicals of concern have different ozone depleting potentials (ODPs) and different half-lives. For example, CFC-11 has an ODP of 1, while HCFC-141b has an ODP of 0.1. This means that a molecule of CFC-11 can destroy ten times as much ozone as HCFC-141b. In addition, CFC-11 has an atmospheric lifetime of 70 years while carbon tetrachloride has an atmospheric lifetime of about 10 years.

What effects on aquatic organisms are associated with excess exposure to these chemicals?

All of the effects from stratospheric ozone depletion are the result of increased exposure of aquatic organisms to UV radiation.

Aquatic Animals-- Solar UV-B radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians and other animals. The most severe effects are decreased reproductive capacity and impaired larval development. Even at current levels, solar UV-B radiation is a limiting factor, and small increases in UV-B exposure could result in significant reduction in the size of organism populations. Even incremental increases or temporary fluctuations in UV-B may affect relatively sensitive species.

Aquatic Plants--Phytoplankton form the foundation on which the very survival of aquatic food webs depends. It has been estimated that a 16% ozone depletion could result in a 5% loss in phytoplankton. Exposure to solar UV-B radiation has been shown to affect both orientation mechanisms and motility in phytoplankton, resulting in reduced survival rates for these organisms. There are likewise possible effects on plant photosynthesis, genetic material, morphology, and growth. Researchers have directly measured the increase in, and penetration of, UV-B radiation in Antarctic waters, and have provided conclusive evidence of direct effects within natural phytoplankton communities. Biological effects of small changes in UV-B exposure may be difficult to determine because the biological uncertainties and variations are large, and the baseline productivity for pre-ozone-loss eras is not well established.

How persistent/reversible is this stressor?

Many of the chemicals of concern have very long atmospheric lives, up to 110 years (CFC 12). Currently, we are experiencing depletion of approximately 5 percent at mid-latitudes, but if no action had been taken to limit CFCs, ozone depletion at mid-latitudes would eventually have reached 20 percent or more. If international agreements (such as the Montreal Protocol) are adhered to, the ozone layer is expected to recover around 2050.

References:

- The EPA Ozone Depletion Website: http://www.epa.gov/ozone/index.html
- UNITED NATIONS ENVIRONMENT PROGRAMME ENVIRONMENTAL EFFECTS OF OZONE DEPLETION: 1994 ASSESSMENT. November 1994. http://sedac.ciesin.org/ozone/UNEP/UNEP94toc.html
- Environmental Chemistry 2nd edition, Nigel Bunce, Wuerz Publishing Ltd. Winnipeg, Canada.

2. Ecosystem Impacts-Terrestrial Organisms

2.1. Habitat Modification

What are the primary chemicals of concern for this stressor?

There are no chemicals associated with habitat modification. Activities that result in habitat modification and can have negative effects on terrestrial ecosystems include development (urban, suburban, and lake-shore), crop production (agriculture), silvaculture, and mining (http://www.orst.edu/instruct/fw251/notebook/habitat.html; http://www.nwf.org/lakesuperior/habitat.html; http://www.endangeredspecie.com/).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Benchmarks do not exist for habitat modification. Defining critical habitat requirements is also difficult, primarily due to inadequate data for many important species. This data includes characterization of many habitat-species interactions that are necessary for successful growth, reproduction, and survival of rare and endangered organisms (http://www.nps.gov/noca/Ltem/AH_Text.htm; http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_10.shtml). Extent and rates of modification are perhaps the best way to evaluate the occurrence of this stressor. Timber production has increased from 2.3 million cords in 1980 to 3.8 million cords in 1999, although the rate of harvest was nearly steady in the 1990's (http://www.mnplan.state.mn.us/mm/indicator.html?Id=60&G=39). The number of acres of cropland decreased between 1982 and 1997 while the number of acres of grassland increased. Nevertheless, there were 21,414,000 acres of cropland in Minnesota in 1997, compared to 4,978,000 acres of grassland. One potential concern is the increase in acres of urban land. The number of urban acres increased by about 27 percent between 1982 and 1997, with a total of 2,186,000 acres in urban land in 1997. Although urban land increased by 27 percent, the state's population increased only 14 percent over the same time period (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41). Over the same time period, the number of highway miles driven increased almost 48 percent, resulting in an increased demand for roads and highways. Other affects of increased driving are mortality among terrestrial organisms, alteration of physical and chemical environments, and spread of exotic organisms (http://www.defenders.org/habitat/highways/new/ecology.html; http://www.wildlandscpr.org/resourcelibrary/reports/wade_report2.html). Another measure of habitat destruction are lists of endangered species, since many of these organisms are endangered because of habitat destruction. In Minnesota, there are 14 endangered animals and 8 endangered plants (http://www.endangeredspecie.com/states/mn.htm).

What effects on terrestrial organisms are associated with excess exposure to these chemicals?

Habitat modification typically leads to decreases or elimination in populations or species. This may occur directly through loss of habitat or by changes in ecosystem functioning. These changes lead to a gradual decrease in ecosystem health (Kaiser et al.; http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_10.shtml; http://www.epa.state.oh.us/dsw/watershed/causetbl.htm; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch4-4.pdf; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch4-4.pdf).

How persistent/reversible is this stressor?

There is general agreement that impacts from habitat modification are slowly reversible or irreversible. Reestablishment of habitat is difficult and may take considerable time, if it can be done at all. Since the primary effect of habitat modification is reduction of or elimination of species or populations, even restoration of habitat may not lead to restoration or full recovery of the terrestrial ecosystem.

2.2. Temperature Increase/Climate Change

What are the primary chemicals of concern for this stressor?

The main anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tropospheric ozone (O_3), and several chlorofluorocarbon (CFC) refrigerants. There are many less important greenhouse gases, including carbon tetrachloride (CCl_4) and sulfur hexafluoride (SF_6). These chemicals absorb infrared light and heat in the atmosphere and warm the surrounding air. Resultant thermal emissions cause surface temperatures to increase.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Health benchmarks (related to climate change) do not exist for these chemicals. It is the effect of increased concentrations of these chemicals in the atmosphere that cause negative impacts, not necessarily direct exposure to the chemicals themselves. Atmospheric concentrations of CO_2 (33%), CH_4 (142%), N_2O (13%), and O_3 (100%) have increased drastically over pre-industrial levels. Man-made chemicals, such as CFCs, were not present at all in the atmosphere prior to industrialization, but some are now measured at hundreds of parts per trillion.

What effects on terrestrial organisms are associated with excess exposure to these chemicals?

Although we can predict a range of possible temperature increases, efforts to assess the specific consequences of climate change are not complete. Estimates of general impact trends are available. Ecosystems in northern states that are adapted to cooler temperatures may be very sensitive to any ambient warming. Forested areas are very likely to be affected by ecosystem shifts. The resulting habitat alteration will impact the health of terrestrial species. Extreme events, such as flooding or severe droughts, would also negatively impact terrestrial species.

How persistent/reversible is this stressor?

Greenhouse gases have atmospheric lifetimes ranging from 5 to 50,000 years, depending on the chemical and atmospheric removal processes. The most common greenhouse gas, carbon dioxide, persists in the atmosphere for 500 years. The duration of the warming effect from these pollutants in the atmosphere depends on the timing and effectiveness of control strategies designed to reduce the emissions of these chemicals. If, for example, emission levels increased at current rates until 2100 and then were linearly phased out, temperatures would still not return to current levels (and certainly not pre-industrial levels) for more than 500 years, and possibly much longer.

References:

- Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix H: Global Climate Change.*

http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html. Accessed 2/6/02.

- http://www.pca.state.mn.us/hot/globalwarming.html

2.3. Toxic Organic Chemicals

What are the primary chemicals of concern for this stressor?

A large number of organic chemicals can impact terrestrial organisms. These include pesticides from agricultural and urban use; PAHs, dioxins, and furans from area source combustion and industry; and petroleum from spills. Some organic chemicals, such as PCBs, accumulate in the food chain.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

There is little information showing the concentrations of toxic organic chemicals in terrestrial ecosystems. Several studies indicate that persistent organic chemicals released to the atmosphere, such as PAHs and dioxins, are found at relatively low concentrations in most terrestrial ecosystems. There are few benchmarks for comparison. Since air deposition is an important source of toxic organic chemicals, trends in emissions may be an indicator of concentrations in terrestrial ecosystems. Emissions of most persistent organic chemicals has decreased in the past 20 years (http://www.unido.org/ssites/env/envlearn/LUthree6011.html; http://ceq.eh.doe.gov/nepa/reports/statistics/tab7x9.html; http://www.ping.be/~ping5859/Eng/ChlorineDiSrc.html).

What effects on terrestrial organisms are associated with excess exposure to these chemicals?

There are few studies that present information on impacts of organic chemicals on terrestrial organisms. Many of the same effects discussed for aquatic organism are likely to apply for terrestrial organisms (see Section 1.7).

How persistent/reversible is this stressor?

Many organic chemicals are very persistent, particularly PAHs and halogenated chemicals such as PCBs, insecticides, and dioxins (http://water.usgs.gov/pubs/circ/circ1133/pesticides.html; http://www.oehha.ca.gov/air/hot_spots/pdf/apeng.pdf). Unless exposure to these chemicals is reduced, such as through sediment burial, the stressor effects only slowly decrease. Many other chemicals, including most herbicides, nonhalogenated chemicals, and some insecticides (e.g. carbamates and organophosphate) have relatively short half-lives (http://ace.orst.edu/info/extoxnet/tibs/movement.htm). Studies of ecosystem recovery following disturbance indicate that recovery can be slow and complex. Often, a particular element of the ecosystem, such as a nutrient or vegetation, will limit recovery and lead to a relatively long period of recovery (http://biology.usgs.gov/s+t/SNT/noframe/np105.htm; http://www.gsenet.org/library/08for/aciddepo.htm; http://www.ornl.gov/ORNLReview/rev27-3/text/envmain.htm).

2.4. Nitrogen

What are the primary chemicals of concern for this stressor?

Nitrate (NO_3) and to a lesser extent, its reduced form, nitrite (NO_2)

What concentrations of these chemicals and benchmark exceedances are we seeing?

Minnesota is a major contributor to environmental releases of nitrogen. We are the sixth largest user of nitrogen fertilizers in the United States. Over 600,000 tons of nitrogen fertilizer are applied annually in the state, roughly 5.5 percent of the national total (http://www.pca.state.mn.us/programs/indicators/iom-0901.html). The heavily-agriculturalized Minnesota River Basin is a large contributor of nitrate-nitrogen to the Mississippi River (and hence, the Gulf of Mexico) with >1,000 kilograms per square kilometer per year contributed.
(http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.135-00.fig6.gif)

What effects on aquatic and terrestrial organisms are associated with excess exposure to nitrogen?

Nitrogen is an essential element for all life, although in excessive amounts, it can be toxic to various forms of life. Nitrogen contributes to eutrophication of lakes, rivers, and oceans; contamination of ground water which may then interact with surface water; development of "dead zones" in oceans and seas because of hypoxia; acidification or other modification of terrestrial and aquatic ecosystems; and global warming. Ingestion of nitrate in excess of 10 mg/l in a water supply can cause methemoglobinemia (blue-baby disease), which affects humans six months of age or younger and may affect young farm animals.
(http://www.pca.state.mn.us/programs/indicators/iom-0901.html)

How persistent/reversible is this stressor?

Nitrate is the primary oxidized form of nitrogen in water. It is soluble (dissolves) in water and may be found in high concentrations if a source of nitrogen and oxygen is present. Most nitrate which enters water comes from anthropogenic (human-derived) sources such as atmospheric deposition of nitrous oxides associated with the combustion of coal and gas, land application of animal manure at farms, and application of fertilizers to agricultural crops and urban yards. Nitrate in shallow ground water can interact with surface water, contributing to problems for terrestrial and aquatic organisms. In well-oxygenated water, various forms of nitrogen such as nitrogen gas, ammonia and nitrite are usually converted quickly to nitrate. However, in the absence of oxygen (reducing conditions) ammonia can be a concern if there are sources of ammonia available to a water supply. Nitrate and ammonia can occur together in reducing waters when a source of nitrogen is nearby, such as a leaking waste lagoon, a poorly-managed feedlot, or a failed septic system.
(http://www.pca.state.mn.us/water/groundwater/pubs/nitrate.pdf)

2.5. Ground-level Ozone

What are the primary chemicals of concern for this stressor?

Ozone

What concentrations of these chemicals and benchmark exceedances are we seeing?

MPCA monitors for ozone in Lake County, St. Louis County, Mille Lacs and the Twin Cities metropolitan area. The values from these monitors are compared to the National Ambient Air Quality Standards (NAAQS). NAAQS include both primary and secondary standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. The primary and secondary NAAQS for ozone are the same: an 8-hour standard of 0.08 ppm (157 $\mu g/m^3$) and a 1-hour standard of .012 ppm (235 $\mu g/m^3$).

Second maximum 1-hour monitored ozone levels in Minnesota in 2000 ranged from 0.72 ppm (Lake County) to 0.087 ppm (Blaine). Fourth maximum 8-hour levels in 2000 ranged from 0.07 ppm (Stillwater) to 0.064 ppm (Anoka County). In 2001, there have been individual 8-hour ozone concentrations above 0.08 ppm. However, because the standard is a 3-year average of 4th daily maximums, no actual exceedences of the standard have been measured.

Although the secondary NAAQS for ozone have not been exceeded, damage can occur to terrestrial organisms at levels below the NAAQS. In fact, ambient ozone concentrations as low as 0.04 ppm can impair growth and yield of plants.

(Monitoring Data information from EPA AIR*Data*, August 2001 & MPCA monitoring data. Note: Only Twin Cities data was available for the 8-hr averaging period)

What effects on aquatic and terrestrial organisms are associated with excess exposure to ozone?

Exposure to tropospheric ozone can cause injury and premature mortality of plant tissues after entering the plant because ozone has strong oxidizing properties and reacts with cellular components. Ground-level ozone interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, and harsh weather. Ozone reduces crop and forest yields and reduces growth and survivability of tree seedlings. In long-lived species, these effects may become evident only after several years or even decades, thus having the potential for long-term effects on forest ecosystems.

Studies indicate that at least 50% of crops studied will exhibit a 10% yield loss at 7 hour seasonal mean ozone concentrations of 0.05 ppm or less.

Currently, most ozone information is based on individual plants or their parts. Little is known about how, and to what extent, effects may be propagated through the different hierarchical levels within natural and forest ecosystems.

How persistent/reversible is this stressor?

Ground-level ozone forms from the reaction of nitrogen oxides, volatile organic compounds in sunlight and heat. Ozone reacts rapidly with nitric oxide (NO), therefore, the atmosphere cleans itself in a few days once the pollution source is removed.

However, ozone can be transported long distances from urban areas. Concentrations of ozone in polluted air masses often remain high for relatively prolonged periods in rural areas, increasing the concern over effects on agriculture, forests, and native ecosystems.

References:

- How Ground-level Ozone Affects the Way We Live and Breathe, US EPA, Office of Air Quality Planning & Standards, November 2000, http://www.epa.gov/air/urbanair/ozone/hlth.html
- Latest Findings on National Air Quality: 2000 Status and Trends, US EPA, September 2001, http://www.epa.gov/air/aqtrnd00/gndozone.html
- Air Quality Criteria for Ozone and Related Photochemical Oxidants, US EPA, Office of Research and Development, July 1996, EPA/600/P-93/004bF

2.6. Toxic Metals

What are the primary chemicals of concern for this stressor?

A large number of metals and metal-like chemicals (metalloids) can adversely impact terrestrial organisms. The most important metals and metalloids are aluminum, copper, cadmium, chromium, lead, arsenic, boron, zinc, silver, mercury, and nickel.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

There is limited information on concentrations of metals in the environment. There are several studies of trace metal concentrations in Minnesota soils, although these studies are generally local (Mielke et al. 1991. The pattern of cadmium in the environment of five Minnesota cities. Environ. Geochem. Health. 13:29-34; Mielke et al. 1983. Lead concentrations in inner-city soils as a factor in the child lead problem. Amer. Jour. Pub. Health. 73:1366-1369; Mielke et al. 1989. Soil-dust lead and childhood lead exposure as a function of city-size and community traffic flow: The case for lead abatement in Minnesota. Environ. Geochem. Health. 9:243-271; Mielke et al. 1984/85. Urban lead in Minnesota. Soil transect results of four cities. Journal of the Minnesota Academy of Science. 50:19-24.; Fruin et al. 1994. Minnesota Pollution Control Agency and Minnesota Department of Health. 1987. Soil Lead Report to the Minnesota State Legislature; Pierce, F.J., R.H. Dowdy, and D.F. Grigal. 1982. Concentrations of six trace metals in some major Minnesota Soil Series. J. Environ. Qual. 11:416-422). Ecological soil screening values are in their early development, but comparison with ambient soil metal concentrations seems to indicate that metal concentrations in Minnesota soils are below criteria (http://www.epa.gov/superfund/programs/risk/ecorisk/exhibits/exhibit10.pdf; http://www.tiem.utk.edu/~sada/soil_benchmarks.html; http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm). Metal contamination of soil therefore appears to be restricted to localized areas near point or nonpoint sources. Except for these sites, the primary metal of concern in Minnesota is mercury.

Mercury is a volatile metal that is released to the atmosphere from a variety of human and natural sources. Once in the atmosphere, mercury can be deposited in aquatic and terrestrial ecosystems. Mercury has the potential to accumulate in the food chain and thus impact terrestrial organisms (http://books.nap.edu/books/0309071402/html/1.html#pagetop). Minnesota has fish consumption advisories for lakes and rivers (http://www.pca.state.mn.us/air/mercury-about.html). There are 27 mercury-impacted water bodies on Minnesota's proposed TMDL list (http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf). These largely occur in northeastern Minnesota, in addition to locations along the Mississippi River and the Minnesota River.

What effects on terrestrial organisms are associated with excess exposure to these chemicals?

Effects of metals on terrestrial organisms vary with individual metals. Aluminum, for example, can be toxic to roots, while lead and vanadium can damage leaf tissue. In general, high metal concentrations can reduce the productivity of terrestrial ecosystems, but do not have severe impacts unless concentrations exceed benchmarks (http://www.icsu-scope.org/downloadpubs/scope45/ch06-6.3.html). Acid rain is one situation where metal concentrations can adversely impact terrestrial ecosystems, since most metals have greater activity and mobility at lower pH. Mercury that builds up through the food chain can have adverse impacts on organisms (e.g. waterfowl, bald eagles) that consume mercury faster than their bodies can eliminate it. These effects appear limited in Minnesota, however, and are most likely in northeastern Minnesota (http://www.pca.state.mn.us/air/mercury-about.html).

How persistent/reversible is this stressor?

As discussed in Section 1.8, most metals preferentially partition to the solid phase. Once in soil, they can be tightly bound and not readily bioavailable. Thus, while metals persist indefinitely in soil, their bioavailability decreases rapidly and effects on terrestrial organisms do not persist, unless some mechanism for recycling metals is introduced into the ecosystem (http://www.cpha.net/hvymtl03.htm ; http://www.state.ma.us/dep/bwsc/files/workgrps/numbers/uptakref.doc; http://es.epa.gov/ncer/progress/centers/schwab.html).

2.7. Acid Deposition

What are the primary chemicals of concern for this stressor?

Sulfur dioxide (SO2) and nitrogen oxides (NOx) are the primary chemicals of concern for acid deposition (http://www.epa.gov/airmarkets/acidrain/#what; http://www.ems.psu.edu/info/explore/AcidRain.html).

What concentrations of these chemicals and health benchmark exceedances are we seeing?

In 1986, Minnesota became the first state to set an acid deposition standard to protect sensitive aquatic and terrestrial ecosystems. The standard limited the amount of sulfate in precipitation to an annual load of 11 kilograms per hectare (kg/ha), or about 10 pounds per acre. Sulfate deposition is monitored under the National Atmospheric Deposition Program (NADP). Representative deposition data show a general decline since the 1970s. Emissions of SO_2 in Minnesota decreased until the middle 1990's when increased coal consumption by electric utilities caused overall emission levels to increase. Nationally, emissions have continued to decrease due to implementation of the federal acid rain program in a utility sector that is relatively dirty compared with Minnesota electric utilities. Although emissions have increased, monitored levels have decreased most likely because the increases have been at relatively remote power plants with high stacks that disperse emissions effectively. Monitors are located in populated areas. Monitored levels remain comfortably below standards with little future risk of violating standards unless sulfur emissions from coal combustion increase dramatically (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf). Nitrogen oxides are regulated differently. The Acid Rain Program reduces NO_x emissions by designating an emission rate for each source. However, total national emissions of NO_x have not declined, although NO_x emission rates from individual plants have declined, because electricity production and vehicle use have increased. In 1990, Congress created the Acid Rain Program under Title IV of the 1990 Clean Air Act Amendments (CAAA). CAAA required significant reductions of SO_2 and NO_x emissions from electric utilities. By 2010, utilities would need to lower their emissions by about half (8.5 million tons) compared to 1980 levels. They would also need to reduce their NO_x emissions by 2 million tons below what they would have been without the Acid Rain Program (beginning in 2000)(http://www.pca.state.mn.us/publications/aq1-11.pdf). Monitored NO_2 levels are currently about one third of the annual NO_2 standard. Although NO_x emissions have increased and may increase further due to increased vehicle travel increased fuel combustion, it is unlikely that these increases will pose a threat to the annual NO_2 standard (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf).

What effects on terrestrial organisms are associated with excess exposure to these chemicals?

Acid deposition contributes to damage of trees at high elevations (for example, red spruce trees above 2,000 feet) and many sensitive forest soils (http://www.epa.gov/airmarkets/acidrain/effects/index.html). Both natural vegetation and crops can be affected. It can alter the protective waxy surface of leaves, lowering disease resistance. It may inhibit plant germination and reproduction. It accelerates soil weathering and removal of nutrients. It makes some toxic elements, such as aluminum, more soluble. High aluminum concentrations in soil can prevent the uptake and use of nutrients by plants. The effects on terrestrial wildlife are hard to assess. Because of pollution-induced alteration of habitat or food resources, acid deposition may cause population decline through stress (because of decreases in available resources) and lower reproductive success (http://www.ns.ec.gc.ca/msc/as/acidfaq.html). Terrestrial animals dependent on aquatic ecosystems are also affected. Waterfowl, for example, depend on aquatic organisms for nourishment and nutrients. As these food sources are reduced or eliminated, the quality of habitat declines and the reproductive success of the birds is affected (http://www.ns.ec.gc.ca/msc/as/acidfaq.html) (http://www.epa.gov/airmarkets/acidrain/effects/forests.html).

How persistent/reversible is this stressor?
There is limited information on persistence and reversibility of acid deposition on terrestrial ecosystems. There are numerous studies of acid deposition effects in forest ecosystems, however, that suggest effects are only slowly reversible (http://www.epa.gov/airmarkets/acidrain/effects/forests.html; http://www.scar.utoronto.ca/~weather/maryp/Effects/terrest.html; http://www.lehigh.edu/~kaf3/books/reporting/acid.html). As discussed in Section 1.11, impaired ecosystems require significant periods to recover. In the case of terrestrial organisms, recovery may be slow if nutrient cycling has been severely disrupted or terrestrial species have disappeared or irreversibly damaged.

2.8. Excess UV from Stratospheric Ozone Depletion

What are the primary chemicals of concern for this stressor?

Chlorofluorocarbons, hydochlorofluorocarbons, 1,1,1-trichloroethane, methyl bromide, carbon tetrachloride, methylene chloride, halons, and hydrobromofluorocarbons.

What concentrations of these chemicals and health benchmark exceedances are we seeing?

Ozone is naturally found in a thin layer in the stratosphere (a layer 15-30 kilometers above the earth's surface). This layer normally absorbs a portion of ultraviolet light called UVB and prevents it from reaching the earth.

Ozone is very reactive and is constantly being formed and destroyed in the stratosphere. The total amount normally remains relatively stable. However, halogens such as chlorine and bromine can act as catalysts in the destruction of ozone, resulting in the net effect that ozone is destroyed faster than it is naturally created.

The chemicals of concern such as CFCs are very stable, so they are able to reach the stratosphere after being released. Once they reach the stratosphere, they are broken down by UV radiation and chlorine and bromine is released. The chlorine and bromine then catalyze the destruction of ozone and result in a net loss of stratospheric ozone. Therefore, less UVB radiation is absorbed and more reaches the earth.

Different chemicals of concern have different ozone depleting potentials (ODPs) and different half-lives. For example, CFC-11 has an ODP of 1, while HCFC-141b has an ODP of 0.1. This means that a molecule of CFC-11 can destroy ten times as much ozone as HCFC-141b. In addition, CFC-11 has an atmospheric lifetime of 70 years while carbon tetrachloride has an atmospheric lifetime of about 10 years.

What effects on terrestrial organisms are associated with excess exposure to these chemicals?

All of the effects from stratospheric ozone depletion are the result of increased exposure of terrestrial organisms to UV radiation.

Terrestrial Animals-- Animals of several species develop skin cancer (mainly squamous cell carcinoma) and cancers of the eye. The body distribution is consistent with sunlight as the causal agent. Cataracts have been induced experimentally in rabbits, with the most effective wavelengths falling mainly within the UV-B range. In animals in which these effects occur under natural conditions, an increase in UV-B irradiation would be expected to exacerbate them. However, it is not possible to estimate the magnitude of such effects because of the lack of information on dose-response and on possible behavioral modifications.

Terrestrial Plants -- Physiological and developmental processes of plants are affected by UV-B radiation, even by the amount of UV-B in present-day sunlight. These effects include changes to plant photosynthesis, genetic material, morphology, and growth. Response to UV-B varies considerably among species. In agriculture, this will necessitate using cultivars that are more UV-B-tolerant and breeding new ones. In forests and grasslands, this will likely result in changes in species composition; therefore, there are implications for the biodiversity in different ecosystems. Indirect changes may be equally, or sometimes more, important. Ecosystem-level effects can be anticipated, but not easily predicted or evaluated, but are of obvious importance in both agriculture and in nonagricultural ecosystems.

How persistent/reversible is this stressor?

Many of the chemicals of concern have very long atmospheric lives, up to 110 years (CFC 12). Currently, we are experiencing depletion of approximately 5 percent at mid-latitudes, but if no action had been taken to limit CFCs, ozone depletion at mid-latitudes would eventually have reached 20 percent or more. If international agreements (such as the Montreal Protocol) are adhered to, the ozone layer is expected to recover around 2050.

References:

- The EPA Ozone Depletion Website: http://www.epa.gov/ozone/index.html
- UNITED NATIONS ENVIRONMENT PROGRAMME ENVIRONMENTAL EFFECTS OF OZONE DEPLETION: 1994 ASSESSMENT. November 1994. http://sedac.ciesin.org/ozone/UNEP/UNEP94toc.html
- Environmental Chemistry 2nd edition, Nigel Bunce, Wuerz Publishing Ltd. Winnipeg, Canada.

3. Human Health Impacts-Cancer

3.1. Particles in Air

Which chemicals of concern are analyzed?

Particulate matter is measured as PM10 (particulate matter less than 10 microns in diameter) or as PM2.5 (particulate matter less than 2.5 microns). In reality, fine particles are made up of directly emitted primary particles and secondary particles created in the atmosphere from precursor gases.

EPA's National Air Toxics Assessment (NATA) estimated emissions of diesel particles, a constituent of fine particles, and predicted ambient concentrations around the country. Diesel particles are of concern due to several studies around the country predicting higher concentrations and health risks in urban areas.

What are the concentrations of chemicals of concern and how do they compare to health benchmarks?

The MPCA monitors PM2.5 in the Boundary Waters Canoe Area for regional haze purposes and at several sites around the state to determine compliance with federal standards. Concentrations at the BWCA site are around 4.5 $\mu g/m^3$. Average concentrations in the metro area range from 11.5 to 14.5 $\mu g/m^3$.

The MPCA's monitoring network has not been in place long enough to measure trends in PM2.5. PM10 concentrations at metro monitoring locations decreased from the mid-1980s to the mid-1990s and then leveled off. PM10 levels at a monitoring site in Virginia, Minnesota remained constant since 1985.

The National Ambient Air Quality Standard (NAAQS) for PM2.5 is 15 $\mu g/m^3$. The standard is an enforceable level that areas must stay below. The US EPA standard of 15$\mu g/m^3$ is believed to be low enough to avoid the most series health impacts, but health effects will still occur below that level. The standard was set at the lowest level at which EPA felt they could show direct health effects with minimal uncertainty.

EPA's National Air Toxics Assessment predicts concentrations of diesel particles of 0.8 $\mu g/m^3$ to 12.2 $\mu g/m^3$ in the metro area, with lower concentrations in the rest of Minnesota.

What health effects are associated with excess exposure to these chemicals?

Cancer, primarily lung.

How many people are exposed to concentrations exceeding health benchmarks?

Regulatory monitoring concentrations are measured at levels that are about 90% of the applicable standard. Maximum concentrations and microenvironmental exposures may be higher than the standard, but will not trigger federal enforcement.

Health effects on susceptible individuals may occur at concentrations below the standard.

Diesel particles may be carcinogens, but neither the US EPA nor the Minnesota Department of Health has adopted a health benchmark for cancer for diesel particles. California adopted a value of 0.033 $\mu g/m^3$ but that value is not widely accepted. Modeled concentrations of diesel particles in Minnesota from EPA's National Air Toxics Assessment are predicted to be several orders of magnitude higher than California's health benchmark.

How many incidences of cancer result from exposures above criteria?

Most effects associated with fine particles are non-cancer health impacts. Recent studies indicate that fine particles may be responsible for increasing the risk of lung cancer for exposed individuals, even non-smokers. The number of cancer incidences attributable to diesel particles is not known.

How persistent/reversible is this stressor?

Particles are removed from the atmosphere by deposition to land and water or washed out of the air by rainfall.

3.2. Toxic Volatile Chemicals in Air

Which chemicals of concern are analyzed?

US EPA's National Air Toxics Assessment (NATA) analyzed emissions and used models to predict ambient concentrations and exposures for 33 air toxics and diesel PM. The pollutants are:

Acetaldehyde	Ethylene Oxide	Acrolein
Formaldehyde	Acrylonitrile	Hexachlorobenzene
Arsenic Compounds	Hydrazine	Benzene
Lead Compounds	Beryllium Compounds	Manganese Compounds
1,3-Butadiene	Mercury Compounds	Cadmium Compounds
Methylene Chloride	Carbon Tetrachloride	Nickel Compounds
Chloroform	PCBs	Chromium Compounds
Polycyclic Organic Matter	Coke Oven Emissions	Quinoline
Dioxins/Furans	1,1,2,2-Tetrachloroethane	Ethylene Dibromide
Perchloroethylene	Propylene Dichloride	Trichloroethylene
1,3-dichloropropene	Vinyl Chloride	Ethylene Dichloride

EPA's Urban Air Toxics Strategy lists these pollutants as those that are of concern in urban areas in the US.

The MPCA's air toxics emissions inventory estimated emissions for 109 pollutants for calendar year 1997, the most recent year data is available. The pollutants inventoried are on EPA's list of 188 hazardous air pollutants (HAPs). The list of pollutants was selected as part of the Great Lakes regional emissions inventory as chemicals that contribute to the contamination of the Great Lakes and/or were requested for inclusion in EPA's National Toxics Inventory.

The MPCA monitors many volatile organic carbon (VOC) compounds, carbonyl compounds, and some metals. The pollutants monitored are those for which the MPCA has a reliable method for measuring their concentration in the air. The MPCA monitoring network includes several long-term sites which have been in place since the early 1990's and a network of sites around that state that collect information for annual 'snapshots' in an effort to analyze pollutant concentrations across the state.

The MPCA does not monitor for semi-volatile chemicals due to the high cost of analysis. Many of these chemicals are persistent and bioaccumulative.

What are the concentrations of chemicals of concern and how do they compare to health benchmarks?

EPA's NATA modeling predicted concentrations of several chemicals at or above their health benchmarks, especially in the Twin Cities metro area. Modeled concentrations of benzene, 1,3-butadiene, carbon tetrachloride, chromium, formaldehyde, and diesel particles exceeded relevant health benchmarks in some or all counties in Minnesota. 1,3-butadiene concentrations were elevated due to an improper emission factor used in the emission inventory upon which the modeling was based. The model assumed all chromium emissions were hexavalent chromium.

Air toxics monitoring performed by the MPCA tended to show concentrations higher than those predicted in the NATA modeling. Details on specific chemicals are provided below.

- The mean benzene concentrations at several metro area sites exceeded the lower bound of the health benchmark ($1.3\ \mu g/m^3$). Benzene concentrations at long-term monitoring sites show a slight downward trend.
- Carbon tetrachloride concentrations appear to be decreasing over time. Recent monitoring data show concentrations below health benchmarks.
- Mean formaldehyde concentrations exceed the health benchmark across the state. The health benchmark may increase in the future due to better toxicity data. Data from the Minneapolis Public Library monitoring site showed a small downward trend in formaldehyde concentrations, but no other sites showed statistically significant trends.
- Most monitored levels of 1,3-butadiene and chromium were below the lower detection limits of the relevant monitoring methods. 1,3-butadiene breaks down rapidly in the atmosphere and may be difficult to monitor. Chromium concentrations above the lower detection limit approach the health benchmark for chromium VI, but it is not clear what percentage of ambient chromium is hexavalent.
- The MPCA does not monitor for diesel particles, but some of the fine particles will be picked up in the MPCA's PM2.5 monitoring effort.
- Lower detection limit problems also hindered the analysis of nickel, arsenic, and ethylene dibromide concentrations in Minnesota. Concentrations of these chemicals may be approaching health benchmarks, but a more sensitive monitoring technique is required.

The health benchmarks are based on the Minnesota Department of Health's proposed Health Risk Values (HRVs). The HRVs were derived based on a negligible cancer risk level of 1 in 100,000. Chemical concentrations exceeding an HRV mean that the upper bound cancer risk from that chemical is greater than 1 in 100,000, but the risk may also be zero.

<u>What health effects are associated with excess exposure to these chemicals?</u>

Cancer. It is difficult to associate specific cancers with specific chemicals.

<u>How many people are exposed to concentrations exceeding health benchmarks?</u>

Both modeling and monitoring work shows concentrations of several pollutants exceeding health benchmarks in the metro area. Local 'hot spots' also exist near sources of these chemicals. Many pollutants are also present at concentrations that are higher than background concentrations but lower than health benchmarks. The cumulative effects of these chemicals are not well understood, but there may be synergistic or additive effects.

Many people may be exposed to concentrations of these chemicals that are higher than those predicted or measured in ambient air. These 'microenvironmental' exposures include many day-to-day activities of Minnesotans. Dry cleaning, automobile refueling, and pesticide use are examples. Concentrations of several pollutants in the cabins of automobiles in traffic have been measured at higher concentrations than the corresponding ambient air.

How many incidences of cancer result from exposures above criteria?

The total number of actual cancer incidences attributable to air toxics is unknown. MPCA analysis of EPA's Cumulative Exposure Project (CEP) modeling predicted upper bound cancer risks of 2.3 to 77.3 in 100,000. If polycyclic organic matter (POM) concentrations, assuming a toxicity similar to benzo(a)pyrene, were included the upper bound cancer risk increased to 16.8 to 169.4 in 100,000. A similar analysis of the MPCA monitoring data estimated upper bound cancer risks of 6.13 to 11.04 in the metro area and 4.86 to 7.48 in the rest of the state. POM was not included in the monitoring analysis. The risk predictions assumed the effects of multiple chemicals was additive and that people were exposed to higher concentrations for 70 years. The CEP modeling was based on 1990 data. EPA's NATA modeling was based on 1996 data and predicted similar concentrations to those in the CEP. POM was not modeled in NATA.

The predicted risks are too small to see in epidemiological studies. In addition, smoking is the main driver of cancers associated with the inhalation of chemicals, often 'drowning out' the effects of other agents in epidemiological studies.

3.3. Toxic Chemicals in Food

What are the primary chemicals of concern?

Persistent bioaccumulative toxic chemicals (PBTs). PBTs include a wide range of chemicals. Many PBTs are known or suspected carcinogens, including dioxins and furans, chlorinated insecticides, chlorinated solvents, some inorganic chemicals, PAHs, and PCBs (http://www.epa.gov/pbt/fact.htm).

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Limited monitoring data and limited multipathway benchmarks exist for these chemicals. Use of many chemicals is decreasing in developed countries; probably not in developing countries or with secondary sources not addressed with regulation (for example, burning). Environmental release is still significant due to recycling of these materials in the environment. Concentrations are highest in densely populated, industrial areas, and areas with significant automobile traffic. Concentrations vary with individual chemicals. PAHs are greatest in high traffic areas, hexachlorobenzene in agricultural areas and areas near incinerators, PCBs near formulation centers, and dioxins where there are general combustion sources. USGS NAWQA studies indicate presence of chlorinated pesticides in sediment of major rivers, although many of these chemicals are banned. Concentrations in Mississippi River Basin frequently exceed freshwater criteria. Between 1975 and 1987, PCB concentrations in fish frequently exceeded the U.S. FDA guideline. Concentrations of PCBs in the environment have declined since 1987 (http://wwwmn.cr.usgs.gov/pcb/pcb.htm#abstract). Similar chemicals were observed in the Red River Basin, but at lower concentrations (http://mn.water.usgs.gov/redn/). Metal and PAH concentrations were below criteria. More research has been conducted in Europe than in the united States (http://recetox.chemi.muni.cz/PBTs/content.htm).

Most PBT pollutant releases occur between the Arctic Circle and the Tropic of Cancer where the majority of industrialized nations are located. In this area, known as the North Temperate Zone, the general population has detectable levels of dioxin in their bodies because of eating contaminated meat, fish, eggs, and dairy products. EPA's draft dioxin reassessment (1994) estimated cancer risk to the U.S. population from this background exposure to be in the 1:10,000 to 1:1,000 range. Dioxin exposure is approaching levels associated with adverse non-cancer effects (NHANES). Also, about 25 percent of children and nine percent of the general U.S. population are exposed to a level of methylmercury that exceeds the current EPA Reference Dose. Those who rely on fish as a main source of food have even higher PBT body burden levels. U.S. tribes tell the EPA that contamination of subsistence foods is their main concern. In the Arctic Zone, located north of the Arctic Circle and centered on the North Pole, PBTs are present due to long-range transport from industrialized nations and exposure of migrating species. PBT levels are substantial in the Arctic Zone and PBTs persist longer there because of the low temperatures. Levels of PBTs are expected to rise in the Arctic due to increased local and southeast Asian industrialization. Global distillation alone means decades more of PBT pollutants entering this area (Bard 1999). For many Arctic tribes, PBT contamination of subsistence foods is linked to their long term survival. PBT exposures are aggravated by the fact that high-food-chain meats are their major source of protein. Extensive recent Canadian research suggests Alaskan wildlife has high PBT levels. If confirmed, most animal protein sources are in question (http://www.epa.gov/pbt/accomp99.htm).

What health effects are associated with excess exposure to these chemicals?

Cancer. It is difficult to associate specific cancers with specific chemicals.

How many people are exposed to concentrations exceeding health benchmarks?

Unknown, since we generally do not know concentrations or have criteria. Since concentrations increase in high density areas, can assume that a significant portion of the population is exposed to elevated levels. In addition, exposure to other populations occurs through ingestion of certain foods, particularly dairy products. Risk for bioconcentrating chemicals is elevated with food ingestion compared to other pathways, since enrichment occurs in foods. Food chain introduces by far the greatest burden for dioxins, PCBs, and pesticides; unknown but likely to be high for some metals; probably less important for PAHs.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

EPA's draft dioxin reassessment (1994) estimated cancer risk to the US population from dioxin exposure to be in the 1:10,000 to 1:1,000 range (http://www.sdearthtimes.com/et0900/et0900s17.html). Estimated cancer deaths associated with environmental pollutants, primarily PBTs, are about 1 percent of all cancer deaths (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-q.pdf). US tribes tell the EPA that contamination of subsistence foods is their main concern.

3.4. Excess UV Radiation from Stratospheric Ozone Depletion

What are the primary chemicals of concern for this stressor?

Chlorofluorocarbons, hydochlorofluorocarbons, 1,1,1-trichloroethane, methyl bromide, carbon tetrachloride, methylene chloride, halons, hydrobromofluorocarbons.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Ozone is naturally found in a thin layer in the stratosphere (a layer 15-30 kilometers above the earth's surface). This layer normally absorbs a portion of ultraviolet light called UVB and prevents it from reaching the earth.

Ozone is very reactive and is constantly being formed and destroyed in the stratosphere. The total amount normally remains relatively stable. However, halogens such as chlorine and bromine can act as catalysts in the destruction of ozone, resulting in the net effect that ozone is destroyed faster than it is naturally created.

The chemicals of concern such as CFCs are very stable, so they are able to reach the stratosphere after being released. Once they reach the stratosphere, they are broken down by UV radiation and chlorine and bromine is released. The chlorine and bromine then catalyze the destruction of ozone and result in a net loss of stratospheric ozone. Therefore, less UVB radiation is absorbed and more reaches the earth.

Different chemicals of concern have different ozone depleting potentials (ODPs) and different half-lives. For example, CFC-11 has an ODP of 1, while HCFC-141b has an ODP of 0.1. This means that a molecule of CFC-11 can destroy ten times as much ozone as HCFC-141b. In addition, CFC-11 has an atmospheric lifetime of 70 years while carbon tetrachloride has an atmospheric lifetime of about 10 years.

What health effects are associated with excess exposure to these chemicals?

All of the health effects from stratospheric ozone depletion are the result of increased exposure of humans to UV radiation.

Skin Cancer -- Excessive exposure to UV radiation is associated with skin cancer in humans. There are two main types of skin cancer, non-melanoma and melanoma. Non-melanoma cancers are normally more treatable than melanoma. Non-melanoma skin cancer includes basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). SCC has a convincing and clear-cut relationship to UV-B radiation, whereas that for BCC is somewhat less compelling. UV radiation increases are associated with increases in melanoma, however, the exact relationship is unknown. Melanoma in humans may well have a multifactorial etiology. Although UV radiation is likely to play a dominant role, (e.g., initiating precursor lesions during youth and suppressing immunity to the tumor cells as a result of a sunburn in the final stage of tumor development), other factors may affect expression of the UV effect.

How many people are exposed to concentrations exceeding health benchmarks?

Every Minnesotan that spends at least some time outdoors is affected by increased levels of UV radiation. Lighter skinned people are at higher risk than darker skinned people. The amount of time spent outdoors will affect exposure and risk as well as the amount of protection used (hats, long-sleeves and long pants, sunscreen, etc.).

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Skin Cancer -- One in five Americans will develop skin cancer in their lifetime, and one American dies every hour from this disease. Melanoma cases in this country have more than doubled in the past 2 decades. More than 1.2 million Americans will develop nonmelanoma skin cancer in 2000 while more than 1,900 will die from the disease.

How persistent/reversible is this stressor?

Many of the chemicals of concern have very long atmospheric lives, up to 110 years (CFC 12). Currently, we are experiencing depletion of approximately 5 percent at mid-latitudes, but if no action had been taken to limit CFCs, ozone depletion at mid-latitudes would eventually have reached 20 percent or more. If international agreements (such as the Montreal Protocol) are adhered to, the ozone layer is expected to recover by 2050.

References:

- The EPA Ozone Depletion Website: http://www.epa.gov/ozone/index.html
- UNITED NATIONS ENVIRONMENT PROGRAMME ENVIRONMENTAL EFFECTS OF OZONE DEPLETION: 1994 ASSESSMENT. November 1994. http://sedac.ciesin.org/ozone/UNEP/UNEP94toc.html
- Environmental Chemistry 2nd edition, Nigel Bunce, Wuerz Publishing Ltd.

3.5. Toxic Chemicals in Water

Which chemicals of concern are analyzed?

1. Public supply
   1.1. VOCs and pesticides are sampled annually or more frequently in wells identified as being vulnerable to contamination.
   1.2. Data may exist for wells impacted or potentially impacted by contaminated sites. These would only be for contaminants identified at the site.
2. Private supply
   2.1. VOC data exist from the MPCA statewide baseline assessment, USGS Red River and Upper Mississippi River NWQA, and other local studies.
   2.2. Parent herbicides have been analyzed for many local studies. For herbicide degradates, limited data exists from local studies.
   2.3. Data may exist for wells impacted or potentially impacted by contaminated sites. These would only be for contaminants identified at the site.
3. Monitoring data
   3.1. Data for VOCs exist from local studies and local monitoring networks at regulated sites.
   3.2. There is some data for herbicides and herbicide degradates from local studies conducted in sensitive hydrologic areas. These areas include the central sands and Southeast Minnesota.
   3.3. There is limited data for PAHs and other halogenated pesticides from MPCA GWMAP studies and USGS NWQA studies.

3.4. Data may exist for wells impacted or potentially impacted by contaminated sites. These would only be for contaminants identified at the site.

What are the concentrations of chemicals of concern?

Public water supply data are not readily available. The Minnesota Department of Health, City of Minneapolis, City of Paynesville, and City of St. Paul publish web-accessible annual reports summarizing water quality of public supplies. Only exceedances are discussed in the MDH reports. Summary data for some chemicals is provided in the St. Paul, Paynesville, and Minneapolis reports. MDH data extend back several years. MDH data include both raw and finished water. There is no statewide comprehensive assessment of water quality in public and community supply wells. There is ready access to the presence or absence of VOCs or pesticides in a public water sample, but not to concentrations.

Private water supplies account for about 10 percent of the population. Individual wells supply almost all of this water. The most comprehensive data is from MPCA's statewide baseline study, conducted from 1992 to 1996 (http://www.pca.state.mn.us/water/groundwater/gwmap/gwbaselinerpt.html). Statewide, 954 wells were sampled. Sampling occurred in the major aquifers of Minnesota. This represents about one percent of the population having private water supply. Trend information is not available because most wells have been sampled just once. There were no wells with a detectable herbicide classified as a Class A or B carcinogen. There were 67 wells with a detectable VOC classified as a Class A or B carcinogen. This represents 7 percent of sampled wells. The minimum, Q_{25}, Q_{50}, Q_{75}, and maximum concentrations in the 67 wells were, as a percentage of the drinking criteria, 0.00, 0.01, 0.01, 0.05, and 2.20. There were an additional 19 detections of chemicals with no defined carcinogenic level. There was no effect of aquifer type or geographic location on the occurrence of samples with a detectable VOC. The geographic scale was inadequate for separating urban from rural land use differences. Detections are summarized below (Note: additivity is considered in the above calculations. Thus, there are more detections than wells with detections, since more than one compound was detected in some wells)

- 1,2-Dichloroethane – 2 detections
- 1,2-Dichloropropane – 2 detections
- Benzene – 13 detections
- Bromodichloromethane – 2 detections
- Chloroform – 47 detections
- Methylene chloride – 3 detections
- Tetrachloroethylene – 3 detections
- Trichloroethylene – 5 detections

There were seventeen detections of VOCs in domestic wells sampled for the USGS Upper Mississippi River NQWA (Fong et al., 1998). Tipping studied 158 wells in Southeast Minnesota. There were four wells with a detectable VOC classified as a Class A or B carcinogen. This represents 1.9 percent of sampled wells. Chloroform was detected on two occasions, 1,2-Dichloroethylene on one occasion, and Trichloroethylene on one occasion. Concentrations, as a percentage of drinking criteria, were 0.01, 0.03, and 0.50. In 38 samples, there were no detectable concentrations of herbicides. Other chemicals of concern were not sampled.

In addition to water supply wells, there is additional information about the occurrence of these chemicals in ground water.

MPCA GWMAP – Twenty-three monitoring wells existed for the St. Cloud land use study. VOCs were consistently detected in seven wells. Concentrations, as a percent of the drinking criteria and including additivity, ranged from 0.005 to 0.37. All the detections are in commercial, industrial, or sewered residential areas. The primary chemicals of concern were tetrachloroethylene, trichloroethylene, and trihalomethanes (particularly chloroform). Alachlor (a herbicide) was not found in any well. Degradates of alachlor were found in most wells from agricultural land use (http://www.pca.state.mn.us/water/groundwater/gwmap/index.html).

NWQA – There were nine detections of VOCs from 30 wells completed in urban areas of the Twin Cities Metropolitan Area (Andrews et al., 1997). Detections included chloroform (3), trichloroethylene (2), methylene chloride (1), bromodichloromethane (1), benzene (1), and tetrachloroethylene (1). The maximum concentration detected was 0.20 percent of the drinking water criteria (http://mn.water.usgs.gov/umis/).

In addition to the two studies cited above, public, private, or monitoring data may exist for regulated sites. This information is not accessible in a format that allows for statewide or regional assessment of concentrations in ground water.

<u>What health effects are associated with excess exposure to these chemicals?</u>

Cancer. Cancers vary with individual chemicals.

<u>Document the exceedances of health benchmarks.</u>

Public water supply – the following table summarizes exceedances of health benchmarks in public water supplies since 1995. Data are from MDH annual reports http://www.health.state.mn.us/divs/eh/watprot.html. MDH reports only consider finished water. Individual wells may exceed health benchmarks. MDH typically decommissions or blends water from these wells to reduce concentrations below criteria. MDH also uses MCLs as benchmarks.

Chemical	**No. systems**	**Average population**	**Population affected**	**Year**	**Notes**
1,2-Dichloroethane	1	20000	20000	1995	Population estimated; well taken out of service
1,1,2-Trichloroethene	1	50	50	1997	Population estimated; well abandoned, residents on bottled water
Tetrachloroethylene	1	1750	1750	1997	Well taken out of service
Tetrachloroethylene	1	5000	5000	1999	Assume 5000 people per system

Summary of water supplies exceeding drinking water standards.

Private water supply – the following table summarizes exceedances of drinking water criteria from the statewide baseline assessment. There were no exceedances of drinking water criteria in either the study by Tipping or the USGS Upper Mississippi River NWQA (Fong et al., 1998).

Chemical	No. systems	Average population	Population affected	Year	Notes
Benzene	1	4	508	1994	Assumes 4 people per house, 954 houses sampled, 483000 people statewide on well water
Tetrachloroethylene	1	4	508	1995	Assumes 4 people per house, 954 houses sampled, 483000 people statewide on well water

Summary of water supplies exceeding drinking water standards.

Monitoring data – There were no exceedances of health benchmarks in wells from the PCA land use study in St. Cloud or from the USGS NWQA study in Brooklyn Park. These results encompass 53 monitoring wells from a variety of land use settings.

<u>How many people are exposed to concentrations exceeding health benchmarks</u>?

The above two tables provide estimates of the number of people exposed to chemical concentrations exceeding health benchmarks. Public supplies are managed to reduce concentrations to acceptable levels. Consequently, duration of exposure is typically less than one year for these water supplies. Drinking criteria, however, are not always reflective of health-based concentrations. Private supplies reflect conditions where humans are potentially exposed for many years, although follow-up sampling does not occur at these wells.

<u>How many incidents of cancer result from exposures above criteria?</u>

Assuming a 1:100000 cancer risk, there are about 1000 people in Minnesota with long-term exposure to concentrations exceeding health benchmarks. Assuming about 5 million people in Minnesota, the number of people contracting cancer is about 0.50. In addition to standard exposure assumptions, this calculation makes the following assumptions.

- The risk in wells exceeding criteria is 1:100000, even though the concentrations exceeded the health benchmark.
- There is no risk of contracting cancer in wells containing chemicals at concentrations below the health benchmarks.
- There is no cancer risk from chemicals not sampled.

3.6. Toxic Chemicals in Soil

<u>Which chemicals of concern are analyzed</u>?

There is no comprehensive assessment of chemical concentrations in Minnesota soils. There are several local studies, primarily for inorganic chemicals (Mielke et al. 1991 Environ. Geochem. Health 13:29-34; Mielke et al. 1983 Amer. Jour. Pub. Health. 73:1366-1369; Mielke et al. 1989 Environ. Geochem. Health. 9:243-271; Mielke et al. 1984/85 Journal of the Minnesota Academy of Science. 50:19-24;
Fruin et al. 1994.; Minnesota Pollution Control Agency and Minnesota Department of Health. 1987; Pierce, F.J., R.H. Dowdy, and D.F. Grigal. 1982 J. Environ. Qual. 11:416-422.). Lead is the most extensively analyzed chemical. There is some Minnesota data for arsenic and beryllium. One study from New Jersey presents results for chlorinated pesticides and PAHs (http://www.state.nj.us/dep/dsr/soilrep.pdf). There may be data for

organic and inorganic chemicals at regulated sites. This information is not readily accessible but is contained in various MPCA files and databases.

What are the concentrations of chemicals of concern?

No repeat monitoring data is readily available. Various studies from the literature show average beryllium concentrations of about 0.5 mg/kg, arsenic concentrations of about 5 mg/kg, and lead of about 15 mg/kg. Several studies show that lead concentrations increase dramatically in urban environments, to more than 100 mg/kg in typical urban environments and more than 400 mg/kg in core areas of older cities such as Minneapolis. Beryllium and arsenic concentrations appear less affected by land use, although arsenic concentrations in urban areas may be about twice those in agricultural soils (New Jersey EPA).

A study from the New Jersey EPA showed the presence of chlorinated pesticides in over half of 80 samples collected. There was no land use pattern, although detection frequency and concentrations were higher on lands where pesticides have been used. DDT, DDE, DDD, Dieldrin, and Beta-BHC were the most commonly detected pesticides. The same study showed no detections of carcinogenic PAHs in 80 samples (http://www.state.nj.us/dep/dsr/soilrep.pdf).

What health effects are associated with excess exposure to these chemicals?

Cancer. Cancers vary with individual chemicals.

Document exceedances of health benchmarks.

There is limited documentation of exceedances of health benchmarks in Minnesota soils. Concentrations of lead in core areas of inner cities appear to consistently exceed the Tier I SRV of 400 mg/kg. Exceedances of the Tier I SRV for arsenic (10 mg/kg) occurred in several studies. In a study conducted by the New Jersey EPA, about 10 percent of samples collected from urban and suburban areas exceed 10 mg/kg. Other 90th percentile concentrations were 3.8 mg/kg for rural areas, 5 mg/kg for golf courses, and 5.6 mg/kg for agricultural soils.

There are other benchmarks utilized when evaluating soil concentrations. The Tier I criteria may not be based on cancer as the endpoint of concern.

How many people are exposed to concentrations exceeding health benchmarks?

Without adequate sampling and monitoring data, we cannot estimate the number of people exposed to soil concentrations exceeding health benchmarks. The primary limitations are lack of data for the organic chemicals and unknown exposure scenarios for the inorganic chemicals. The likelihood of exposure at concentrations exceeding benchmarks seems low, however, since many if not most contaminated sites have been identified and cleaned up.

How many incidences of cancer result from exposures above criteria?

We cannot estimate the incidences of cancer based on exposures above criteria. For some chemicals, there is no link between the criteria and the likelihood of cancer. In studies of lead, for example, non-cancer effects are generally considered (http://www.atsdr.cdc.gov/cxlead.html). Studies exist that consider exposure to elevated arsenic concentrations adjacent to coal power plants, but no data are presented linking cancer incidence to exposure (http://www.icconsultants.co.uk/expascan.html). Soil exposure to anthropogenic sources of beryllium is considered minimal (http://www.epa.gov/ttnuatw1/hlthef/berylliu.html). Increased cancer risk is likely to be negligible for natural concentrations of PAHs (http://www.oakparkparks.com/BarriePark/bphealtconsult.html). Cancer incidences in children have increased in the past 25 years. Some experts say toxins in the air, food, dust, soil and drinking water are prime suspects (http://www.chem-tox.com/cancerchildren/default.htm), but there is no evidence to substantiate this nor is there information to differentiate between the different routes of exposure.

Some researchers consider the greatest cancer risk for the soil pathway to be associated with proximity to hazardous waste sites. "Proximity to hazardous-waste sites or contaminated wells may have health effects, but it has not been shown to impart a measurable excess risk for cancer. It is not certain whether the lack of association is genuine or a reflection of the limited capacity of statistical methods to document a very weak correlation" (http://www.sciam.com/0996issue/0996trichopoulos.html).

4. Human Health Impacts-Non-cancer Acute

4.1. Particles in Air

What are the primary chemicals of concern for this stressor?

Particulate matter is measured as PM10 (particulate matter less than 10 microns in diameter) or as PM2.5 (particulate matter less than 2.5 microns). Fine particles are made up of directly emitted primary particles and secondary particles created in the atmosphere from gaseous precursors.

EPA's 1996 National Air Toxics Assessment (NATA) estimated emissions of diesel particles, a constituent of total fine particles, and predicted ambient concentrations around the country. Diesel particles are of concern due to several studies around the country predicting higher concentrations and health risks in urban areas.

What are the concentrations of these chemicals and what health benchmark exceedences are we seeing?

The MPCA monitors PM2.5 in the Boundary Waters Canoe Area for regional haze purposes and at several sites around the state to determine compliance with federal standards. Concentrations at the BWCA site are around 4.5 µg/m^3. Average concentrations in the metro area range from 11.5 to 14.5 µg/m^3.

The MPCA's monitoring network has not been in place long enough to measure trends in PM2.5. PM10 concentrations at metro monitoring locations decreased from the mid-1980s to the mid-1990s and then leveled off. PM10 levels at a monitoring site in Virginia, Minnesota remained constant since 1985.

The National Ambient Air Quality Standard (NAAQS) for PM2.5 is 15 µg/m^3. The standard is an enforceable level that areas must stay below. The US EPA standard of 15µg/m^3 is believed to be low enough to some health impacts, but health effects will still occur below that level. The standard was set at the lowest level at which EPA felt they could show direct health effects with minimal uncertainty.

EPA's National Air Toxics Assessment predicts concentrations of diesel particles of 0.8 $\mu g/m^3$ to 12.2 $\mu g/m^3$ in the metro area, with lower concentrations in the rest of Minnesota. The MDH's proposed Health Risk Value for diesel exhaust for non-cancer effects is 5 $\mu g/m^3$.

<u>What health effects are associated with excess exposure to these chemicals?</u>

Groups susceptible to health impacts from ambient particles include individuals with respiratory disease, children, and the elderly. Those people with respiratory or cardiovascular illness are at greater risk of hospitalization, aggravation of symptoms, and death. The elderly are also at greater risk for hospitalization and premature mortality due to PM-induced cardiopulmonary problems. Asthmatics are at greater risk of more frequent asthma attacks. Children may experience impaired lung function.

Other specific health impacts from particulate matter include bronchitis (acute and chronic) and increased respiratory disease. Short-term exposures to diesel particles can cause irritation in the respiratory system, worsen allergic reactions, and, some studies conclude, impair lung function. Long-term exposures can cause localized inflammation.

<u>How many people are exposed to concentrations exceeding health benchmarks?</u>

Regulatory monitoring concentrations are measured at levels that are about 90% of the applicable standard. Maximum concentrations and microenvironmental exposures may be higher than the standard, but will not trigger federal enforcement. Health effects on susceptible individuals may occur at concentrations below the standard. EPA's NATA predicts average concentrations in all counties in Minnesota to be below the health benchmark.

<u>How many incidences of the diseases/ailments of concern result from exposures above criteria?</u>

The MPCA is currently not monitoring levels of fine particulate matter exceeding air quality standards. However, health effects may occur below the standards.

<u>How persistent/reversible is this stressor?</u>

Particles are removed from the atmosphere by deposition to land and water or washed out of the air by rainfall.

4.2. Temperature Increase/Climate Change

<u>What are the primary chemicals of concern for this stressor?</u>

The main anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tropospheric ozone (O_3), and several chlorofluorocarbon (CFC) refrigerants. There are many less important greenhouse gases, including carbon tetrachloride (CCl_4) and sulfur hexafluoride (SF_6). These chemicals absorb infrared light and heat in the atmosphere and warm the surrounding air. Resultant thermal emissions cause surface temperatures to increase.

<u>What are the concentrations of these chemicals and what health benchmark exceedences are we seeing?</u>

Health benchmarks (related to climate change) do not exist for these chemicals. It is the effect of increased concentrations of these chemicals in the atmosphere that cause negative impacts, not necessarily direct exposure to the chemicals themselves. Atmospheric concentrations of CO_2 (33%), CH_4 (142%), N_2O (13%), and O_3 (100%) have increased drastically over pre-industrial levels. Man-made chemicals, such as CFCs, were not present at all in the atmosphere prior to industrialization, but some are now measured at hundreds of parts per trillion.

<u>What health effects are associated with excess exposure to these chemicals?</u>

Health effects may occur from direct exposure to some of the greenhouse gases, but the climate change stressor refers to health effects caused by climate change impacts. Higher temperatures may lead to heat exhaustion, heat stroke, and other similar ailments. Hotter summers may also exacerbate ozone and other air pollution problems. Weather pattern changes induced by climate change may lead to more fatalities from tornadoes and other severe weather. Some studies link climate variability with increases in microbial agents in water. Transmission patterns of vector and rodent-borne diseases, such as yellow fever and dengue fever, are sensitive to rainfall, temperature, and other weather variables that may be impacted by climate change (http://www.pca.state.mn.us/hot/globalwarming.html; http://www.epa.gov/globalwarming/impacts/stateimp/minnesota/).

<u>How many people are exposed to concentrations exceeding health benchmarks? How many incidences of the diseases/ailments of concern result from exposures above criteria?</u>

Climate change is a global problem, although specific impacts vary based on regional climate differences. Areas near the tropics may see malaria and other tropical diseases moving north. Urban areas could see increases in summertime pollution levels and heat-related health problems. Storms would impact everyone in the area.

<u>How persistent/reversible is this stressor?</u>

Greenhouse gases have atmospheric lifetimes ranging from 5 to 50,000 years, depending on the chemical and atmospheric removal processes. The most common greenhouse gas, carbon dioxide, persists in the atmosphere for 500 years. The duration of the warming effect from these pollutants in the atmosphere depends on the timing and effectiveness of control strategies designed to reduce the emissions of these chemicals. If, for example, emission levels increased at current rates until 2100 and then were linearly phased out, temperatures would still not return to current levels (and certainly not pre-industrial levels) for more than 500 years, and possibly much longer.

References:

- Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix H: Global Climate Change.* http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html. Accessed 2/6/02.
- See attached documents.

4.3. Ground-level Ozone

See *Ozone* in Section 4.11, *Other Criteria Pollutants in Air*.

4.4. Pathogens in Water

What are the primary chemicals of concern?

Bacteria (Salmonella, Campylobacter), viruses, or small parasites (Cryptosporida, Giardia, and Toxoplasma) are the most common water-borne diseases (http://www.hlth.gov.bc.ca/hlthfile/hfile49a.html#E46E500).

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

These organisms are not typically tested in water supplies. Coliform bacteria are tested and used as an indicator for organisms that can cause disease. In a typical year, 15 to 25 public water systems test positive for indicator bacteria. About half of these are non-community systems. There is limited data for private wells, but the occurrence of organisms in properly constructed wells is very low (http://www.health.state.mn.us/divs/eh/water/cinfo/cinfo.html; http://www.pca.state.mn.us/water/groundwater/gwmap/index.html). There are no benchmarks for lakes and rivers, although exposure may occur through recreational activity (http://www.nps.ars.usda.gov/programs/programs.htm?npnumber=201&docid=340&page=4).

Water supply systems with detections of total coliforms but not fecal coliforms are unlikely to be impacted by organisms that will cause adverse health impacts in humans. Although systems that test positive are immediately treated, this does not prevent short-term exposures that occurred prior to treatment and does not eliminate the potential for future exposures. Most contamination results from poor construction or poor waste management in private wells and problems with distribution systems in public supplies.

What health effects are associated with excess exposure to these chemicals?

Many people who are infected with the more common water-borne disease agents will have no symptoms at all, and probably won't even know they've been infected. For people who get sick from water-borne disease, the symptoms vary depending on the infectious agent. For many water-borne diseases, symptoms begin from two to ten days after drinking the contaminated water, and may include diarrhea, stomach cramps, nausea, vomiting, and low grade fever. People with toxoplasmosis may have fever, swollen glands and loss or blurring of vision (http://www.hlth.gov.bc.ca/hlthfile/hfile49a.html).

How many people are exposed to concentrations exceeding health benchmarks?

Assuming an average size of about 1000 people for each impacted system, 15000 to 25000 people are potentially exposed annually. There are likely to be several thousand people exposed to indicator bacteria from private wells. Since these wells are typically not tested until problems are suspected, the potential for adverse health effects is greater in private wells, since the period of exposure is longer. Potential exposure through recreation is very large.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

There is limited data on incidence of water-borne diseases in Minnesota. A 1995 study by the CDC showed one exposure affecting 33 people for a drinking water supply, and three exposures affecting 20 people via recreational activity.

4.5. Odorous Chemicals from Biological Processes

What are the primary chemicals of concern for this stressor?

Pollutants associated with the biological degradation of organic matter are mainly volatile organic compounds. Ammonia and hydrogen sulfide are two inorganic chemicals emitted by these processes.

What are the concentrations of these chemicals and what health benchmark exceedences are we seeing?

According to the MPCA web site (http://www.pca.state.mn.us/hot/fl-odor.html; http://www.pca.state.mn.us/hot/legislature/factsheets/feedodor.pdf), Minnesota's ambient standard for hydrogen sulfide "is a 30-minute average of 30 parts per billion twice in five days, or a 30-minute average of 50 parts per billion twice per year."

The MPCA monitors hydrogen sulfide levels near feedlots only after receiving complaints of odors. Of those sites monitored, approximately one-half exceed the ambient standard at some time. Many other sites are never monitored, so it is not known if the ambient concentrations are higher than the standard.

Hydrogen sulfide is only one chemical that can lead to odor. The MPCA does not have a relevant standard for other pollutants that lead to odor complaints.

What health effects are associated with excess exposure to these chemicals?

Many acute symptoms are associated with odor exposures, including eye, nose, and throat irritation, headaches, diarrhea, and chest tightness. The effects are normally experienced at the time of exposure and subside thereafter. Asthmatics and other sensitive individuals may experience persistent symptoms and exacerbated effects related to their existing condition (http://coeh.berkeley.edu/Research/envtox/envtox.htm#smell; http://www.schs.state.nc.us/epi/mera/iloodoreffects.html).

How many people are exposed to concentrations exceeding health benchmarks?

Sources of odor are typically located in rural areas, so the total population exposed to concentrations exceeding health benchmarks is likely to be lower than the population exposed to pollution in urban areas. Exceptions include industries that use large quantities of solvents (http://www.pca.state.mn.us/programs/projectxl/aw-olfinal.pdf) and ethanol plants (http://www.pca.state.mn.us/news/nr041601.html) that are located in urban areas.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

The MPCA does not track health effects that may be caused by odors or similar pollutants. A study of hog confinement operations in North Carolina showed that about 50 percent of residents living within a mile of large hog-confinement facilities claimed to display one or more affects associated with excess odor (http://www.schs.state.nc.us/epi/mera/iloodoreffects.html).

How persistent/reversible is this stressor?

Hydrogen sulfide, ammonia, and other pollutants associated with odor readily disperse and break down in the environment once the source is removed.

4.6. Toxic Chemicals in Water

What are the primary chemicals of concern?

Nitrate (associated with methemoglobinemia in infants less than 6 months in age).

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Nitrate exceeds the criteria of 10 ppm in about 3.5 percent of private wells in Minnesota. Typically, in any given year, two to five municipalities are impacted by nitrate concentrations exceeding the criteria. Many municipalities in Minnesota have elevated nitrate concentrations and one or more wells in a municipal well field often exceed criteria. Through blending, treatment, and drilling new wells, chronic exposure above drinking criteria is minimized.

What health effects are associated with excess exposure to these chemicals?

Ingestion of nitrate can cause methemoglobinemia, which affects infants six months or younger in age (http://pmep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.html).

How many people are exposed to concentrations exceeding health benchmarks?

As many as 100,000 people in Minnesota are likely to be exposed to nitrate concentrations above the criteria sometime during a given year (based on extrapolation of number stated above). Perhaps 30,000 people continually consume water having nitrate concentrations exceeding drinking water criteria (based on the assumption that public water supplies will be treated and private wells will not be treated). Only infants less than six months in age are affected by methemoglobinemia.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Death attributable to methemoglobinemia has not been documented for several decades. MDH is conducting a study to evaluate children health effects from consumption of drinking water having high concentrations of nitrate.

How persistent/reversible is this stressor?
The occurrence of nitrate in drinking water is strongly correlated with sources of nitrogen to water and to geochemical conditions in water. In the presence of oxygen, nitrate is extremely persistent and decreases in concentration only through dilution of water (http://www.pca.state.mn.us/water/groundwater/gwmap/gwsens.pdf).

4.7. Explosive-flammable Materials – High-level Accidental Exposure
What are the primary chemicals of concern for this stressor?
Volatile organic compounds found in gasoline, aviation fuel, and crude oil.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Gasoline	LEL = 1.2% UEL = 7.6%
Aviation Gasoline	LEL = 1.4% UEL = 7.6%
Crude Oil	Depends on the source

With any spill or uncontrolled release of these materials there is the potential for ignition. Upon ignition in a closed atmosphere or system, an explosion will occur. Small spills of even one gallon in confined areas such as a utility vault or sewer can result in a fire or explosion. Sources can be residents dumping into the storm or sanitary sewer, leaking tanks, leaking pipelines, vehicle traffic accidents, and truck transport accidents.

What health effects are associated with excess exposure to these chemicals?
If an explosion occurs, people can get burned or hit by flying debris/objects. Injuries from flying objects can vary from lacerations to death.

How many people are exposed to concentrations exceeding health benchmarks?
It is unknown. The state gets notifications when assistance or a spill/release is reported. Therefore, if it is not reported any number is a guess. MPCA's database does not track explosions specifically.

How many incidences of the diseases/ailments of concern result from exposures above criteria?
In five years perhaps 2 or 3 incidents.

4.8. Noise
What are the primary chemicals of concern for this stressor?
There are no chemicals associated with noise. The primary sources of environmental noise are airplanes, industry, and automobile traffic (http://www.nonoise.org/library/highway/probresp.htm; http://www.lhh.org/noise/facts/airport.htm; http://www3.sympatico.ca/noise/; http://www.nonoise.org/news/noisenew.htm).

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Some studies indicate that health effects are primarily associated with noise peaks, rather than continuous exposure at an ambient level. This is particularly true of acute health effects. There are many sources of environmental noise that exceed 85 decibels, which is considered the threshold value above which continuous exposure for prolonged periods will lead to hearing loss (http://www.md.huji.ac.il/depts/occenvmed/aicraftnoise.html; http://www.lhh.org/noise/decibel.htm). Noise levels are monitored throughout the Twin Cities Metro Area by MNDOT (http://www.dot.state.mn.us/metro/tps/htms/noise/noise.html). The Metropolitan Airports Commission monitors noise complaints (http://www.macavsat.org/whatsnew.htm#jan10).

What health effects are associated with excess exposure to these chemicals?

The following statement (http://hebw.uwcm.ac.uk/healthyenvironments/Chapter3.html) summarizes general health effects from noise: "Society is getting more noisy, but the sources of noise are changing. There is less noise from industrial sources and more traffic and domestic noise. Noise is often linked with stress, sleep disturbance, and aggressive behavior. Evidence of acute effects is strongest for annoyance, sleep disturbance and poor performance by school children. Evidence for other consequences such as psychiatric disorder is equivocal".

How many people are exposed to concentrations exceeding health benchmarks?

There is limited information on the number of people exposed to environmental noise at a level that could lead to acute health impacts (http://hebw.uwcm.ac.uk/healthyenvironments/Chapter2.html; http://hebw.uwcm.ac.uk/healthyenvironments/Chapter1.html; http://james.ilo.ucl.ac.uk/links/vmlweb/info/ilo/research/pan/). European estimates indicate that about 5 percent of the population is at risk for health effects related to noise, but most of this is associated with occupational noise and most is probably associated with chronic effects. Any individual living near a source of noise that exceeds the threshold is at risk from acute effects. These largely occur in urban areas, such as near airports, highways, construction, and industries.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Noise complaints recorded by MAC Aviation Noise and Satellite Program staff for 2001 were down from the previous year. Compared to 2000, total noise complaints recorded in 2001 fell 20.7% from 14,049 in 2000 to 11,131 in 2001 (http://www.macavsat.org/whatsnew.htm#jan10). Noise complaints cannot be compared directly to health effects, but provide an indication of the number of people bothered by noise.

How persistent/reversible is this stressor?

Noise is quickly dispersed in the environment and is therefore not persistent. A continuous source of noise, however, can provide persistent noise levels that lead to acute health effects.

4.9. Toxic Chemicals – High-level Accidental Exposure

What are the primary chemicals of concern for this stressor?

Virtually any hazardous chemical represents a potential health hazard when releases through an accident. There are extensive databases listing these chemicals (http://response.restoration.noaa.gov/cameo/links.html;).

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Concentrations vary with the severity of the accident or spill. Benchmarks are typically based on acute exposure concentrations, which vary by chemical.

What health effects are associated with excess exposure to these chemicals?

Burns, poisoning, blindness, death.

How many people are exposed to concentrations exceeding health benchmarks?

It is unknown. The state gets notifications when assistance or a spill/release is reported. Therefore, if it is not reported any number is a guess. MPCA's database does not track exposures specifically.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Unknown, probably less than what was reported for *Explosive-flammable Materials – High-level Accidental Exposure* above.

How persistent/reversible is this stressor?

Persistence varies with each chemical. Because the concern is acute exposure, most chemical releases are rapidly diluted in air or water.

4.10. Toxic Volatile Organic Chemicals in Air

What are the primary chemicals of concern for this stressor?

US EPA's National Air Toxics Assessment (NATA) analyzed emissions and used models to predict ambient concentrations and exposures for 33 air toxics and diesel PM. The pollutants are:

Acetaldehyde	Ethylene Oxide	Acrolein
Formaldehyde	Acrylonitrile	Hexachlorobenzene
Arsenic Compounds	Hydrazine	Benzene
Lead Compounds	Beryllium Compounds	Manganese Compounds
1,3-Butadiene	Mercury Compounds	Cadmium Compounds
Methylene Chloride	Carbon Tetrachloride	Nickel Compounds
Chloroform	PCBs	Chromium Compounds
Polycyclic Organic Matter	Coke Oven Emissions	Quinoline
Dioxins/Furans	1,1,2,2-Tetrachloroethane	Ethylene Dibromide
Perchloroethylene	Propylene Dichloride	Trichloroethylene
1,3-dichloropropene	Vinyl Chloride	Ethylene Dichloride

EPA's Urban Air Toxics Strategy lists these pollutants as those that are of concern in urban areas in the US.

The MPCA's air toxics emissions inventory estimated emissions for 109 pollutants for calendar year 1997, the most recent year data is available. The pollutants inventoried are on EPA's list of 188 hazardous air pollutants (HAPs). The list of pollutants was selected as part of the Great Lakes regional emissions inventory as chemicals that contribute to the contamination of the Great Lakes and/or were requested for inclusion in EPA's National Toxics Inventory.

The MPCA monitors many volatile organic carbon (VOC) compounds, carbonyl compounds, and some metals. The pollutants monitored are those for which the MPCA has a reliable method for measuring their concentration in the air. The MPCA monitoring network includes several long-term sites which have been in place since the early 1990's and a network of sites around that state that collect information for annual 'snapshots' in an effort to analyze pollutant concentrations across the state.

The MPCA does not monitor for semi-volatile chemicals due to the high cost of analysis. Many of these chemicals are persistent and bioaccumulative.

What are the concentrations of these chemicals and what health benchmark exceedences are we seeing?

EPA's NATA modeling predicted concentrations of several chemicals at or above their health benchmarks, especially in the Twin Cities metro area. Modeled concentrations of acrolein were predicted to exceed the non-cancer health benchmark. Air toxics monitoring performed by the MPCA tended to show concentrations higher than those predicted in the NATA modeling.

What health effects are associated with excess exposure to these chemicals?

A variety of health impacts are associated with high concentrations of air toxics due to the diversity of chemicals included in the broad definitions. The health impacts include respiratory irritation, asthma exacerbation, and developmental problems. The specific health impacts depend entirely on what suite of chemicals are considered.

How many people are exposed to concentrations exceeding health benchmarks?

Modeling predicts concentrations of acrolein exceeding health benchmarks in the metro area. Local 'hot spots' may exist near sources of air toxics. Many pollutants are also present at concentrations that are higher than background concentrations but lower than health benchmarks. The cumulative effects of these chemicals are not well understood, but there may be synergistic or additive effects.

Many people may be exposed to concentrations of these chemicals that are higher than those predicted or measured in ambient air. These 'microenvironmental' exposures include many day-to-day activities of Minnesotans. Dry cleaning, automobile refueling, and pesticide use are examples. Concentrations of several pollutants in the cabins of automobiles in traffic have been measured at higher concentrations than the corresponding ambient air.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

The MPCA is not measuring concentrations of any air toxics above non-cancer benchmarks. For many chemicals, there is no benchmark.

Many individuals are exposed to higher concentrations of many air toxics in certain microenvironments (gas stations, dry cleaners). Many chemicals are present in urban air at levels below health benchmarks, but the health effects due to the cumulative exposure to the these pollutants, if any, is unknown.

How persistent/reversible is this stressor?

Some air toxics break down quickly in the environment, while others are extremely persistent.

References

- http://www.epa.gov/ttn/atw/nata/
- http://www.pca.state.mn.us/air/toxics.html
- http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html

4.11. Other Criteria Pollutants in Air

Other criteria pollutants include carbon monoxide, ozone, nitrogen oxides, and sulfur oxides.

Carbon Monoxide (CO)

What are the primary chemicals of concern for this stressor?

Carbon Monoxide.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for CO in St. Cloud, Duluth, and the Twin Cities metropolitan area. The values from these monitors are compared to the National Ambient Air Quality Standards (NAAQS). The NAAQS for CO are an 8-hour standard of 9 ppm (10,000 $\mu g/m^3$) and a 1-hour standard of 35 ppm (40,000 $\mu g/m^3$). Second maximum 1-hour monitored CO levels in Minnesota in 2000 ranged from 1.5 ppm (Dakota County) to 6.6 ppm (St. Paul). Second maximum 8-hour levels in 2000 ranged from 1.4 ppm (Dakota County) to 5.1 ppm (St. Paul)No exceedences of the standard have been measured since at least 1996. (Monitoring Data information from EPA AIR*Data*, August 2001)

What health effects are associated with excess exposure to these chemicals?

Carbon monoxide can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues.

Cardiovascular Effects - The health threat from lower levels of CO is most serious for those who suffer from heart disease, like angina, clogged arteries, or congestive heart failure. For a person with heart disease, a single exposure to CO at low levels may cause chest pain and reduce that person's ability to exercise; repeated exposures may contribute to other cardiovascular effects.

Central Nervous System Effects - Even healthy people can be affected by high levels of CO. People who breathe high levels of CO can develop vision problems, reduced ability to work or learn, reduced manual dexterity, and difficulty performing complex tasks. At extremely high levels, CO is poisonous and can cause death.

Smog - CO contributes to the formation of smog ground-level ozone, which can trigger serious respiratory problems. (Air Quality Where you Live http://www.epa.gov/air/urbanair/6poll.html).

How many people are exposed to concentrations exceeding health benchmarks?

Currently, ambient monitored concentrations of CO are at least half the national standards. According to monitored data, exceedences have not occurred since at least 1996. Individuals in microenvironments may be exposed to levels above the NAAQS.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

MPCA currently is not measuring ambient CO above the NAAQS. There may be individuals in microenvironments affected by high CO levels.

How persistent/reversible is this stressor?

CO is insoluble and relatively unreactive. The tropospheric sinks for carbon monoxide are uptake in soil, followed by microbial oxidation to CO_2, and atmospheric oxidation by the hydroxyl radical (OH).

References

- http://www.epa.gov/air/urbanair/co/index.html
- http://www.pca.state.mn.us/air/emissions/co.html

Ozone

What are the primary chemicals of concern for this stressor?

Ozone

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for ozone in Lake County, St. Louis County, Mille Lacs and the Twin Cities metropolitan area. The values from these monitors are compared to the NAAQS. The NAAQS for ozone are an 8-hour standard of 0.08 ppm (157 $\mu g/m^3$) and a 1-hour standard of .012 ppm (235 $\mu g/m^3$). Second maximum 1-hour monitored ozone levels in Minnesota in 2000 ranged from 0.72 ppm (Lake County) to 0.087 ppm (Blaine). Fourth maximum 8-hour levels in 2000 ranged from 0.07 ppm (Stillwater) to 0.064 ppm (Anoka County). In 2001, there have been individual 8-hour ozone concentrations above 0.08 ppm. However, because the standard is a 3-year average of 4th daily maximums, no actual exceedences of the standard have been measured. (Monitoring Data information from EPA AIR*Data*, August 2001 & MPCA monitoring data. Note: Only Twin Cities data was available for the 8-hr averaging period).

What health effects are associated with excess exposure to these chemicals?

Ground-level ozone even at low levels can adversely affect everyone. Ozone can irritate lung airways and cause inflammation much like a sunburn. Other symptoms include wheezing, coughing, pain when taking a deep breath, and breathing difficulties during exercise or outdoor activities. People with respiratory problems are most vulnerable, but even healthy people that are active outdoors can be affected when ozone levels are high. Repeated exposure to ozone pollution for several months may cause permanent lung damage. Anyone who spends time outdoors in the summer is at risk, particularly children and other people who are active outdoors. Even at very low levels, ground-level ozone triggers a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. (Air Quality Where you Live http://www.epa.gov/air/urbanair/6poll.html).

How many people are exposed to concentrations exceeding health benchmarks?

Thus far, the NAAQS have not been exceeded for ozone. However, several times in the summer of 2001, high ozone levels have resulted in air quality conditions in the unhealthy for sensitive groups range. These warnings have been in the highly populated Twin Cities metropolitan area and high ozone would potentially affect large populations of people.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

MPCA is unsure about the actual incidences without tracking hospital admissions and doctor visits. Anecdotal evidence indicates problems among people with respiratory preconditions. There are indications that health concerns may exist below the NAAQS.

How persistent/reversible is this stressor?

Ground-level ozone forms from the reaction of nitrogen oxides, volatile organic compounds in sunlight and heat. Ozone tends to be a local problem. Ozone reacts rapidly with nitric oxide (NO), therefore, the atmosphere cleans itself in a few days once the pollution source is removed.

References

- http://www.epa.gov/air/urbanair/ozone/index.html
- Preliminary Assessment of Ozone Air Quality Issues in the Minneapolis/St.Paul Region: Final Report. Sonoma Technology, Inc. October 10, 2002. http://www.pca.state.mn.us/air/ozonestudy.html

Nitrogen oxides

What are the primary chemicals of concern for this stressor?

Nitrogen dioxide (NO_2) and nitric oxide (NO)

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for NO_2 in the Twin Cities metropolitan area. The values from these monitors are compared to the NAAQS. The NAAQS for NO_2 is an annual mean concentration of 0.053 ppm (100 $\mu g/m^3$). Annual means of NO_2 levels in Minnesota in

2000 ranged from 0.009ppm (Rosemount) to 0.022 ppm (Minneapolis). No exceedences of the standard was measured. (Monitoring Data information from EPA AIR*Data*, August 2001)

What health effects are associated with excess exposure to these chemicals?

Short-term exposures (e.g., less than 3 hours) to low levels of nitrogen dioxide (NO_2) may lead to changes in airway responsiveness and lung function in individuals with pre-existing respiratory illnesses and increases in respiratory illnesses in children (5-12 years old). Long-term exposures to NO_2 may lead to increased susceptibility to respiratory infection and may cause permanent alterations in the lung. Nitrogen oxides react in the air to form ground-level ozone and fine particle pollution which are both associated with adverse health effects. (Latest Findings on National Air Quality: 1999 Status and Trends, EPA, August 2000, EPA-454/F-00-0002)

How many people are exposed to concentrations exceeding health benchmarks?

The measured annual means tend to be less than a third of the standard at most monitoring locations. Minneapolis is at about half of the NAAQS. The main human health concern for NO_X is as a precursor in the formation of ground-level ozone.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Greater disease/ailment is expected from the reaction product, ozone. There may be individual exposure to elevated NO_X in microenvironments.

How persistent/reversible is this stressor?

Nitrogen oxides react in the atmosphere to form nitrates, nitrites, nitric acid and N-nitroso compounds. Nitric acid and acid nitrates, such as ammonium nitrate are components of acid rain. In fact, the formation of HNO_3 is an important sink for removing nitrogen dioxide from the atmosphere.

References

- http://www.epa.gov/air/urbanair/nox/index.html
- http://www.pca.state.mn.us/air/emissions/no2.html

Sulfur oxides

What are the primary chemicals of concern for this stressor?

Sulfur dioxide (SO2), H_2SO_3, and H_2SO_4

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for SO_2 in the Twin Cities metropolitan area and several greater Minnesota locations. The values from these monitors are compared to the NAAQS. The NAAQS for SO_2 are an annual mean concentration of 0.03 ppm (80 $\mu g/m^3$), a 24-hour standard of 0.14 ppm (365 $\mu g/m^3$), and a state 1-hour standard of 0.5 ppm (1300 $\mu g/m^3$). Annual means of SO_2 levels in Minnesota in 2000 ranged from 0.001-0.002 ppm at all sites. The 24-hour monitored concentrations in 2000 ranged from 0.001 ppm

(International Falls) to 0.023 ppm (Minneapolis). No exceedences of the standard was measured. (Monitoring Data information from EPA AIR*Data*, August 2001).

What health effects are associated with excess exposure to these chemicals?

SO_2 causes a variety of health and environmental impacts because of the way it reacts with other substances in the air. Particularly sensitive groups include people with asthma who are active outdoors and children, the elderly, and people with heart or lung disease.

Respiratory Effects from Gaseous SO_2 - Peak levels of SO_2 in the air can cause temporary breathing difficulty for people with asthma who are active outdoors. Longer-term exposures to high levels of SO2 gas and particles cause respiratory illness and aggravate existing heart disease.

Respiratory Effects from Sulfate Particles - SO_2 reacts with other chemicals in the air to form tiny sulfate particles. When these are breathed, they gather in the lungs and are associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death. (Air Quality Where you Live http://www.epa.gov/air/urbanair/6poll.html).

How many people are exposed to concentrations exceeding health benchmarks?

The measured concentrations at all monitoring locations in 2000 were 80-90% below the NAAQS.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Current, ambient atmospheric levels of SO_2 are not expected to cause human health concerns. There may be individual exposure to elevated SO_2 in microenvironments.

How persistent/reversible is this stressor?

The half-lives of SO_2 and SO_3 in the atmosphere are of the order of several days. SO_2 undergoes three processes, oxidation of SO_2 to SO_3, deposition of H_2SO_3, and deposition of H_2SO_4. Acid precipitation is a regional, tropospheric pollution issue, but not a global problem.

References
- http://www.epa.gov/air/urbanair/so2/index.html
- http://www.pca.state.mn.us/air/emissions/so2.html

Other references
- http://www.epa.gov/airtrends/

4.12. Toxic Chemicals in Soil

What are the primary chemicals of concern?

Acute exposure to chemicals in soil is unlikely except in the case of spills, stockpiling of contaminated soils, poor containment of contaminated sites, or other situations where access to contaminated soils is not controlled. Although any hazardous chemical can lead to acute health effects, the most likely chemicals are chlorinated chemicals (e.g. PCBs, dioxin), some metals (e.g. lead, arsenic), cyanide, and pesticides.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

EPA has developed screening values for acute soil exposure to some contaminants (http://www.epa.gov/superfund/resources/soil/). As discussed above, concentrations exceeding acute benchmark concentrations are rarely exceeded.

What health effects are associated with excess exposure to these chemicals?

Severe acute effects of most toxic chemicals are related to neurological impairment or affects on the central nervous system. Lead for example, has neurological effects, while pesticides typically affect the central nervous system (http://www.lbl.gov/ehs/html/msds.ht1m; http://www1.nature.nps.gov/toxic/index.html). There are several less severe acute health effects from exposure to contaminants in soil, including chloracne (http://www.goiv.com/ao/chloracne.html), respiratory irritation, eye irritation, etc.

How many people are exposed to concentrations exceeding health benchmarks?

Exposure to contaminants in soil at concentrations that lead to acute health effects is unlikely. The population at greatest risk is children because of their size, sensitivity, and because they made have greater contact with soils compared to adults (http://ehpnet1.niehs.nih.gov/docs/1997/105-12/calabrese.html).

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Unknown. Exposure to soils with chemical concentrations exceeding benchmarks is likely to result in adverse health impacts, but the likelihood of exposure is low.

How persistent/reversible is this stressor?

Most of the chemicals of concern are very persistent in the environment. Long-term exposure to soils having concentrations exceeding benchmarks is unlikely because these soils will typically be remediated or disposed. If soils are not remediated or disposed however, long-term exposure can occur because of the persistence of these chemicals (metals, dioxin, PCBs).

5. Human Health Impacts-Non-cancer Chronic

5.1. Particles in Air

What are the primary chemicals of concern for this stressor?

Particulate matter is measured as PM10 (particulate matter less than 10 microns in diameter) or as PM2.5 (particulate matter less than 2.5 microns). Fine particles are made up of directly emitted primary particles and secondary particles created in the atmosphere from gaseous precursors.

EPA's 1996 National Air Toxics Assessment (NATA) estimated emissions of diesel particles, a constituent of total fine particles, and predicted ambient concentrations around the country. Diesel particles are of concern due to several studies around the country predicting higher concentrations and health risks in urban areas.

<u>What are the concentrations of these chemicals and what health benchmark exceedences are we seeing?</u>

The MPCA monitors PM2.5 in the Boundary Waters Canoe Area for regional haze purposes and at several sites around the state to determine compliance with federal standards. Concentrations at the BWCA site are around 4.5 $\mu g/m^3$. Average concentrations in the metro area range from 11.5 to 14.5 $\mu g/m^3$.

The MPCA's monitoring network has not been in place long enough to measure trends in PM2.5. PM10 concentrations at metro monitoring locations decreased from the mid-1980s to the mid-1990s and then leveled off. PM10 levels at a monitoring site in Virginia, Minnesota remained constant since 1985.

The National Ambient Air Quality Standard (NAAQS) for PM2.5 is 15 $\mu g/m^3$. The standard is an enforceable level that areas must stay below. The US EPA standard of 15$\mu g/m^3$ is believed to be low enough to some health impacts, but health effects will still occur below that level. The standard was set at the lowest level at which EPA felt they could show direct health effects with minimal uncertainty.

EPA's National Air Toxics Assessment predicts concentrations of diesel particles of 0.8 $\mu g/m^3$ to 12.2 $\mu g/m^3$ in the metro area, with lower concentrations in the rest of Minnesota. The MDH's proposed Health Risk Value for diesel exhaust for non-cancer effects is 5 $\mu g/m^3$.

<u>What health effects are associated with excess exposure to these chemicals?</u>

Groups susceptible to health impacts from ambient particles include individuals with respiratory disease, children, and the elderly. Those people with respiratory or cardiovascular illness are at greater risk of hospitalization, aggravation of symptoms, and death. The elderly are also at greater risk for hospitalization and premature mortality due to PM-induced cardiopulmonary problems. Asthmatics are at greater risk of more frequent asthma attacks. Children may experience impaired lung function.

Other specific health impacts from particulate matter include bronchitis (acute and chronic) and increased respiratory disease. Short-term exposures to diesel particles can cause irritation in the respiratory system, worsen allergic reactions, and, some studies conclude, impair lung function. Long-term exposures can cause localized inflammation.

<u>How many people are exposed to concentrations exceeding health benchmarks?</u>

Regulatory monitoring concentrations are measured at levels that are about 90% of the applicable standard. Maximum concentrations and microenvironmental exposures may be higher than the standard, but will not trigger federal enforcement. Health effects on susceptible individuals may occur at concentrations below the standard. EPA's NATA predicts average concentrations in all counties in Minnesota to be below the health benchmark.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

The MPCA is currently not monitoring levels of fine particulate matter exceeding air quality standards. However, health effects may occur below the standards.

How persistent/reversible is this stressor?

Particles are removed from the atmosphere by deposition to land and water or washed out of the air by rainfall.

5.2. Toxic Chemicals in Food

What are the primary chemicals of concern?

PBTs, Endocrine disrupters.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Limited monitoring data and limited multipathway benchmarks exist for these chemicals. Use of many chemicals is decreasing in developed countries; probably not in developing countries; secondary sources not addressed with regulation (for example, burning). Environmental release is still significant due to recycling of these materials. Concentrations are highest in densely populated, industrial areas, and areas with significant automobile traffic. Concentrations vary with individual chemicals. PAHs are greatest in high traffic areas, hexachlorobenzene in agricultural areas and areas near incinerators, PCBs near formulation centers, and dioxins where there are general combustion sources. USGS NAWQA studies indicate presence of chlorinated pesticides in sediment of major rivers. Concentrations in Miss. R. Basin frequently exceeded freshwater criteria. Between 1975 and 1987, PCB concentrations in fish frequently exceeded the U.S. FDA guideline. Concentrations have declined since 1987 (http://wwwmn.cr.usgs.gov/pcb/pcb.htm#abstract). Similar chemicals were observed in the Red River Basin, but at lower concentrations (http://mn.water.usgs.gov/redn/). Metal and PAH concentrations were below criteria. More research has been conducted in Europe than in the united States (http://recetox.chemi.muni.cz/PBTs/content.htm).

What health effects are associated with excess exposure to these chemicals?

- Endocrine disruption (pesticides, dioxins)
- Reproductive – effects on systems and fetal development (PAHs, pesticides, dioxins, PCN)
- Developmental (PAHs)
- Neurological (pesticides)
- Immune system (HCB, dioxins, PCN)
- Whole body effects (HCB)
- The populations at greatest risk to PBTs are children and the developing fetus (http://www.epa.gov/pbt/fact.htm).

For more information on specific health effects, see http://www.lbl.gov/ehs/html/msds.ht1m or http://www1.nature.nps.gov/toxic/index.html.

How many people are exposed to concentrations exceeding health benchmarks?

Unknown, since we generally do not have concentrations or criteria. Since concentrations increase in high density areas, can assume that a significant portion of the population is exposed to elevated levels. In addition, exposure to other populations occurs through ingestion of certain foods, particularly dairy products. Risk for bioconcentrating chemicals is elevated with food ingestion compared to other pathways, since enrichment occurs in foods. Food chain introduces by far the greatest burden for dioxins, PCBs, and pesticides; unknown but likely to be high for some metals; probably less important for PAHs (http://recetox.chemi.muni.cz/PBTs/content.htm).

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Unknown. It is difficult to connect specific incidences of health effects to food chain exposure of PBTs and endocrine disrupting chemicals.

How persistent/reversible is this stressor?

These chemicals are very persistent in the environment and readily cycle through food chains.

5.3. Toxic Chemicals in Water

What are the primary chemicals of concern?

A large number of chemicals that have chronic effects may occur in drinking water. The most important chemicals are pesticides, VOCs, trace inorganic chemicals, and possibly some pharmaceuticals.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Herbicides and VOCs exceed criteria in less than 0.5 percent of private wells, although the detection frequency for these chemicals is much higher (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-baseline.html; http://www.pca.state.mn.us/water/groundwater/gwmap/gw-landuse.html). Typically, about ten public water supplies have lead concentrations exceeding the action level of 15 ppb (MDH). Exceedances of VOCs in public water supplies are rare, but VOCs are frequently detected (http://www.health.state.mn.us/divs/eh/water/cinfo/cinfo.html). Recent studies have shown the presence of pharmaceuticals and other chemicals not previously sampled in surface and ground water. Benchmarks do not exist for these chemicals (http://www.nlm.nih.gov/medlineplus/news/fullstory_6570.html; http://toxics.usgs.gov/regional/emc_sourcewater.html).

We assume most exceedances for trace inorganics are due to natural occurrence of these chemicals. They are therefore not included. Herbicide degradates are found in many private wells (maybe more than 20%) and health impacts of degradates are unknown. Additivity is not factored in, but is unimportant unless herbicide degradates are important. Herbicide degradates are not tested in public water supplies. Lead contamination is primarily associated with piping.

What health effects are associated with excess exposure to these chemicals?

Chronic health effects are documented for many chemicals that occur in ground water (http://www.lbl.gov/ehs/html/msds.ht1m; http://www1.nature.nps.gov/toxic/index.html). The health impacts of herbicide degradates and pharmaceuticals are unknown.

How many people are exposed to concentrations exceeding health benchmarks?

People consuming drinking water from municipal supplies are unlikely to be exposed at concentrations that exceed benchmarks, since water supplies are routinely tested and treated if needed. Long-term exposure for people owing private wells is unlikely because few private wells are contaminated above health benchmarks. Health effects of herbicide degradates and pharmaceuticals are unknown. These chemicals have not been routinely tested in drinking water and their occurrence appears to be more widespread than originally thought (http://www.pca.state.mn.us/water/groundwater/gwmap/index.html; http://www.nlm.nih.gov/medlineplus/news/fullstory_6570.html; http://toxics.usgs.gov/regional/emc_sourcewater.html).

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Unknown. If most heavily contaminated drinking water supplies have been identified and remedied, there is a low likelihood of significant long-term health effects. However, this is countered by our lack of information for herbicide degradates, pharmaceuticals, and other 'new' chemicals that are being detected in drinking water supplies.

5.4. Noise

What are the primary chemicals of concern for this stressor?

There are no chemicals associated with noise. The primary sources of environmental noise are airplanes, industry, and automobile traffic (http://www.nonoise.org/library/highway/probresp.htm; http://www.lhh.org/noise/facts/airport.htm; http://www3.sympatico.ca/noise/; http://www.nonoise.org/news/noisenew.htm).

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Exposure to noise at 55 dB or more leads to sleep deprivation (http://hebw.uwcm.ac.uk/healthyenvironments/Chapter3.html). Some studies indicate that health effects are primarily associated with noise peaks, rather than continuous exposure at an ambient level. There are many sources of environmental noise that exceed 85 decibels, which is considered the threshold value above which continuous exposure for prolonged periods will lead to hearing loss (http://www.md.huji.ac.il/depts/occenvmed/aicraftnoise.html; http://www.lhh.org/noise/decibel.htm). Noise levels are monitored throughout the Twin Cities Metro Area by MNDOT (http://www.dot.state.mn.us/metro/tps/htms/noise/noise.html). The Metropolitan Airports Commission monitors noise complaints (http://www.macavsat.org/whatsnew.htm#jan10).

What health effects are associated with excess exposure to these chemicals?

Chronic health effects include gastrointestinal changes, hearing loss, physiological changes, angina, hypertension, and negative impacts on mental health (http://www.lhh.org/noise/facts/health.htm; http://hebw.uwcm.ac.uk/healthyenvironments/Chapter3.html). It is unclear if there are reproductive and cardiovascular effects from noise (http://www.nonoise.org/library/epahlth/epahlth.htm).

How many people are exposed to concentrations exceeding health benchmarks?

There is limited information on the number of people exposed to environmental noise at a level that could lead to health impacts (http://hebw.uwcm.ac.uk/healthyenvironments/Chapter2.html; http://hebw.uwcm.ac.uk/healthyenvironments/Chapter1.html; http://james.ilo.ucl.ac.uk/links/vmlweb/info/ilo/research/pan/). European estimates indicate that about 5 percent of the population is at risk for health effects related to noise, but most of this is associated with occupational noise. Any individual living near a source of noise that exceeds the threshold is at risk from acute effects. These largely occur in urban areas, such as near airports, highways, construction, and industries.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Noise complaints recorded by MAC Aviation Noise and Satellite Program staff for 2001 were down from the previous year. Compared to 2000, total noise complaints recorded in 2001 fell 20.7% from 14,049 in 2000 to 11,131 in 2001 (http://www.macavsat.org/whatsnew.htm#jan10). Noise complaints cannot be compared directly to health effects, but provide an indication of the number of people bothered by noise.

How persistent/reversible is this stressor?

Noise is quickly dispersed in the environment and is therefore not persistent. A continuous source of noise, however, can provide persistent noise levels that lead to acute health effects.

5.5. Odorous Chemicals from Biological Processes

What are the primary chemicals of concern for this stressor?

Pollutants associated with the biological degradation of organic matter are mainly volatile organic compounds. Ammonia and hydrogen sulfide are two inorganic chemicals emitted by these processes.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

According to the MPCA web site (http://www.pca.state.mn.us/hot/fl-odor.html; http://www.pca.state.mn.us/hot/legislature/factsheets/feedodor.pdf), Minnesota's ambient standard for hydrogen sulfide "is a 30-minute average of 30 parts per billion twice in five days, or a 30-minute average of 50 parts per billion twice per year."
The MPCA monitors hydrogen sulfide levels near feedlots only after receiving complaints of odors. Of those sites monitored, approximately one-half exceed the ambient standard at some time. Many other sites are never monitored, so it is not known if the ambient concentrations are higher than the standard.
Hydrogen sulfide is only one chemical that can lead to odor. The MPCA does not have a relevant standard for other pollutants that lead to odor complaints.

What health effects are associated with excess exposure to these chemicals?

Many acute symptoms are associated with odor exposures, including eye, nose, and throat irritation, headaches, diarrhea, and chest tightness. The effects are normally experienced at the time of exposure and subside thereafter.

Although most symptoms of odor exposure subside shortly, asthmatics and other sensitive individuals may experience persistent symptoms and exacerbated effects related to their existing condition.

How many people are exposed to concentrations exceeding health benchmarks?

Sources of odor are typically located in rural areas, so the total population exposed to concentrations exceeding health benchmarks is likely to be lower than the population exposed to pollution in urban areas.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

The MPCA does not track health effects that may be caused by odors or similar pollutants.

How persistent/reversible is this stressor?

Hydrogen sulfide, ammonia, and other pollutants associated with odor readily disperse and break down in the environment once the source is removed.

References

- http://www.penweb.org/issues/sludge/health-odor.htm

5.6. Toxic Volatile Organic Chemicals in Air

What are the primary chemicals of concern for this stressor?

US EPA's National Air Toxics Assessment (NATA) analyzed emissions and used models to predict ambient concentrations and exposures for 33 air toxics and diesel PM. The pollutants are:

Acetaldehyde	Ethylene Oxide	Acrolein
Formaldehyde	Acrylonitrile	Hexachlorobenzene
Arsenic Compounds	Hydrazine	Benzene
Lead Compounds	Beryllium Compounds	Manganese Compounds

1,3-Butadiene	Mercury Compounds	Cadmium Compounds
Methylene Chloride	Carbon Tetrachloride	Nickel Compounds
Chloroform	PCBs	Chromium Compounds
Polycyclic Organic Matter	Coke Oven Emissions	Quinoline
Dioxins/Furans	1,1,2,2-Tetrachloroethane	Ethylene Dibromide
Perchloroethylene	Propylene Dichloride	Trichloroethylene
1,3-dichloropropene	Vinyl Chloride	Ethylene Dichloride

EPA's Urban Air Toxics Strategy lists these pollutants as those that are of concern in urban areas in the United States.

The MPCA's air toxics emissions inventory estimated emissions for 109 pollutants for calendar year 1997, the most recent year data is available. The pollutants inventoried are on EPA's list of 188 hazardous air pollutants (HAPs). The list of pollutants was selected as part of the Great Lakes regional emissions inventory as chemicals that contribute to the contamination of the Great Lakes and/or were requested for inclusion in EPA's National Toxics Inventory.

The MPCA monitors many volatile organic carbon (VOC) compounds, carbonyl compounds, and some metals. The pollutants monitored are those for which the MPCA has a reliable method for measuring their concentration in the air. The MPCA monitoring network includes several long-term sites which have been in place since the early 1990's and a network of sites around that state that collect information for annual 'snapshots' in an effort to analyze pollutant concentrations across the state.

The MPCA does not monitor for semi-volatile chemicals due to the high cost of analysis. Many of these chemicals are persistent and bioaccumulative.

What are the concentrations of these chemicals and what health benchmark exceedences are we seeing?

EPA's NATA modeling predicted concentrations of several chemicals at or above their health benchmarks, especially in the Twin Cities metro area. Modeled concentrations of acrolein were predicted to exceed the non-cancer health benchmark. Air toxics monitoring performed by the MPCA tended to show concentrations higher than those predicted in the NATA modeling.

What health effects are associated with excess exposure to these chemicals?

A variety of health impacts are associated with high concentrations of air toxics due the diversity of chemicals included in the broad definitions. The health impacts include respiratory irritation, asthma exacerbation, and developmental problems. The specific health impacts depend entirely on what suite of chemicals are considered.

How many people are exposed to concentrations exceeding health benchmarks?

Modeling predicts concentrations of acrolein exceeding health benchmarks in the metro area. Local 'hot spots' may exist near sources of air toxics. Many pollutants are also present at concentrations that are higher than background concentrations but lower than health benchmarks. The cumulative effects of these chemicals are not well understood, but there may be synergistic or additive effects.

Many people may be exposed to concentrations of these chemicals that are higher than those predicted or measured in ambient air. These 'microenvironmental' exposures include many day-to-day activities of Minnesotans. Dry cleaning, automobile refueling, and pesticide use are examples. Concentrations of several pollutants in the cabins of automobiles in traffic have been measured at higher concentrations than the corresponding ambient air.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

The Minnesota Pollution Control Agency is not measuring concentrations of any air toxics above non-cancer benchmarks. For many chemicals, there is no benchmark.

Many individuals are exposed to higher concentrations of many air toxics in certain microenvironments (gas stations, dry cleaners). Many chemicals are present in urban air at levels below health benchmarks, but the health effects due to the cumulative exposure to the these pollutants, if any, is unknown.

How persistent/reversible is this stressor?

Some air toxics break down quickly in the environment, while others are extremely persistent.

References

- http://www.epa.gov/ttn/atw/nata/
- http://www.pca.state.mn.us/air/toxics.html
- http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html

5.7. Ground-level Ozone

See *Ozone* in Section 5.10, *Other Criteria Pollutants in Air*.

5.8. Excess UV radiation from Stratospheric Ozone Depletion

What are the primary chemicals of concern for this stressor?

Chlorofluorocarbons, hydochlorofluorocarbons, 1,1,1-trichloroethane, methyl bromide, carbon tetrachloride, methylene chloride, halons, hydrobromofluorocarbons.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

Ozone is naturally found in a thin layer in the stratosphere (a layer 15-30 kilometers above the earth's surface). This layer normally absorbs a portion of ultraviolet light called UVB and prevents it from reaching the earth.

Ozone is very reactive and is constantly being formed and destroyed in the stratosphere. The total amount normally remains relatively stable. However, halogens such as chlorine and bromine can act as catalysts in the destruction of ozone, resulting in the net effect that ozone is destroyed faster than it is naturally created.

The chemicals of concern such as CFCs are very stable, so they are able to reach the stratosphere after being released. Once they reach the stratosphere, they are broken down by UV radiation and chlorine and bromine is released. The chlorine and bromine then catalyze the destruction of ozone and result in a net loss of stratospheric ozone. Therefore, less UVB radiation is absorbed and more reaches the earth.

Different chemicals of concern have different ozone depleting potentials (ODPs) and different half-lives. For example, CFC-11 has an ODP of 1, while HCFC-141b has an ODP of 0.1. This means that a molecule of CFC-11 can destroy ten times as much ozone as HCFC-141b. In addition CFC-11 has an atmospheric lifetime of 70 years while carbon tetrachloride has an atmospheric lifetime of about 10 years.

<u>What health effects are associated with excess exposure to these chemicals?</u>

All of the health effects from stratospheric ozone depletion are the result of increased exposure of humans to UV radiation.

Ocular Effects -- The best documented short-term ocular effect of exposure to UV radiation is photokeratoconjunctivitis (`snow blindness' and 'welder eyes'), i.e., an inflammatory reaction of the surface of the eyeball. Pterygium (tissue growth that can block vision) and cataract (clouding of the eye lens) resulting from excess exposure to UV radiation is less well documented. This is because they result after many years of exposure, and, in part, at least for cataract, because many other factors are known to have etiologic role.

Immunological Effects -- Because skin is an important immunological organ, the immune system is vulnerable to modification by environmental agents, including UV-B radiation. Demonstrations that systemic immunity can be perturbed by exposing skin to UV-B radiation raise the concern that ozone depletion might adversely influence immunity to infectious diseases.

<u>How many people are exposed to concentrations exceeding health benchmarks?</u>

Every Minnesotan that spends at least some time outdoors is affected by increased levels of UV radiation. Lighter skinned people are at higher risk than darker skinned people. The amount of time spent outdoors will affect exposure and risk as well as the amount of protection used (hats, long-sleeves and long pants, sunscreen, etc.).

<u>How many incidences of the diseases/ailments of concern result from exposures above criteria?</u>

Ocular Effects -- It is difficult to estimate the magnitude of the increase in ocular effects without adequate information on the wavelength dependence of these effects and proper dose-response relationships. However, cataracts diminish the eyesight of millions of Americans and it is believed that these problems can be lessened with reduced exposure to UV radiation.

Immunological Effects -- Scientists have found that overexposure to UV radiation may suppress proper functioning of the body's immune system and the skin's natural defenses. However, the etiology and incidence is still somewhat speculative.

<u>How persistent/reversible is this stressor?</u>

Many of the chemicals of concern have very long atmospheric lives, up to 110 years (CFC 12). Currently, we are experiencing depletion of approximately 5 percent at mid-latitudes, but if no action had been taken to limit CFCs, ozone depletion at mid-latitudes would eventually have reached 20 percent or more. If international agreements (such as the Montreal Protocol) are adhered to, the ozone layer is expected to recover by 2050.

References:

- The EPA Ozone Depletion Website: http://www.epa.gov/ozone/index.html
- UNITED NATIONS ENVIRONMENT PROGRAMME ENVIRONMENTAL EFFECTS OF OZONE DEPLETION: 1994 ASSESSMENT. November 1994. http://sedac.ciesin.org/ozone/UNEP/UNEP94toc.html
- Environmental Chemistry 2nd edition, Nigel Bunce, Wuerz Publishing Ltd.

5.9. Toxic Chemicals in Soil

What are the primary chemicals of concern?

Long-term exposure to contaminated soils is unlikely except for chemicals deposited through off-site deposition. The primary chemical of concern is lead. Other trace chemicals such as beryllium, and some organic chemicals, such as PAHs and pesticides, may be elevated locally.

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

There is limited information of chemical concentrations. Lead concentrations exceed the benchmark (400 mg/kg) in some core areas of large cities. Studies show limited exceedance of criteria for other chemicals ((Mielke et al. 1991 Environ. Geochem. Health 13:29-34; Mielke et al. 1983 Amer. Jour. Pub. Health. 73:1366-1369; Mielke et al. 1989 Environ. Geochem. Health. 9:243-271; Mielke et al. 1984/85 Journal of the Minnesota Academy of Science. 50:19-24; Fruin et al. 1994.; Minnesota Pollution Control Agency and Minnesota Department of Health. 1987; Pierce, F.J., R.H. Dowdy, and D.F. Grigal. 1982 J. Environ. Qual. 11:416-422).

What health effects are associated with excess exposure to these chemicals?

Lead has a variety of impacts, including neurological effects. Effects for other chemicals vary widely. Pesticides typically affect the central nervous system. Non-carcinogenic PAHs impact a variety of targets, including the kidneys, gastro-intestinal system, and the liver (http://www.lbl.gov/ehs/html/msds.ht1m; http://www1.nature.nps.gov/toxic/index.html).

How many people are exposed to concentrations exceeding health benchmarks?

Without adequate sampling and monitoring data, we cannot estimate the number of people exposed to soil concentrations exceeding health benchmarks.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Unknown. Exposure to soils with chemical concentrations exceeding benchmarks is likely to result in adverse health impacts, but the likelihood of exposure is low.

How persistent/reversible is this stressor?

Most of the chemicals of concern are very persistent in the environment. Long-term exposure to soils having concentrations exceeding benchmarks is unlikely because these soils will typically be remediated or disposed. If soils are not remediated or disposed however, long-term exposure can occur because of the persistence of these chemicals (metals, dioxin, PCBs).

5.10. Other Criteria Pollutants in Air

Carbon Monoxide (CO)

What are the primary chemicals of concern for this stressor?

Carbon Monoxide

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for CO in St. Cloud, Duluth, and the Twin Cities metropolitan area. The values from these monitors are compared to the National Ambient Air Quality Standards (NAAQS). The NAAQS for CO are an 8-hour standard of 9 ppm (10,000 $\mu g/m^3$) and a 1-hour standard of 35 ppm (40,000 $\mu g/m^3$). Second maximum 1-hour monitored CO levels in Minnesota in 2000 ranged from 1.5 ppm (Dakota County) to 6.6 ppm (St. Paul). Second maximum 8-hour levels in 2000 ranged from 1.4 ppm (Dakota County) to 5.1 ppm (St. Paul)No exceedences of the standard have been measured since at least 1996 (Monitoring Data information from EPA AIR*Data*, August 2001).

What health effects are associated with excess exposure to these chemicals?

Carbon monoxide can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues.

Cardiovascular Effects - The health threat from lower levels of CO is most serious for those who suffer from heart disease, like angina, clogged arteries, or congestive heart failure. For a person with heart disease, a single exposure to CO at low levels may cause chest pain and reduce that person's ability to exercise; repeated exposures may contribute to other cardiovascular effects.

Central Nervous System Effects - Even healthy people can be affected by high levels of CO. People who breathe high levels of CO can develop vision problems, reduced ability to work or learn, reduced manual dexterity, and difficulty performing complex tasks. At extremely high levels, CO is poisonous and can cause death.

Smog - CO contributes to the formation of smog ground-level ozone, which can trigger serious respiratory problems. (Air Quality Where you Live http://www.epa.gov/air/urbanair/6poll.html).

How many people are exposed to concentrations exceeding health benchmarks?

Currently, ambient monitored concentrations of CO are at least half the national standards. According to monitored data, exceedences have not occurred since at least 1996. Individuals in microenvironments may be exposed to levels above the NAAQS.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

MPCA currently is not measuring ambient CO above the NAAQS. There may be individuals in microenvironments affected by high CO levels.

How persistent/reversible is this stressor?

CO is insoluble and relatively unreactive. The tropospheric sinks for carbon monoxide are uptake in soil, followed by microbial oxidation to CO_2, and atmospheric oxidation by the hydroxyl radical (OH).

References

- http://www.epa.gov/air/urbanair/co/index.html
- http://www.pca.state.mn.us/air/emissions/co.html

Ozone

What are the primary chemicals of concern for this stressor?

Ozone

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for ozone in Lake County, St. Louis County, Mille Lacs and the Twin Cities metropolitan area. The values from these monitors are compared to the NAAQS. The NAAQS for ozone are an 8-hour standard of 0.08 ppm (157 $\mu g/m^3$) and a 1-hour standard of 0.012 ppm (235 $\mu g/m^3$). Second maximum 1-hour monitored ozone levels in Minnesota in 2000 ranged from 0.72 ppm (Lake County) to 0.087 ppm (Blaine). Fourth maximum 8-hour levels in 2000 ranged from 0.07 ppm (Stillwater) to 0.064 ppm (Anoka County). In 2001, there have been individual 8-hour ozone concentrations above 0.08 ppm. However, because the standard is a 3-year average of 4th daily maximums, no actual exceedences of the standard have been measured. (Monitoring Data information from EPA AIR*Data*, August 2001 & MPCA monitoring data. Note: Only Twin Cities data was available for the 8-hr averaging period).

What health effects are associated with excess exposure to these chemicals?

Repeated exposure to ozone pollution for several months may cause permanent lung damage. Anyone who spends time outdoors in the summer is at risk, particularly children and other people who are active outdoors. Even at very low levels, ground-level ozone triggers a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. (Air Quality Where you Live http://www.epa.gov/air/urbanair/6poll.html).

How many people are exposed to concentrations exceeding health benchmarks?

Thus far, the NAAQS have not been exceeded for ozone. However, several times in the summer of 2001, high ozone levels have resulted in air quality conditions in the unhealthy for sensitive groups range. These warnings have been in the highly populated Twin Cities metropolitan area and high ozone would potentially affect large populations of people.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

MPCA is unsure about the actual incidences without tracking hospital admissions and doctor visits. Anecdotal evidence indicates problems among people with respiratory preconditions. There are indications that health concerns may exist below the NAAQS.

How persistent/reversible is this stressor?

Ground-level ozone forms from the reaction of nitrogen oxides, volatile organic compounds in sunlight and heat. Ozone tends to be a local problem. Ozone reacts rapidly with nitric oxide (NO), therefore, the atmosphere cleans itself in a few days once the pollution source is removed.

References

- http://www.epa.gov/air/urbanair/ozone/index.html
- Preliminary Assessment of Ozone Air Quality Issues in the Minneapolis/St.Paul Region: Final Report. Sonoma Technology, Inc. October 10, 2002. http://www.pca.state.mn.us/air/ozonestudy.html

Nitrogen oxides

What are the primary chemicals of concern for this stressor?

Nitrogen dioxide (NO_2) and nitric oxide (NO)

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for NO_2 in the Twin Cities metropolitan area. The values from these monitors are compared to the NAAQS. The NAAQS for NO_2 is an annual mean concentration of 0.053 ppm (100 $\mu g/m^3$). Annual means of NO_2 levels in Minnesota in 2000 ranged from 0.009ppm (Rosemount) to 0.022 ppm (Minneapolis). No exceedences of the standard was measured. (Monitoring Data information from EPA AIR*Data*, August 2001)

What health effects are associated with excess exposure to these chemicals?

Long-term exposures to NO_2 may lead to increased susceptibility to respiratory infection and may cause permanent alterations in the lung. Nitrogen oxides react in the air to form ground-level ozone and fine particle pollution which are both associated with adverse health effects (Latest Findings on National Air Quality: 1999 Status and Trends, EPA, August 2000, EPA-454/F-00-0002).

How many people are exposed to concentrations exceeding health benchmarks?

The measured annual means tend to be less than a third of the standard at most monitoring locations. Minneapolis is at about half of the NAAQS. The main human health concern for NO_X is as a precursor in the formation of ground-level ozone.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Greater disease/ailment is expected from the reaction product, ozone. There may be individual exposure to elevated NO_X in microenvironments.

How persistent/reversible is this stressor?

Nitrogen oxides react in the atmosphere to form nitrates, nitrites, nitric acid and N-nitroso compounds. Nitric acid and acid nitrates, such as ammonium nitrate are components of acid rain. In fact, the formation of HNO_3 is an important sink for removing nitrogen dioxide from the atmosphere.

References

- http://www.epa.gov/air/urbanair/nox/index.html
- http://www.pca.state.mn.us/air/emissions/no2.html

Sulfur oxides

What are the primary chemicals of concern for this stressor?

Sulfur dioxide (SO2), H_2SO_3, and H_2SO_4

What are the concentrations of these chemicals and what health benchmark exceedances are we seeing?

MPCA monitors for SO_2 in the Twin Cities metropolitan area and several greater Minnesota locations. The values from these monitors are compared to the NAAQS. The NAAQS for SO_2 are an annual mean concentration of 0.03 ppm (80 $\mu g/m^3$), a 24-hour standard of 0.14 ppm (365 $\mu g/m^3$), and a state 1-hour standard of 0.5 ppm (1300 $\mu g/m^3$). Annual means of SO_2 levels in Minnesota in 2000 ranged from 0.001-0.002 ppm at all sites. The 24-hour monitored concentrations in 2000 ranged from 0.001 ppm (International Falls) to 0.023 ppm (Minneapolis). No exceedences of the standard was measured. (Monitoring Data information from EPA AIR*Data*, August 2001).

What health effects are associated with excess exposure to these chemicals?

SO_2 causes a variety of health and environmental impacts because of the way it reacts with other substances in the air. Particularly sensitive groups include people with asthma who are active outdoors and children, the elderly, and people with heart or lung disease.

Respiratory Effects from Gaseous SO2 - Longer-term exposures to high levels of SO2 gas and particles cause respiratory illness and aggravate existing heart disease.

Respiratory Effects from Sulfate Particles - SO_2 reacts with other chemicals in the air to form tiny sulfate particles. When these are breathed, they gather in the lungs and are associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death. (Air Quality Where you Live http://www.epa.gov/air/urbanair/6poll.html).

How many people are exposed to concentrations exceeding health benchmarks?

The measured concentrations at all monitoring locations in 2000 were 80-90% below the NAAQS.

How many incidences of the diseases/ailments of concern result from exposures above criteria?

Current, ambient atmospheric levels of SO_2 are not expected to cause human health concerns. There may be individual exposure to elevated SO_2 in microenvironments.

How persistent/reversible is this stressor?

The half-lives of SO_2 and SO_3 in the atmosphere are of the order of several days. SO_2 undergoes three processes, oxidation of SO_2 to SO_3, deposition of H_2SO_3, and deposition of H_2SO_4. Acid precipitation is a regional, tropospheric pollution issue, but not a global problem.

References

- http://www.epa.gov/air/urbanair/so2/index.html
- http://www.pca.state.mn.us/air/emissions/so2.html

Other references

http://www.epa.gov/airtrends/

Appendix C: Documentation for Sources

Note to readers: This appendix and others refer to reports and documents indicated as clickable internet links, which were live when the report was drafted. It is likely that some of these links are no longer live and current, as the MPCA cannot maintain those belonging to other organizations. If you are interested in a particular reference and cannot access it, please contact Michael Trojan at 651/297-5219.

Information in this Appendix was collected by the EIR Team with assistance from MPCA technical staff. Information was used in internal discussions among the EIR team in assigning scores for sources.

This document is organized by stressors, since the EIR focuses on stressors. The Table of Contents lists the 24 stressors used in the EIR. Within each stressor, we identify the sources that contribute to that stressor. For each source, we provide documentation on relative contribution of each source, our confidence in assigning relative contribution, and our assessment of the trend in contribution from that source. In some cases, sources occurred more than once for a particular stressor. For example, off-road equipment occurs twice for Acid Deposition because it is a source that contributes to Acid Deposition in both aquatic and terrestrial ecosystems.

We do not discuss relative contribution, confidence, and trend for each of the 304 stressor-impact-source combinations, but rather discuss sources within a stressor only. When there are differences for a particular source within a stressor, we identify these differences and provide a general discussion of the overall impact of that source on that stressor.

At the end of this Appendix, we include an index that allows the reader to identify stressors that have common sources. We included this because many references for a particular source within a stressor may not be included for the same source under a different stressor, even though the information may be relevant. For example, Feedlots is a source for the stressors Nitrogen and Phosphorus. There may be references listed for Nitrogen that would also apply to Phosphorus, but that we did not include in the Phosphorus section.

While this document provides supporting information for our estimates of contribution, confidence, and trend, those estimates were largely based on knowledge of expert staff participating in development of the EIR. Many of these staff are listed in Appendix A. The assumption is that our technical staff are experts within their field and therefore have sufficient knowledge of the environmental importance of different sources. When reviewing this document, readers are encouraged to review the additional references listed within the references that we provide. In many cases, we simply provide a general link through which the reader can obtain more information.

Table of Contents

1. Acid Deposition
Impact Categories: Aquatic Organisms, Terrestrial Organisms
Sources: Coal-fired Power Plants, On-road Vehicles, Off-road Equipment

Acid deposition occurs when gases released to the atmosphere, primarily NO_x and SO_2, are oxidized and deposited in wet or dry form. Natural acids may also be released to the atmosphere, particularly hydrochloric acid. Acid deposition can lower ambient pH in aquatic and terrestrial ecosystems to 4.5 or less, which can have a variety of negative impacts on the ecosystems and individual organisms (http://royal.okanagan.bc.ca/mpidwirn/atmosphereandclimate/acidprecip.html#a).

Comparative Contribution of Sources

Coal-fired Power Plants: High contribution. About 25 percent of nitrogen oxides (NO_x) come from thermoelectric generating stations. About 73 percent of sulfur dioxide (SO_2) emissions come from point sources, primarily coal-fired power plants (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.ns.ec.gc.ca/msc/as/acidfaq.html; http://www.epa.gov/oar/aqtrnd00/acidrain.html).

On-road Vehicles: Medium contribution. About 32% of nationwide NOx emissions come from on-road vehicles. On-road sources emit a much smaller percentage of SO2 emissions (~2%). (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.ns.ec.gc.ca/msc/as/acidfaq.html; http://www.epa.gov/oar/aqtrnd00/acidrain.html; http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf).

Off-road Equipment: Medium contribution. Off-road engines and other equipment contribute about 22% of US NOx emissions and 6% of SO2 emissions. (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.ns.ec.gc.ca/msc/as/acidfaq.html; http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf).

Confidence Level

Coal-fired power plants: Reasonably confident. Coal-fired power plants are required to have a permit to discharge to the atmosphere. Therefore, we have reasonably good information about discharges from these facilities. In addition, there are several monitoring sites in Minnesota, primarily located near point sources (http://www.pca.state.mn.us/air/pubs/aqtrends.pdf).

On-road vehicles: Moderately confident. We have reasonably good information on the number of vehicles in Minnesota. We can estimate vehicle miles driven and fuel consumption. Vehicle emissions of SO_2 have decreased in the past ten years because of mandated improvements in vehicles (http://www.pca.state.mn.us/hot/legislature/factsheets/mobile.pdf; http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-i.pdf; http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf).

Off-road vehicles: Moderately confident. Minnesota has limited data regarding off-road emissions of SO_2 and NO_x. Several western states have compiled this information, which indicates off-road mobile sources constitute more than half of all nonindustrial SO_2 and less than half the nitrogen oxide emissions. Construction, planes, and agricultural equipment are the most important off-road sources (http://www.wrapair.org/forums/MSF/MOBILE.HTM; http://transaq.ce.gatech.edu/epatac/documents/cackette.pdf; http://www.gbcpa.org/state_imp_plan.htm).

Source Trends

Coal-fired Power Plants: No trend. Emissions of SO_2 have increased about 25 percent in the past ten years because of increased energy demand. Concentrations in the atmosphere, however, have decreased by nearly 50 percent over the same period. This apparent discrepancy may be due to decreasing emissions nationally and location of monitoring sites in areas that do not reflect recent increases in emissions. There has been a slight upward trend in emissions of NO_x in Minnesota, but this trend does not appear statistically significant. Because of the uncertainty about SO_x emissions and the lack of significant upward trend for NO_x emissions, we assigned no trend to this source (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.epa.gov/oar/aqtrnd00/acidrain.html).

On-road vehicles: No trend. Emissions of SO_2 from automobiles have decreased significantly in the past 15 to 20 years because of improved technology (http://environment.about.com/library/weekly/blair3.htm). However, vehicle traffic has increased and fuel efficiency has lowered over the past ten years. There has been a slight upward trend in emissions of NO_x in Minnesota, but this trend does not appear statistically significant. Mobile sources, particularly automobiles, would likely account for any trend in emissions of NO_x. Nationally, NO_x emissions have decreased slightly over the past ten years (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.epa.gov/oar/aqtrnd00/acidrain.html).

Off-Road Vehicles: No trend. It is difficult to evaluate trends in contributions from off-road vehicles. Construction, air transportation, and agricultural activity have not decreased, and regulations for improved fuel efficiency apply only to diesel vehicles (http://environment.about.com/library/weekly/blair3.htm). Since use of off-road vehicles has not decreased and may have increased over the past ten years, decreases in emissions due to improved fuel efficiency have probably been offset.

2. Ammonia

Impact Categories: Aquatic Organisms

Sources: Feedlots, Municipal and Industrial Wastewater, Septic Systems

Ammonia is a natural constituent of many wastes, primarily animal wastes. Ammonia is toxic to fish. Ammonia may also be formed through oxidation of nitrogen in organic matter. Because this reaction requires oxygen, however, this ammonia is often converted to more oxidized forms of nitrogen, such as nitrate. We therefore do not include fertilizer as a source for this stressor (http://ohioline.osu.edu/b896/b896_2.html; http://www.cryotech.com/urea.html).

Comparative Contribution of Sources

Feedlots: High contribution. There are nearly 9.5 million pigs, 0.9 million cows (dairy and cattle), 0.2 million sheep, 43.5 million turkeys, 44.2 million chickens, and 35000 permitted feedlots in Minnesota (http://www.nass.usda.gov/mn/agstat99.htm#sect3; http://www.nass.usda.gov:81/ipedb/; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch7.pdf; http://www.nass.usda.gov/mn/agstat00/page889.PDF). Although the average farm size has increased from 332 to 367 acres and livestock operations have increased in size over the past ten years, many livestock operations continue to occur in open lots or areas where surface water is easily contaminated from manure (http://www.nass.usda.gov:81/ipedb/; http://www.ae.iastate.edu/L&EHomestudy/openall3.htm; http://www.spatialhydrology.com/journal/paper/feedlot/Feedlot.pdf). Land application of manure is another potential source of surface water contamination (http://www.agric.gov.ab.ca/agdex/500/576-3.html). Nitrogen concentrations in animal waste are high and feedlot waste has a high biochemical oxygen demand. Consequently, most nitrogen will be in a reduced form (ammonia and organic nitrogen). Ammonia concentrations in animal manure are about 0.1 percent, but vary widely (Douglas, B.F., and F.R. Magdoff. 1991. *An Evaluation of Nitrogen Mineralization Indices for Organic Residues*. Jour. Environ. Qual. 20:368-372). Ammonia may enter surface water bodies from either direct overland runoff or seepage into ground water that eventually discharges to surface water. Ammonia concentrations in ground water beneath unlined manure basins may be as high as 250 mg/L, although concentrations are typically less than 30 mg/L under lined basins. Ammonia is not very mobile in ground water, but high concentrations can occur more than 200 feet from unlined basins that have been in operation for several years (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-manure.html). A 1979 MPCA study estimated that only 4.9 percent of the 5000 feedlots located in shorleand areas did not discharge pollutants during a 25-yr/24-hr rainstorm (http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch7.pdf). Much of the nitrogen generation from livestock occurs in hydrologically sensitive areas, such as central, southeast, and southwest Minnesota (http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch7.pdf). An Iowa study on impaired waters indicates lakes, rivers, and streams are primarily impacted from agricultural nonpoint sources, which includes feedlot runoff (http://www.agric.gov.ab.ca/sustain/water/quality/primer5.html). In a Nebraska study, agriculture was the most important source of ammonia discharged to surface water (http://www.ianr.unl.edu/pubs/water/nf460.htm). In Minnesota, all but one of the locations where the TMDL for ammonia was exceeded occurred in agricultural areas. In most of the areas, particularly in southern Minnesota, locations on the TMDL list for ammonia were also on the list for fecal coliform (http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf). The primary contributor to surface water is nonpoint pollution, such as feedlots (http://www.pca.state.mn.us/water/basins/305briver.html).

Municipal and Industrial Wastewater: Medium contribution. Historically, wastewater was an important source of ammonia contamination in surface water. Studies show that wastewater treatment plants remain an important source for ammonia (http://www.bham.ac.uk/CivEng/resproj/heng/; http://www-dinind.er.usgs.gov/nawqa/wr03006.htm;

http://water.usgs.gov/pubs/circ/circ1162/nawqa91.6.html). Wastewater treatment plants are regulated through the NPDES permitting process, which includes effluent limitations. Ammonia is not always required but is frequently monitored in effluent (http://www.pca.state.mn.us/publications/wq-wwprm1-02.pdf). Because of effluent regulations, instances of ammonia contamination of surface water have decreased, although concentrations of ammonia downgradient of treatment facilities exceed upgradient concentrations.

Septic Systems: Low contribution. Septic systems can contribute to ammonia contamination by discharging ammonia to ground water that eventually enters surface water, or by direct runoff from failing septic systems. Septic systems are designed to minimize loss of organic carbon. This is achieved by allowing a separation between the bottom of the drainfield and the top of the ground water table. This zone contains oxygen. Ammonia that passes into this oxygenated zone is transformed to nitrate. Consequently, little ammonia is lost from septic systems that are in compliance. If there is no oxygenated zone between the water table and the bottom of the drainfield, ammonia may enter ground water. Ammonia is not very mobile in ground water, however, and is rarely found more than 50 feet from the drainfield. The greatest risk from ammonia contamination comes from failing systems where septage occurs at the land surface. These systems must be quickly remedied, however, because they represent an immediate health risk (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-nonsewered.html; http://www.pca.state.mn.us/programs/ists/index.html). Septic systems therefore contribute only small amounts of ammonia to surface water.

Confidence Level

Feedlots: Moderately confident. We have good estimates of the number of livestock and feedlots in Minnesota. Minnesota milestone sites represent a small percentage of Minnesota's surface water and results at each site cannot be easily linked to land use (i.e. contaminant sources). Several research studies illustrate the relationship between surface water quality and manure management, but extrapolation of these results to an entire state may be misleading. We therefore assigned a moderate confidence to our estimate, since we have good information on the amount of potential waste but lack of information linking actual effects to the source.

Municipal and Industrial Wastewater: Reasonably confident. Regulations have resulted in decreased discharge of ammonia to surface water. Several studies illustrate the link between treatment plants and water quality. Some information in Minnesota illustrates improvements in surface water quality following upgrade of treatment facilities. We are therefore reasonably confident about impacts from municipal and industrial wastewater.

Septic Systems: Moderately confident. We have good estimates of the number of septic systems in Minnesota. Minnesota milestone sites represent a small percentage of Minnesota's surface water and results at each site cannot be easily linked to land use (i.e. contaminant sources). Several research studies illustrate the relationship between surface water quality and septic systems, but extrapolation of these results to an entire state may be misleading. We therefore assigned a moderate confidence to our estimate, since we have good information on the amount of potential waste but lack of information linking actual effects to the source.

Source Trends

Feedlots: No trend. There were downward trends in ammonia concentrations at 83 percent of Minnesota milestone sites, with 14 percent having no trend (http://www.pca.state.mn.us/publications/reports/305bfinalreport-2000.pdf). The average increase in farm size, a shift to larger animal operations, improvements in manure storage and management (http://www.extension.iastate.edu/Publications/AE3077G.pdf), and increasingly stringent regulations on open lots and discharges from permitted facilities lead to a decreasing trend in releases to surface water. This is counterbalanced, however, by increased land application of manure and increased livestock numbers. Because of these uncertainties, no trend was assigned to this source.

Municipal and Industrial Wastewater: Downward trend. Increased regulation of treatment facilities and improved treatment has resulted in decreases in ammonia contamination of surface waters. Data for Minnesota are lacking, but studies from other states reveal a downward trend in ammonia released to surface water from treatment facilities (http://wwwga.usgs.gov/publications/abstracts/wrir96-4101.html; http://www.anl.gov/OPA/env/EMfacts.html).

Septic Systems: No trend. Between 1980 and 1990, the number of homes served by an individual sewage treatment system increased 22 percent. Despite this increase, these newer systems are likely to be in compliance and therefore contribute little ammonia to surface water. Simultaneously, older systems are increasingly being brought into compliance as some municipalities and counties in Minnesota attempt to upgrade old septic systems (http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch14-1.pdf; http://www.pca.state.mn.us/programs/ists/index.html). We therefore assigned no trend to this source.

3. Dissolved Solids

Impact Categories: Aquatic Organisms
Sources: Municipal and Industrial Wastewater, Urban Runoff

Dissolved solids include a large number of chemicals that may impact aquatic ecosystems. The primary chemical of concern is chloride because there are many anthropogenic sources and elevated chloride concentrations are widely observed in surface waters. Other dissolved solids may have local impacts on aquatic ecosystems, but they are not considered in this discussion. Although there are many sources of chloride, we only discuss municipal and industrial wastewater and urban runoff, since these may lead to concentrations of chloride that negatively impact aquatic organisms. Thus, other sources, such as septic systems, manure, and fertilizers, are not included (http://www.texasep.org/html/wql/wql_2sfc.html).

Comparative Contribution of Sources

Municipal and Industrial Wastewater: Low contribution. Wastewaters, particularly some industrial wastewaters, have high chloride concentrations. These concentrations may be of concern because the wastewater is discharged directly to surface water and there are few effective strategies for reducing chloride concentrations in wastewater (http://www-oh.er.usgs.gov/reports/Abstracts/wrir.99-4201.html; http://www.gns.cri.nz/earthres/groundwater/sites/tasman/site_wwd3314.htm; http://emmap.mtu.edu/gem/community/publications/wellspring/salt_follow-up.html; http://www.dnr.state.wi.us/org/water/wm/ww/wwpubs/slines4.htm#CHLOR). Impacts are likely to be limited in geographic extent, however.

Urban Runoff: High contribution. Road salt is the primary urban source of chloride (http://www.epa.gov/npdes/menuofbmps/poll_12.htm). Research conducted by the United States Geological Survey clearly shows elevated chloride concentrations in urban areas of Minnesota. These studies suggest that many locations in urban areas could be placed on the TMDL list because of chloride concentrations (http://water.usgs.gov/nawqa/informing/tmdls.html). Studies in other urban areas show similar results (http://radburn.rutgers.edu/andrews/projects/nbcrp/pdfs/salt.htm; http://www.cciw.ca/wqrjc/34-4/34-4-545.htm).

Confidence Level

Municipal and Industrial Wastewater: Reasonably confident. Effluent limits exist for major wastewater discharges and we therefore have reasonably good information on release of chloride to surface water from these point sources.

Urban Runoff: Moderately confident. Few studies exist that show concentrations of chloride in urban runoff, but there are numerous studies that illustrate increased chloride concentrations in urban surface and ground water (http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html; (http://water.usgs.gov/nawqa/informing/tmdls.html; http://radburn.rutgers.edu/andrews/projects/nbcrp/pdfs/salt.htm; http://www.cciw.ca/wqrjc/34-4/34-4-545.htm). We therefore have moderate confidence about the relative contribution of chloride to aquatic organism impacts.

Source Trends

Municipal and Industrial Wastewater: No trend. Although effluent limits are set for many pollutants associated with wastewater, chloride cannot be effectively removed from the waste stream. Consequently, there is no trend in releases of chloride from wastewater.

Urban Runoff: Upward trend. Use of road salt continues to increase in Minnesota, despite no trend in national use (http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html; http://gulliver.trb.org/publications/sr/sr235/017-030.pdf).

4. Excess UV Radiation from Stratospheric Ozone Depletion

Impact Categories: Aquatic Organisms, Terrestrial Organisms, Human Health Cancer, Human Health Noncancer Chronic

Sources: Fire Extinguishers, Industry, Refrigerants, Unpermitted Waste Disposal

Ozone is very reactive and is constantly being formed and destroyed in the stratosphere. The total amount normally remains relatively stable. Halogens such as chlorine and bromine, however, can act as catalysts in the destruction of ozone, resulting in the net effect that ozone is destroyed faster than it is naturally created.

The chemicals of concern (Chlorofluorocarbons, hydochlorofluorocarbons, 1,1,1-trichloroethane, methyl bromide, carbon tetrachloride, methylene chloride, halons, hydrobromofluorocarbons) are very stable, so they are able to reach the stratosphere after being released. Once they reach the stratosphere, they are broken down by UV radiation, resulting in chlorine and bromine being released. The chlorine and bromine then catalyze the destruction of ozone and result in a net loss of stratospheric ozone. Therefore, less UVB radiation is absorbed and more reaches the earth.

Different chemicals of concern have different ozone-depleting potentials (ODPs) and different half-lives. For example, CFC-11 has an ODP of 1, while HCFC-141b has an ODP of 0.1. This means that a molecule of CFC-11 can destroy ten times as much ozone as HCFC-141b. In addition, CFC-11 has an atmospheric lifetime of 70 years while carbon tetrachloride has an atmospheric lifetime of about 10 years.

Large fires and certain types of marine life produce one stable form of chlorine that does reach the stratosphere. However, numerous experiments have shown that CFCs and other widely used chemicals produce roughly 85% of the chlorine in the stratosphere, while natural sources contribute only 15%.

Comparative Contribution of Sources

Due to the long atmospheric lifetime of ozone depleting substances, it is difficult to determine comparative contributions. Many of the sources that contributed chemicals with high ODPs have been phased out in the United States. However, these sources were the main contributors of the halogens that are currently in the stratosphere. For this exercise, we attempted to list the current sources of ozone depleting substances.

Refrigerants: Medium Contribution. CFCs have been phased out as a source of refrigerants. Their replacements (HCFCs), however, are also ozone-depleting substances and may continue to be released into the atmosphere. HCFCs have a lower ODP than hard CFCs.

Fire extinguishers: Low Contribution. Halon production was banned in 1994 and the formulation of halon blends was banned in 1998. Although existing halon fire protection systems are still in use and can be recharged using recycled halons or halons produced before the ban, new fire protection systems do not contain halons..

Unpermitted waste disposal: Low Contribution. CFCs were used in refrigerants and foams. Many of these sources are still in existence. If they are not properly recycled and disposed of, the CFCs are released into the atmosphere. Some fire protection systems are also currently charged with halon. If these systems are replaced without recycling of the halon, it may also be released into the atmosphere.

Industry: Low Contribution. Many ozone depleting substances were used in industry. CFCs were used as cleaning solvents for electrical components. Solvents such as carbon tetrachloride and methyl chloroform were also used. This industrial usage has been banned and has for the most part ceased.

Confidence Level

Refrigerants, Fire Extinguishers, Unpermitted Waste Disposal: Somewhat speculative. For each of these it is known that some ozone-depleting substances are still being released, but it is difficult to track actual releases or to know how many CFC and HCFC refrigerants are in use or how many halon fire systems exist or how much illegal waste disposal is occurring. Therefore, the ranking is somewhat speculative.

Industry: Moderately confident. We are more confident, compared to the other sources, that industry has minimal releases of ozone depleting substances because industrial solvents are more carefully tracked by regulatory agencies. In addition, solvent stockpiles would be gone through quickly and should no longer exist.

Source Trends

Overall, there is no trend in UV radiation. This is because ozone depletion is believed to be leveling off. The source trends are generally down from the highest 1993/94 levels. However, over the last few years, some ozone depleting substances are actually increasing (such as HCFCs). Total chlorine is decreasing, but total bromine is increasing in the atmosphere. We thus assigned an upward and downward trend to the sources for this stressor.

References

- The EPA Ozone Depletion Website: http://www.epa.gov/ozone/index.html
- UNITED NATIONS ENVIRONMENT PROGRAMME ENVIRONMENTAL EFFECTS OF OZONE DEPLETION: 1994 ASSESSMENT. November 1994. http://sedac.ciesin.org/ozone/UNEP/UNEP94toc.html
- Environmental Chemistry 2nd edition, Nigel Bunce, Wuerz Publishing Ltd. Winnipeg, Canada.
- Scientific Assessment of Ozone Depletion: 1998. World Meteorological Organization Global Ozone Research and Monitoring Project -Report No. 44. National Oceanic and Atmospheric Administration

5. Explosive/Flammable Materials – High Level Accidental Exposure

Impact Categories: Human Health Noncancer Acute

Sources: Industry, On-road Vehicles, Pipelines, Residences, Tanks, Trains

This stressor involves various petroleum products and materials that are released and have the potential to ignite. The comparative contributions of the sources are based on the database maintained by the MPCA's Emergency Response Program (as reported to us by Dorene Fier-Tucker in an e-mail on 9/6/01). The estimates are based on numbers of releases, not volume (which might result in different comparative contributions).

Comparative Contribution of Sources

On-Road Vehicles: High Contribution.
Tanks: High Contribution.
Pipelines: Medium Contribution.
Trains: Medium Contribution.
Industry: Low Contribution.
Residences: Low Contribution.

Confidence Level

The confidence level for the comparative contribution of sources is considered "reasonable" for all the sources. This is because unlike most other stressors we have a database from which to calculate numbers.

Source Trends

On-Road Vehicles: Upward.
Tanks: Downward.
Pipelines: Downward.
Trains: No trend.
Industry: No trend.
Residences: No trend.

These trends are based on the judgment of Steve Lee, Supervisor of Emergency Response program (in an e-mail dated 9/25/01).

6. Ground-level Ozone

Impact Categories: Terrestrial Organisms, Human Health Noncancer Acute, Human Health Noncancer Chronic, Quality of Life Aesthetics

Sources: Area Source Combustion, Coal-fired Power Plants, Industry, Off-road Equipment, On-road Vehicles, Petroleum Storage and Transfer, Solvent Utilization

Ground level ozone is formed when nitrogen oxides (NO_x) react with hydrocarbons (also known as volatile organic compounds (VOCs)) and oxygen in the atmosphere. Ozone concentrations increase during periods of high temperatures and stagnant atmospheric conditions. Atmospheric reactions to form ozone are limited by either the amount of NO_x or VOC in the air, but it is not known which group of chemicals limits the formation of ozone in Minnesota.

Comparative Contribution of Sources

On-Road Vehicles: High Contribution. On-road vehicles emit 32% of NO_x and 30% of VOCs nationwide.

Off-Road Vehicles: High Contribution. Off-road engines are responsible for 22% of NO_x and 14% of VOC emissions, according to EPA's 1998 Trends report.

Area Source Combustion: Low Contribution. Residential fuel combustion is a small, but significant, source of NO_x emissions, and contributes to VOC emissions.

Industrial Sources: Low Contribution. Industrial fuel combustion, like residential combustion, emits comparably small amounts of NO_x. Industrial combustion is an important source of VOC.

Coal-Fired Power Plants: Medium Contribution. Nationwide, 25% of NO_x emissions come from electric utilities.

Solvent Utilization: Medium Contribution. 29% of VOC emissions are emitted by solvent utilization for industrial and commercial uses.

Petroleum Storage & Transfer: Low Contribution. Storing and transporting gasoline and other petroleum fuels to their distribution points releases large amounts of VOC into the air: 7% of total emissions.

Confidence Level

The confidence level for the comparative contribution is considered moderately confident for all the sources, although holes in understanding exist. Emissions of NO_x and VOCs from industrial sources are tracked at the state level on an annual basis. Emissions estimates from small industrial or commercial ("area") and mobile sources are tracked at the national level by EPA. Uncertainties in the methodologies exist, but the main sources of the pollutants are known. More uncertainty exists in the contribution of specific sources to ozone formation. The atmospheric chemistry and meteorology is complex and Minnesota has not conducted modeling studies looking at specific sources of ozone in Minnesota.

Source Trends

Overall, emissions of VOCs in the United States are decreasing. The decrease is driven by the reductions in emissions by on-road vehicles and the solvent utilization sector, although most emissions reductions occurred during the 70's and 80's. In recent years, emissions are level or decreasing slightly. Emissions of VOCs from petroleum solvent and transport and non-road vehicles and engines has been steady in recent years. Coal fired power plants, other industrial sources, and area source combustion are not large sources of VOCs but their contribution has recently been steady. Nationwide, NO_X emissions remained constant over the past several years. Emissions from off-road vehicles and engines increased slightly, but other sources, such as on-road vehicles and coal-fired power plants, neither increased nor decreased. Solvent utilization and petroleum storage and transfer are insignificant sources of NOx. Ozone is formed secondarily in the atmosphere through chemical reaction, so trends in source emissions of pollutants that react to form ozone may not be exactly reflected in ozone concentrations. Other factors, such as heat, play a significant role in ozone formation.

References

US Environmental Protection Agency (USEPA). March 2000. *National Air Pollutant Trends, 1900-1998*. http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf. Accessed 2/6/02.

7. Habitat Modification

Impact Categories: Aquatic Organisms, Terrestrial Organism, Quality of Life Aesthetics

Sources: Drainage and Channelization, Dredging, Urban/Suburban/Lakeshore Development, Agriculture, Mining, Silvaculture

Habitat modification affects aquatic and terrestrial organisms, which in turn can affect the aesthetic quality of environmental resources. Habitat modification, as discussed here, includes any human activity that affects habitat to such an extent that it can no longer fully sustain its original use. Thus agriculture, for example, creates habitat suitable for certain species of terrestrial organisms, but we only consider effects associated with shifts in habitat from grassland or forest to agriculture, particularly row crop agriculture. Similarly, attempts to improve habitat through modification are not considered in this discussion.

Comparative Contribution of Sources

It is nearly impossible to quantify the comparative contribution of different sources for habitat modification. The primary obstacle is lack of a uniform way for determining impacts from habitat modification. For example, in one case, habitat may be modified at a local level but result in loss of a population, while in another case, there may be widespread modification that diminishes the health of a particular species.

Agriculture: High contribution. There are about 21 million acres of cropland in Minnesota, most in row crop agriculture. Cultivation of soil and loss of native vegetation as a result of agriculture has irreversibly changed the native habitat of Minnesota (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Drainage and Channelization: High contribution. About 5 million acres of Minnesota wetlands have been drained, 20 percent with tiles and 80 percent with ditches (http://www.house.leg.state.mn.us/hrd/pubs/drainage.pdf). The loss of wetlands is irreversible or at best, very slowly reversible. Drainage therefore represents a direct loss of habitat. Drainage also impacts the hydrology of water bodies (http://ohioline.osu.edu/b871/b871_24.html). For example, loss of wetlands may lead to increased peaks in flooding. Channelization may significantly alter aquatic environments by changing flow and riparian habitat http://www.epa.gov/opperspd/futures/risk/crexamples/examples/Arizona/ecosystems/strmriv.txt; http://www.wri.org/wr-98-99/freshwat.htm).

Dredging: Medium contribution. Dredging results in the temporary elevation of suspended solids emanating from the project area as a turbidity plume. The suspended sediments are generally high in organic matter and clay, both of which may be biologically and chemically active. The removal of bottom sediments during dredging operations can disrupt the entire benthic community and eliminate a significant percentage of the feeding habitat available to fish for a significant period of time (http://www.psmfc.org/efh/Jan99-sec3-23B.html#Dredging; http://www.isu.edu/departments/bios/Minshall/Publications/Report.pdf;). Dredging in Minnesota is primarily limited to the states navigation routes, such as the Minnesota River, Mississippi River, and Lake Superior. Some urban lakes are dredged periodically. Effects on habitat, while significant locally, are therefore limited in geographic extent.

Mining: Low contribution. Open pit mining has severe effects on habitat, with nearly complete destruction of habitat in a mined area (http://www.kudremukh.org/news/iisc.html). Excluding peat mining, the extent of mined areas is limited to the Mesabi Range in northern Minnesota, however. There is also evidence that abandoned mine areas, if somewhat limited in geographic extent, recover relatively quickly when surface water has not been contaminated (http://www.mii.org/babbitt/babbitt.html; http://www.mii.org/steeprock/steeprock.html; http://www.mii.org/Sunrise/Sunrise.html). Thus, this stressor ranked low for overall comparative contribution.

Silvaculture: High contribution. Silvaculture, like agriculture, has had dramatic impacts on the ecological landscape. In 1999, 3.8 million cords of wood were harvested in Minnesota (http://www.mnplan.state.mn.us/mm/indicator.html?Id=60&G=39; http://www.afandpa.org/forestry/Facts/Forest_Ownership.pdf). Impacts include loss of old growth forests, soil erosion, fire suppression, sedimentation, and nutrient loading of surface water. An important impact of silvaculture is reduced species diversity (http://www.sprise.com/shs/habitatnet/FieldProblems.htm; http://www.ire.ubc.ca/fepa/proj_silva_proposal.html). This stressor rated high because of the geographic extent of silvacultural activities, although silvacultural practices have increasingly incorporated environmental management practices.

Urban/suburban/lakeshore development: High contribution. Minnesota converted to urban use a total of 232,000 acres between 1992 and 1997, placing it 17th among the 50 states for its rate of development of non-federal land. There are about 2.2 million acres of urban area in Minnesota. Although a relatively small percentage of Minnesota's land is urban, highly dispersed development patterns can fragment habitats into small, disconnected plots and significantly affect ecosystems and the viability of species that depend on them (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41; http://ceres.ca.gov/planning/hcp/). Highly developed urban areas essentially destroy the original ecological environment. Development also results in sedimentation and nutrient enrichment of surface water. Lakeshore development can also degrade habitat through fragmentation, sedimentation, and nutrient enrichment http://www.uwsp.edu/cnr/uwexlakes/fs_12.pdf; http://es.epa.gov/ncer/progress/grants/99/futures/lemberg00.html; http://royal.okanagan.bc.ca/kokanee/fishredu.htm).

Confidence Level

Our confidence level for all sources was reasonable. Habitat modification is readily observed. Sources of modification are typically easy to determine. Examples of habitat modification can be found in the references cited above (for Comparative Contribution).

Source Trends

Agriculture: No trend. Cropland acreage in Minnesota decreased by about 7 percent in the 1980's but remained relatively constant during the 1990's (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Drainage and Channelization: Upward trend. In Minnesota, wetland acres continue to be drained faster than they are restored, although the rate of drainage has decreased dramatically in the past few decades. Drainage associated with development continues to increase (http://www.epa.gov/owow/wetlands/vital/status.html; http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/wetlands2_trends.htm).

Dredging: No trend. There is limited information to determine trends in dredging in Minnesota. We assumed that dredging primarily occurs on navigable waters and has therefore changed little in the past few decades.

Mining: No trend. In 2000, about 43 million tons of taconite were produced in Minnesota, compared to about 45 million tons in 1980. Acres in mining increased from about 50,000 in 1969 to 80,000 in 1990. The increase in acreage is somewhat offset by ecological recovery of previously mined areas (http://www.iic.state.mn.us/finfo/landscap/1/assess/G2_nomap.pdf; http://www.state.mn.us/ebranch/mdor/mining/forms/pdf/01mining_guide.pdf).

Silvaculture: No trend. Forested acres in Minnesota increased slightly from 1.60 million to 1.62 million acres between 1982 and 1997. Timber production increased slightly from 3.5 million cords in 10090 to 3.8 million cords in 1999. These changes are relatively insignificant (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41; http://www.mnplan.state.mn.us/mm/indicator.html?Id=60&G=39).

Urban/suburban/lakeshore development: Upward trend. Between 1982 and 1997, urban land climbed from 1.7 million to 2.2 million acres, up 27 percent, while Minnesota's population rose about 14 percent (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41). Seasonal or vacation home growth was about 7 percent statewide between 1980 and 1990 (http://www.iic.state.mn.us/finfo/landscap/1/assess/G2_nomap.pdf).

8. Nitrogen

Impact Categories: Aquatic Organism, Terrestrial Organisms

Sources: Agricultural Runoff, Feedlots, Municipal and Industrial Wastewater, Septic Systems, Urban Runoff, Area Source Combustion, Coal-fired Power Plants, Fertilizer Use, Land-Applied Manure, Off-road Equipment, On-road Vehicles

Nitrogen is an important element in the environment, comprising 78 percent of the earth's atmosphere. Nitrogen is an essential element for all life, although in excessive amounts, it can be toxic to various forms of life. The standard for nitrate-nitrogen in drinking water is 10 ppm. Ingestion of nitrate above 10 ppm can cause methemoglobinemia (blue-baby disease), which affects infants six months of age or younger and may also affect young farm animals. Nitrogen is also an important nutrient in surface water. Although phosphorus is generally the limiting nutrient in surface water, nitrogen can occasionally lead to algae blooms. Nitrogen is also the primary chemical of concern for hypoxia in coastal waters (http://wwwrcolka.cr.usgs.gov/midconherb/hypoxia.html; http://www.esa.org/education/factsheets/hypoxia.htm). Nitrogen deposited from the atmosphere can impact terrestrial ecosystems. Impacts include changes in productivity, shifts in species, and changes in carbon cycling. Terrestrial impacts may also result from non-atmospheric forms of deposition, but these are poorly documented and not considered in this discussion (http://www.usgcrp.gov/usgcrp/ProgramElements/bio.htm; http://www.nps.gov/noca/Ltem/AtmText.htm; http://www.marine.unc.edu/Paerllab/research/atmospheric/adn_opening.html; http://h2osparc.wq.ncsu.edu/wetland/aqlife/atmosdep.html; http://www.usgs.gov/public/press/public_affairs/press_releases/pr1361m.html).

Comparative Contribution of Sources

Agricultural runoff: High contribution. Agricultural runoff affects aquatic ecosystems and includes fertilizer use. It therefore was assigned a high relative contribution, since fertilizer use is generally acknowledged as the most important source of nitrogen in most surface water, including the Minnesota and Mississippi Rivers (http://wwwrcolka.cr.usgs.gov/midconherb/st.louis.hypoxia.html; http://ohioline.osu.edu/agf-fact/0204.html; http://www.epa.gov/ceisweb1/ceishome/atlas/nationalatlas/threats_to_health_of_us_waters.htm; http://www.pca.state.mn.us/water/basins/mnriver/mgmt-fw.html; http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.135-00.html#HDR3).

Municipal and industrial wastewater: Medium contribution. The contribution of nitrate from municipal and industrial wastewater discharges to waters of the state has been relatively stable over the past five years. Reported discharges from the 85 major treatment facilities comprising 27 industrial and 58 municipal sources have averaged about 4500 thousand kilograms over this time, according to Discharge Monitoring Reports (DMRs) submitted to the MPCA. Point source contributions, of which wastewater is the most important, account for less than 10 percent of nitrogen discharged to the Minnesota River (http://www.pca.state.mn.us/water/basins/mnriver/mgmt-fw.html; http://www.texasep.org/html/wql/wql_2sfc.html).

Feedlots: Low to Medium contribution. Contributions to terrestrial ecosystems come from volatilization of manure and subsequent atmospheric deposition, as well as runoff from feedlots and subsequent deposition in terrestrial habitats. These effects are not well documented, but even if they were considerable, effects would be local in nature. Impacts to terrestrial ecosystems are therefore considered to be low. Impacts to aquatic ecosystems are significant. Open feedlots contribute large quantities of organic matter and ammonia to surface waters, and the nitrogen from these sources can be persistent in oxygenated waters. Manure handling remains a critical concern in some areas of the state where large confined feedlot operations are concentrated. Although there is concern about increasing size of feedlots, these feedlots are generally permitted, have concrete liners, and may require an NPDES permit. Consequently, they contribute significantly less nitrogen to surface water than open feedlots and feedlots having unpermitted liners (http://lakeaccess.org/feedlots.html; http://ace.orst.edu/info/extoxnet/faqs/safedrink/feed.htm; http://www.pca.state.mn.us/water/groundwater/gwmap/gw-manure.html).

Urban runoff: Medium contribution. Increased urbanization and use of fertilizers on lawns and plantings have been offset somewhat by better management practices for fertilizer application and implementation of runoff controls (http://www.mda.state.mn.us/appd/ace/turfideas.pdf; http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://wwwga.usgs.gov/edu/urbannitrogen.html).

Septic systems: Low contribution. Septic systems contribute large quantities of nitrogen to ground water. Although this nitrogen may be discharged to surface water and thus impact aquatic ecosystems, studies show that most nitrogen is removed in riparian zones adjacent to surface water. Impacts to surface water can be significant when these riparian zones do not exist or have been modified (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-nonsewered.html; http://www.crjc.org/riparianbuffers.htm; http://www.dnrec.state.de.us/dnrec2000/Library/RIPARIANBUFFERS1.PDF).

Area Source Combustion: Low contribution. Residential fuel combustion is a small, but significant, source of NO_x emissions. About 6 percent of NO_x comes from area sources (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://h2osparc.wq.ncsu.edu/wetland/aqlife/atmosdep.html).

Coal-fired Power Plants: High contribution. Point sources account for an estimated 39 percent of NO_x emissions. Total nitrogen released annually to the atmosphere in the form of NO_x is more than 450,000 tons. Coal-fired power plants are the most important point source (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://h2osparc.wq.ncsu.edu/wetland/aqlife/atmosdep.html).

Fertilizer Use: Medium contribution. In agricultural watersheds, fertilizers are considered an important source of atmospheric nitrogen, primarily through volatilization of ammonia, although contributions from dust can also be important (http://water.usgs.gov/nawqa/sparrow/coast/agu_sparrow.html; http://www.dnr.state.md.us/streams/atmosphere/sources.html; http://h2osparc.wq.ncsu.edu/wetland/aqlife/atmosdep.html; http://www.usgs.gov/public/press/public_affairs/press_releases/pr1361m.html).

Land-Applied Manure: Medium contribution. About 20 percent of nitrogen in nonincorporated, land-applied manure is lost through volatilization. Considering the generation of approximately 1 million tons of nitrogen in livestock manure annually, and assuming that a significant portion of this is applied to agricultural fields, land-applied manure represents a significant anthropogenic source of atmospheric nitrogen (http://www.gov.mb.ca/agriculture/soilwater/manure/fdb01s03.html; http://www.agcom.purdue.edu/AgCom/Pubs/AY/AY-277.html; http://www.ces.uga.edu/pubcd/c826-w.html; http://www.nps.ars.usda.gov/programs/programs.htm?npnumber=206&docid=344).

Off-road Equipment: Medium contribution. Non-point sources account for an estimated 55 percent of NO_x emissions. Off-road equipment is considered less important than on-road vehicles (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf).

On-road Vehicles: High contribution. Nonpoint sources account for an estimated 55 percent of NO_x emissions. Total nitrogen released annually to the atmosphere in the form of NO_x is more than 450,000 tons. On-road vehicles are the most important nonpoint source (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://h2osparc.wq.ncsu.edu/wetland/aqlife/atmosdep.html).

Confidence Level

Except for urban runoff, where the extent of monitoring is very limited, our confidence level for the contribution of the above sources to nitrogen in our water resources (aquatic organisms) is medium to reasonable. Municipal and industrial wastewater treatment plants are required to monitor and report nitrogen levels in their discharges. Runoff controls and some site-specific monitoring are required of larger feedlots and some septic systems. A number of research studies have quantified the amount of nitrogen entering surface water as a result of runoff from agricultural tile lines. Minnesota's contribution to hypoxia in the Gulf of Mexico is approximately 7%, according to the White House Office of Science and Technology. Our confidence for terrestrial sources is more uncertain.

Agricultural Runoff: Reasonably confident. Fertilizer contributions to overall nitrogen loading have been estimated for some important surface water basins in Minnesota, including the Minnesota and Mississippi. Similar estimations have been made for other surface water basins in the United States (http://wwwrcolka.cr.usgs.gov/midconherb/st.louis.hypoxia.html; http://ohioline.osu.edu/agf-fact/0204.html; http://www.epa.gov/ceisweb1/ceishome/atlas/nationalatlas/threats_to_health_of_us_waters.htm; http://www.pca.state.mn.us/water/basins/mnriver/mgmt-fw.html).

Feedlots: Somewhat speculative to moderately confident. Runoff from feedlots into surface water is well documented (moderately confident for aquatic ecosystems). Less is known about impacts of feedlots on terrestrial ecosystems (somewhat speculative).

Municipal and Industrial Wastewater: Reasonably confident. Wastewater treatment facilities are largely regulated and have effluent limits.

Septic Systems: Moderately confident. We have good information on the approximate number of septic systems in Minnesota. Research clearly shows effects of septic systems on water quality. There are few studies, however, linking these effects to impacts on aquatic ecosystems.

Urban Runoff: Somewhat speculative. Fertilizer application in urban areas has been increasing in recent years, but there is little information regarding the fate of that fertilizer. There are few studies that directly link nitrogen in urban runoff with impacts to aquatic ecosystems.

Area Source Combustion: Somewhat speculative. Area sources are largely unregulated and we therefore have limited information on emissions. Since there are a large number of area sources, the cumulative effect of these is speculative.

Coal-fired Power Plants: Moderately confident. Emissions of NO_x from industrial sources are tracked at the state level on an annual basis. Emissions estimates from small industrial or commercial ("area") and mobile sources are tracked at the national level by EPA. Uncertainties in the methodologies exist, but the main sources of the pollutants are known. What is not understood, however, is the fate of nitrogen that is deposited to terrestrial systems from the atmosphere. Quantities of nitrogen in the atmosphere vary by region (http://www.nstl.gov/research/onepage/rainqual.html; http://www.wri.org/trends/; http://www.ubavie.gv.at/tfmm/reports/agenda02/Trends_Uk.pdf).

Fertilizer Use: Moderately confident. We have information on fertilizer use and have some information on rates of loss from fertilizers, but impacts to terrestrial systems are largely unknown.

Land-Applied Manure: Somewhat speculative. There is limited information on the quantities of manure that are land applied, although it is likely to be a significant percent of the manure generated by livestock in the state. There is limited information on methods of manure application, and the method of application significantly affects the fate of nitrogen.

Off-road Equipment: Somewhat speculative. We have limited information on the amount of nitrogen released from off-road equipment.

On-road Vehicles: Moderately confident. There is reasonably good information on number of vehicle miles driven and gasoline consumption for Minnesota. We can make estimates of quantities of nitrogen released from these vehicles. There is less certainty about the environmental fate of that nitrogen.

Source Trends

Nitrogen is the only common water pollutant to show an increasing trend in both surface and ground water over the last 30 years. Nitrogen levels have increased at 75 percent of monitored surface water sites across the state in the past 30 years. More efficient agricultural drainage systems (primarily through tiling) and a trend toward increased rainfall in the 1990's have contributed to this trend. The increasing trend is due to factors such as increased tiling of agricultural land and increased urbanization. We do not have monitoring data for terrestrial ecosystems, but globally, there is an upward trend in nitrogen concentrations of terrestrial ecosystems (http://www.usgcrp.gov/usgcrp/ProgramElements/bio.htm; http://www.geog.ouc.bc.ca/physgeog/contents/9s.html; http://www.geog.ouc.bc.ca/physgeog/contents/9s.html).

Agricultural Runoff: Upward trend. Since this source includes fertilizer use and aquatic ecosystems, the trend is upward. Nitrogen fertilizer use has leveled in the past ten years, but agricultural drainage continues, although at a decreasing rate. This drainage results in loss of nitrogen to tile lines, which eventually is discharged to streams and rivers. Increasing nitrogen trends are observed at about 90 percent of Minnesota Milestone sites in the Minnesota, Des Moines, and Missouri River basins. These are areas that are intensively farmed and extensively drained (http://www.ag.ndsu.nodak.edu/aginfo/entomology/ndsucpr/Years/2000/July/27th/soils_27july00.htm; http://www.pca.state.mn.us/publications/reports/305bfinalreport-2000.pdf).

Feedlots: No trend. There appears to be no trend in the number of livestock and feedlots in Minnesota, although there is an increasing trend in size of newly permitted lots. These newer, larger lots are less likely to pollute surface water than older lots if they are properly managed, since many have concrete-lined manure basins and they must have a NPDES permit (http://hermes.ecn.purdue.edu/cgi/convwqtest?wq-7.in.ascii; http://ace.orst.edu/info/extoxnet/faqs/safedrink/feed.htm; http://www.pca.state.mn.us/water/groundwater/gwmap/gw-manure.html).

Municipal and Industrial Wastewater: No trend. Although wastewater effluent is regulated, nitrogen is not a specific chemical required for monitoring in effluent. New treatment practices may be effective at removing reduced forms of nitrogen, but will not be useful for reducing nitrate concentrations. Because treatment practices have been in place for several years, we assumed no trend in nitrogen concentrations from wastewater treatment facilities.

Septic Systems: Upward trend. The number of septic systems in Minnesota continues to increase as urban areas expand beyond municipal services. Nitrate, unlike most other chemicals in septic waste, is not treated within the septic system and therefore readily enters ground water. Several researchers have observed elevated ground water nitrate concentrations in areas serviced by septic systems. This ground water may discharge to surface water and impact aquatic ecosystems (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-nonsewered.html).

Urban Runoff: Upward trend. The percent of urban land in Minnesota increased about 27 percent between 1982 and 1997. Several studies have demonstrated negative impacts of urban runoff on aquatic organisms (http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://www.ocrm.nos.noaa.gov/pcd/6217.html; http://capita.wustl.edu/NEW/oconnor.html; http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Area Source Combustion: No trend. The effect of area source combustion is on nitrogen loading to terrestrial ecosystems. We have limited data on trends in area source combustion. Nitrogen increases in the atmosphere are considered to primarily originate from on-road and off-road equipment and vehicles.

Coal-fired Power Plants: No trend. The effect of coal-fired power plants is on atmospheric nitrogen loading to terrestrial ecosystems. There has been a slight upward trend in emissions of NO_x in Minnesota, but this trend does not appear statistically significant. Mobile sources, particularly automobiles, would likely account for any trend in emissions of NO_x. Nationally, NO_x emissions have decreased slightly over the past ten years (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.epa.gov/oar/aqtrnd00/acidrain.html).

Fertilizer Use: No trend. Fertilizer use has not changed dramatically in agricultural areas in the past years. Use appears to have increased in urban areas.

Land-Applied Manure: No trend. There is little documentation about the amount of manure applied to agricultural fields. Since the number of livestock has not increased dramatically in the past ten years, and assuming farmers are not applying different quantities of manure than in the past, we estimated there was no trend in contributions from land-applied manure.

Off-road Equipment: Upward trend. The effect of off-road equipment is on atmospheric nitrogen loading to terrestrial ecosystems. There has been a slight upward trend in emissions of NO_x in Minnesota, but this trend does not appear statistically significant. Mobile sources, particularly automobiles, would likely account for any trend in emissions of NO_x. Nationally, NO_x emissions have decreased slightly over the past ten years (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.epa.gov/oar/aqtrnd00/acidrain.html).

On-road Vehicles: Upward trend. The effect of on-road vehicles is on atmospheric nitrogen loading to terrestrial ecosystems. There has been a slight upward trend in emissions of NO_x in Minnesota, but this trend does not appear statistically significant. Mobile sources, particularly automobiles, would likely account for any trend in emissions of NO_x. Nationally, NO_x emissions have decreased slightly over the past ten years (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf; http://www.epa.gov/oar/aqtrnd00/acidrain.html).

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9. Noise

Impact Categories: Human Health Noncancer Acute, Human Health Noncancer Chronic, Quality of Life-Aesthetics

Sources: Aircraft, Industry, Off-road Equipment, On-road Vehicles

Noise has acute and chronic impacts to human health, as well as aesthetic effects. Health effects include hearing impairment, headaches, loss of sleep, cardiovascular effects, etc. (http://www.nonoise.org/library/whonoise/whonoise.htm).

There are many sources of noise. Occupational exposure, which is not considered in the EIR, is the most common cause of adverse health effects from noise. In the EIR, we considered on-road vehicles (e.g. cars, trucks, etc.), industry, aircraft, and off-road equipment (e.g. jackhammers, snowmobiles, chainsaws, etc.). Berglund and Lindvall, 1995 (http://www.nonoise.org/library/whonoise/whonoise.htm#4.2), provide a discussion of sources of noise and potential health effects resulting from exposure to various sources for a variety of durations. The Noise Pollution Clearinghouse is an additional source of information on sources of noise and human health effects associated with noise (http://www.nonoise.org/cgi-bin/query.cgi?query=noise+complaints&db=news&db=lawlib&db=library&format=long).

Although many agencies have regulations, standards, or criteria for noise, there appears to be little environmental monitoring (http://www.pca.state.mn.us/programs/pubs/noise.pdf). Despite this, the contribution of sources was based on monitored levels, since there is little documentation of health impacts or complaints associated with noise.

Comparative contribution of sources

In a poll conducted by the U.S. EPA Office of Noise Abatement and Control (1977), 46% of respondents from 24 large U.S. metropolitan areas indicated they had been annoyed by noise in their neighborhoods. Thirty-one percent of the "annoyed" people were highly annoyed. About one percent cited noise as a sufficient reason for moving (http://www.nonoise.org/library/urban/urban.htm#top). Motor vehicle noise was considered the most pervasive source in larger metropolitan areas, while aircraft were more important in smaller metropolitan areas. Overall, on-road sources accounted for the three most important sources, followed by construction and then aircraft.

On-road Vehicles: High contribution. Typical noise levels adjacent to major highways are about 70 dB. Noise criteria (75 dB) for federal highways are used to trip a federal funding mechanism for noise abatement on highway projects. Criteria (80 dB) also exist for state highways. There are more than 100 monitored sites along major highways and roadways in the Twin Cities Metro Area. The Minnesota Department of Transportation estimates it will take about 17 years to install noise abatement structures at the most important locations (http://www.dot.state.mn.us/govrel/positionstatements/noisewal.html; http://www.dot.state.mn.us/metro/tps/htms/noise/mndot_noise_policy.html; http://www.dot.state.mn.us/govrel/positionstatements/noisewal.html).

Aircraft: High contribution. Typical noise levels within 100 meters of aircraft exceed 100 dB. In January of 2002, there were 573 complaints filed by 73 complainants in the Twin Cities Metro Area (http://macavsat.org/pdf_files/monthly_reports/jan02_ta.pdf). The FAA has source regulations for commercial jet engines. All commercial jet engines must meet noise emission criteria prior to being certified for flight (http://macavsat.org/technologies/anoms/index.htm).

Industry: Medium contribution. The MPCA has a receiver-based standard intended to limit noise levels and protect the health and welfare of the general public. These typically are applied to industrial sources (http://www.pca.state.mn.us/programs/noise.html). Industries generally do not contribute to excessive noise, but do contribute to background noise in metropolitan areas. There are cases of MPCA fining individual industries for exceeding noise standards (http://www.pca.state.mn.us/news/nr041601.html).

Off-Road Equipment: Medium contribution. The Minnesota DNR has source standards for snowmobiles, motorboats, personal watercraft and off-highway vehicles (http://www.pca.state.mn.us/programs/pubs/noise.pdf). Monitoring occurs only within specific locations, such as the Iron Range Off-Highway Vehicle Recreation Area (http://www.dnr.state.mn.us/trails_and_waterways/iron_range/gilbert/monitoring.html). Noise complaints, although not tabulated, do occur in specific locations as a result of use of off-road equipment (http://news.mpr.org/features/199708/27_losurem_skis/; http://www.nonoise.org/news/snow.htm).

Confidence Level

The confidence level for the stressor (Noise) was somewhat speculative. The primary concerns were a lack of monitoring information, uncertainty in relating observed health effects to noise levels, and lack of tabulation of noise complaints for most sources. All of the sources had a reasonable confidence level, however, because these are widely known to be the most important sources of noise and there is ample documentation that these are the most important sources of noise.

Source Trends

There was little information to suggest a trend in actual monitored noise levels. Air and on-road vehicle traffic, however, have increased (http://www.atag.org/natf/; http://www.pca.state.mn.us/air/mvetlocation.html).

10. Odorous Chemicals from Biological Processes

Impact Categories: Human Health Noncancer Acute, Human Health Noncancer Chronic, Quality of Life Aesthetics

Sources: Agriculture, Ethanol Production, Feedlots, Treatment/settling Ponds

Noxious odors from businesses are a common complaint. This is a difficult issue to deal with because odor is not necessarily directly associated with harmful effects (http://www.health.state.mn.us/divs/eh/hazardous/gopher/#odors). Some chemicals are lethal well below the odor threshold, while others have an odor threshold well below any health benchmark. MPCA and other agencies do not have a consistent tracking method for odors, so it was difficult to prepare a comparative contribution for sources.

The chemicals that are most frequently cited in odor complaints are hydrogen sulfide (and other chemicals in the H_2S family), ammonia, alcohols, and other VOCs. These chemicals often cause odor complaints at levels where health effects are not expected (http://www.pca.state.mn.us/hot/fl-odor.html).

The contribution was primarily ranked according to the perception of number of complaints, since MPCA does not conduct odor monitoring (MPCA does some H_2S monitoring as a surrogate for comparison to odor benchmarks). Complaints are not coded by SIC code.

Comparative Contribution of Sources

Feedlots: High Contribution. The majority of odor complaints are associated with feedlot operations. The suspected source of approximately 600 of the 900 odor complaints received by the Minnesota Pollution Control Agency between 1995 and 2000 were hog feedlots. About 50 percent of the 600 complaints were attributed to six or seven large hog feedlots (http://www.pca.state.mn.us/hot/fl-odor.html).

Treatment/settling ponds: Medium Contribution. Treatment ponds such as sugar beet wastewater ponds, municipal settling ponds, etc. also cause odor complaints, though these are considerably less in number than complaints from feedlots.

Agriculture: Medium Contribution. Manure spreading on fields and other agricultural processes can result in odor complaints.

Ethanol Production: Low Contribution. There are only a few ethanol plants in Minnesota. However, some of them such as the ethanol plant in St Paul are in urban areas and have received many complaints (http://www.health.state.mn.us/divs/eh/hazardous/gopher/).

Confidence Level

The confidence level for all of the sources to odorous chemicals is somewhat speculative, with many assumptions at play. The sources are based on professional judgment regarding the extent of odor complaints. Complaints are dependent on many factors and MPCA does not track SIC codes for facility complaints. In addition, there is not necessarily a correlation between odor complaints and health impacts from odors.

Source Trends

It is difficult to determine trends since odors are not monitored. For feedlots, controls and processes for reporting and responding to odor complaints are improving, but this is countered by increasing facility size, particularly for hogs, which pose the greatest risk for odors (http://www.extension.umn.edu/distribution/livestocksystems/DI7637.html). We can only speculate trends based on trends in the sources, rather than based on actual data.

Feedlots: Upward trend. The upward trend is based on increasing size of hog facilities, which have a much greater potential for adverse effects from odors than other livestock operations (http://www.extension.umn.edu/distribution/livestocksystems/DI7637.html).

Treatment/settling ponds: No trend. There is limited information about the number and size of treatment and settling ponds that could create odor problems. There appears to be no trend in the number of industries most likely to cause odor problems, however, such as sugar beet or other vegetable wastewater ponds and municipal settling ponds.

Agriculture: No trend. Since livestock numbers have not changed significantly in the past ten years, we assume no trend in the contribution from agriculture, since manure spreading will be the primary source of odors from agriculture.

Ethanol Production: Upward trend. Ethanol production is increasing in both Minnesota and the United States, and there is increased demand for ethanol fuel (http://www.mda.state.mn.us/Ethanol/MEP4'99.HTM; http://news.mpr.org/features/200111/08_postt_harvest-m/ethanol.shtml; http://www.energy.ca.gov/reports/2001-08-29_600-01-017.PDF). Although most facilities are located in rural areas, increasing populations and construction of ethanol plants in urban areas are likely to result in a greater potential for odor impacts.

11. Other Criteria Pollutants in Air

Impact Categories: Human Health Noncancer Chronic, Human Health Noncancer Acute
Sources: Coal-fired Power Plants, industry, Off-road Equipment, On-road Vehicles, Residential fuel Combustion

Criteria pollutants are those for which we have National Ambient Air Quality Standards (NAAQS) established by the federal government under the Clean Air Act. There are six criteria pollutants: sulfur dioxide (SO2), nitrogen dioxide (NO2), lead (Pb), ozone (O3), carbon monoxide (CO), and particulate matter (PM). These pollutants have effects on both human health and the environment. The 'Other Criteria Pollutants in Air' stressor covers the human health effects of SO2, NOx, and CO. Other stressors cover the remaining pollutants and non-human health effects.

Comparative Contribution of Sources

On-Road Vehicles: High Contribution. According to EPA's 1998 Trends Report, on-road vehicles account for 32% of nation-wide NO_x and 56% of CO emissions. On-road vehicles are a small source of SO_2.

Coal-Fired Power Plants: High Contribution. Electric utilities are responsible for 25% of NO_x emissions and 64% of total SO_2 emitted.

Off-Road Equipment: Medium Contribution. Off-road equipment and vehicles emit 22% of NO_x, 22% of CO, and 6% of SO_2 emissions nationwide.

Industry: Medium Contribution. Industrial fuel combustion is a significant, but smaller, source of NO_x compared to on-road vehicles and coal-fired power plants. Industry, excluding coal-fired power plants, is responsible for 15% of SO_2 emissions.

Residential Fuel Combustion: Low Contribution. Residential fuel combustion emits significant amounts of NO_x into the air, although the total is small compared to mobile sources. Home wood burning is a small source of CO emissions.

Confidence Level

All of the source contributions had a moderate confidence level, with the exception of Off-road vehicles and Residential fuel combustion. Emissions of CO, NO_x, and SO_2 from industrial sources are tracked at the state level on an annual basis. Emission estimates from small industrial or commercial ("area") and mobile sources are tracked at the national level by EPA. Uncertainties in the methodologies exist, but the main sources of the pollutants are known. The highest uncertainties are for non-road sources, where local activity data is difficult to ascertain, and residential fuel combustion, where scant activity data and poor emission factors impede accurate emission estimates. Consequently, we assigned a confidence of Somewhat Speculative to these two sources.

<u>Source Trends</u>

On-Road Vehicles: Downward Trend. Improvements in vehicle emission control technology as newer cars enter the fleet caused reductions in CO and SO2 emissions. NOx emissions are also lower than they were twenty years ago but the increase in vehicle miles traveled caused the downward trend in NOx emissions to level out recently.

Coal-Fired Power Plants: No trend. Trends in CO emissions from coal-fired power plants are level or increasing slightly, but power plants are not a significant source of overall CO levels. Overall, emissions levels of SO2 and NOx appear to be steady.

Off-Road Equipment: No trend. Emissions contributions from off-road engines and vehicles are level.

Industry: Downward trend. CO and NOx emissions from industrial fuel combustion (the largest industrial source of these pollutants) have neither increased nor decreased overall over the past several years. SO2 emissions have decreased somewhat over time.

Residential Fuel Combustion: No trend. Emissions of SO2, NOx, and CO from residential burning of wood have not significantly varied over time.

<u>References</u>

- US Environmental Protection Agency (USEPA). March 2000. *National Air Pollutant Trends, 1900-1998*. http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf. Accessed 2/6/02.

12. Oxygen-demanding Pollutants

Impact Categories: Aquatic Organisms, Quality of Life-Aesthetics
Sources: Agricultural runoff, Feedlots, Municipal and Industrial Wastewater, Septic Systems, Spills, Urban Runoff

The primary chemicals of concern for dissolved oxygen depletion are organic matter, phosphorus, and nitrogen. Phosphorus and nitrogen are discussed in separate sections. Much of the discussion from Sections 8 (Nitrogen), 15 (Phosphorus), and 24 (Transported Sediment) can be applied to this section. Sources for these stressors are typically the same in their relative contribution as they are for oxygen-demanding pollutants. Trends and our confidence in estimating the comparative contribution are also similar for these different stressors.

<u>Comparative Contribution of Sources:</u>

Agricultural Runoff: Medium contribution. Agricultural runoff considers only overland flow from agricultural fields (i.e. not runoff from feedlots). Organic matter and nutrients, particularly phosphorus, can lead to oxygen depletion in surface water by stimulating microbiological activity (http://www.cwn.org/docs/reports/wet_h2o/wetmajorpoll.htm; http://ohioline.osu.edu/b374/b374_10.html; http://www.great-lakes.net/teach/pollution/water/water2.html). Hypoxia is a depletion of oxygen in coastal waters that is partly attributable to inputs nitrogen from human activity. Tile line drainage of agricultural lands is an important contributor of nitrogen, particularly in southern Minnesota rivers. Hypoxia, however, was considered under Nitrogen (Section 8), and effects from hypoxia are not considered here (http://state-of-coast.noaa.gov/bulletins/html/hyp_09/hyp.html). Effects of phosphorus on algae growth and, hence, oxygen depletion, are discussed in Section 15. Highly cultivated agricultural lands may lose relatively small amounts of organic matter through erosion because much of the organic matter in highly erodible soils has already eroded or been oxidized after cultivation. The primary concerns come with application of manure, particularly on steeper slopes or when manure is not properly applied.

Feedlots: High contribution. Open feedlots, where animals are active on bare soils, have very high runoff rates because of compaction caused by animal movement. Since manure exists at the soil surface, large quantities of manure are eroded from these open lots. Animals may also contribute organic matter directly to surface waters if they are allowed access to a water body. The large quantities of relatively fresh organic matter make feedlots a high contributor for oxygen depletion (http://www.ces.uga.edu/pubcd/c827-w.html#Non-Point Source; http://www.ces.uga.edu/pubcd/c827-w.html; http://www.pca.state.mn.us/water/pubs/feedlot33.pdf; http://www.cotf.edu/ete/modules/waterq/wqglossary.html).

Municipal and Industrial Wastewater: Medium contribution. At one time, wastewater was the primary contributor to oxygen depletion in surface waters. Wastewater treatment is now regulated and effluent limits are in force for chemicals that contribute to biochemical oxygen demand (http://www.pca.state.mn.us/water/wastewater.html). Oxygen demand of municipal wastewater is widely documented, as are improvements in surface waters in the past ten years as a result of wastewater effluent controls (http://ohioline.osu.edu/aex-fact/0768.html; http://h2osparc.wq.ncsu.edu/info/do.html; http://www.ci.san-jose.ca.us/esd/wpcp.htm; http://www.soundkeeper.org/programinitdetail.asp?ID=38; http://www.silverton.or.us/ogpwwp1.htm; http://themes.eea.eu.int/Specific_media/water/indicators; http://themes.eea.eu.int/Specific_media/water/indicators/bod/index_html). A study from New York indicates that wastewater treatment facilities account for about 20 percent of the biochemical oxygen demand in an urban stream (http://www.stormwater-resources.com/Library/071PLAlleyCreek.pdf). Less is known about other types of wastewater, although many wastewaters, such as agricultural wastewater, have very high oxygen demand (http://foodsci.unl.edu/fmc/need-07.htm; http://www.jpf.org/LRV/wetlands%20constructed.htm).

Septic Systems: Low contribution. Although human waste has a high oxygen demand, septic systems are designed to minimize loss of organic matter. Consequently, septic systems, except those that are failing, have minimal impact on oxygen depletion in surface waters (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-nonsewered.html). A study from New York indicates that failing septic systems account for about 1 percent of the biochemical oxygen demand in an urban stream (http://www.stormwater-resources.com/Library/071PLAlleyCreek.pdf).

Spills: Low contribution. Spills of oxygen demanding chemicals, such as raw sewage, can have dramatic and catastrophic short-term effects on aquatic ecosystems. Spills, however, generally have limited impact both in geographic extent and over long periods of time. In addition, environmental agencies have emergency response staff who respond to spills that threaten or impact the environment (http://www.pca.state.mn.us/cleanup/ert.html; http://www.owasa.org/wastemgt/wwm1.asp; http://www.ae.iastate.edu/Ae573_ast475/Water_Impacts_Notes.htm).

Urban runoff: Medium contribution. Urban runoff includes chemicals that have oxygen demand, including yard waste, fertilizers, oil, and human waste from sewer systems. A study from New York indicates that stormwater runoff and loss from combined sewer overflows account for about 65 percent of the biochemical oxygen demand in an urban stream (http://www.stormwater-resources.com/Library/071PLAlleyCreek.pdf). Runoff from industries, such as salvage facilities where oil is drained and contaminates surface soils, can have very high oxygen demand (http://www.ce.berkeley.edu/~hermanowicz/ce212/notes/water_pollut_b.pdf).

Confidence Level

Agricultural Runoff: Moderately confident. Oxygen demand of agricultural runoff is documented. There is limited recent information on the amount of runoff occurring from agriculture and effects on aquatic ecosystems.

Feedlots: Moderately confident. Oxygen demand of animal waste and runoff from open feedlots are well documented. There is limited information on the amount of runoff occurring from feedlots and effects on aquatic ecosystems.

Municipal and Industrial Wastewater: Reasonably confident. Wastewater facilities are regulated and effluent standards exist for chemicals having an oxygen demand (http://www.pca.state.mn.us/water/wastewater.html).

Septic Systems: Moderately confident. There is considerable research that demonstrates likely impacts from adequately-performing septic systems are low. We have poor information, however, on the extent of nonconforming systems.

Spills: Reasonably confident. Spills must be reported, and emergency response plans are established to remedy spills. We therefore feel there is good information on environmental impacts associated with spills.

Urban runoff: Moderately confident. Research shows that urban runoff, particularly runoff associated with sewer overflow, has a high oxygen demand. There is limited information linking urban runoff to impacts on aquatic ecosystems.

Source Trends

Agricultural Runoff: No trend. The number of acres in agricultural production has not changed significantly in the past 15 years (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Feedlots: No trend. There are about 45,000 feedlots in Minnesota, with more than 30,000 of these being permitted. The number of permits issued to feedlots having less than 500 animal units did not change between 1990 (134 permits) and 1999 (131 permits). These are facilities likely to be of greatest concern for surface water quality. The trend toward larger operations is likely to lead to improvements in water quality because of better manure management, but it is difficult to relate permits to actual environmental changes. We therefore assigned no trend to this source (http://www.pca.state.mn.us/hot/fl-permits.html#trends; http://www.auditor.leg.state.mn.us/ped/1999/pe9904.htm).

Municipal and Industrial Wastewater: Downward trend. Regulatory control of discharges from wastewater facilities has resulted in improvements in wastewater treatment. In addition, wastewater management has been one of the areas where successful pollution prevention practices have been implemented. Consequently, oxygen demand in surface waters has decreased in many areas, including 89 percent of monitored streams and rivers in Minnesota (http://www.pca.state.mn.us/publications/reports/305bfinalreport-2000.pdf; http://www.mntap.umn.edu/POTW/Potw.htm; http://themes.eea.eu.int/Specific_media/water/indicators/bod/index_html)

Septic Systems: No trend. The number of septic systems is increasing in Minnesota as suburban areas lacking municipal services increase in their extent. There is an increased awareness, however, of potential water impacts from septic systems, and many municipalities are therefore upgrading old systems. Failing systems, which represent the greatest threat to aquatic ecosystems, are imminent environmental hazards and must be remedied (http://www.pca.state.mn.us/programs/ists/index.html).

Spills: No trend. Despite preventive efforts, spills still occur. There appears to be no trend in the occurrence of spills.

Urban runoff. Upward trend. The percent of land in urban use in Minnesota increased by more than 27 percent between 1982 and 1997. Studies of aquatic habitat in coastal areas of the United States show a trend of increasing degradation associated with urban runoff. Similar studies are limited for Minnesota, but impacts to aquatic ecosystems are likely to be similar in Minnesota as in other areas of the United States (http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://www.ocrm.nos.noaa.gov/pcd/6217.html; http://capita.wustl.edu/NEW/oconnor.html).

13. Particles in Air

Impact Categories: Human Health Cancer, Human Health Noncancer Acute, Human Health Noncancer Chronic, Quality of Life Aesthetics

Sources: Agriculture, Area Source Combustion, Coal-fired Power Plants, Fugitive Dust, Industry, Municipal and Industrial Wastewater, Off-road Equipment, On-road Vehicles

Air particles may be directly emitted (e.g., from grinding operations or combustion processes) or formed by other chemicals in the atmosphere. Directly emitted particles tend to be larger (on the order of 10 microns or sometimes larger) than those that are secondarily formed. Recent studies on the impacts of particles on human health have focused on the smaller particles (on the order of 2.5 microns or smaller); therefore sources of the large particles may be less of a concern when looking at the health impacts of the stressor as a whole. In addition, the health impacts may be from the nature of the particles themselves or from the chemicals of which the particles are comprised. Metals and some semi-volatile compounds can condense with acid gases such as NOx and SO2 to form particles. The nature of particles from particular sources may also be important. Some researchers of focusing on the effects of particles released from diesel-powered engines.

Comparative Contribution of Sources

Coal-fired power plants, on-road vehicles, and off-road engines are all important sources of particles and their precursors. Research is ongoing to describe the relative importance of these sources in atmospheric particle formation and culpability for various health effects.

Coal-Fired Power Plants: High Contribution. Coal combustion by electric utilities emits 5% of the directly emitted, non-fugitive dust $PM_{2.5}$ according to the EPA 1998 emissions inventory. In addition, coal combustion by utilities accounts for 63% of SO_2 and 22% of NO_x emissions in the US. Both pollutants are important precursors for secondary formation of fine particles.

On-Road Vehicles: High Contribution. On-road sources account for 7% of the primary, non-fugitive dust emissions of $PM_{2.5}$ in EPA's 1998 national emissions inventory. On-road vehicles emit 32% of NO_x emissions, an important precursor to secondary particle formation. On-road diesel engines are responsible for 23% of diesel PM emissions according to the 1997 Minnesota Air Toxics Emissions Inventory.

Off-Road Vehicles and Engines: High Contribution. Off-Road engines emit 14% of the primary, non-fugitive dust emissions of $PM_{2.5}$ in EPA's 1998 national emissions inventory. Off-road sources also are account for 6% of nationwide SO_2 and 22% of nationwide NO_x emissions, both of which are particle precursors. Off-road engines emit 77% of the diesel PM emissions in Minnesota.

Area Source Combustion: Medium Contribution. According to EPA's 1998 Trends report, small combustion sources (such as open and agricultural burning) account for 37% of the primary, non-fugitive dust emissions of $PM_{2.5}$. Residential wood burning accounts for an additional 12% of the direct $PM_{2.5}$ emissions.

Agricultural Practices: Medium Contribution. Livestock management, fertilizer application, and other agricultural activities emit 86% of national ammonia emissions. Ammonia is an important precursor for secondary particle formation.

Wastewater Treatment: Low Contribution. The treatment of wastewater is a minor source of ammonia, an important particle precursor.

Fugitive Dust: Low Contribution. Fugitive dust sources emit large amounts of small particles according to EPA emission inventory data, but many of the particles do not travel long distances and may play a much smaller role in the health impacts of fine particle exposure.

Industry: Low Contribution. Non-combustion industrial processes emit smaller amounts of primary $PM_{2.5}$ and particle precursors. Specific sources may emit large amounts of fine particles.

Confidence Level

The confidence in coal-fired power plants contribution to fine particulates is moderately confident due to the relative ease in measuring emissions from large smokestacks (vs. many tailpipes or atmospheric reaction). The confidence in the other sources' contributions to total fine particle loadings in Minnesota is somewhat speculative. EPA's emissions inventory data reported in the 1998 Trends report provides a rough outline of the direct emissions of $PM_{2.5}$ and the emissions of several precursors to atmospheric formation. EPA is working to improve nearly all the methodologies for estimating emissions of $PM_{2.5}$. The role of secondary formation is also poorly understood; it may account for a majority or few of the fine particles in ambient air. Ongoing research is attempting to determine what 'parts' of the fine particles lead to the well-known health effects.

Source Trends

Source trends are difficult to determine. As described above, many of the sources emit both particles and their precursors. The uncertainties surrounding the estimates of primary emissions and the formation of secondary particles make the determination of trends in source contributions nearly impossible. It is possible to track the trends of some sources, such as agricultural practices, that emit only precursors. We can say the emissions of ammonia are increasing, but it is not clear if that means the amount of particles attributed to that source is also increasing. Overall, direct emissions of both large (PM_{10}) and small ($PM_{2.5}$) particles are increasing from some sources and decreasing from others. The same can be said about precursor compounds such as NO_x, SO_2, and ammonia. Consequently, we assigned a trend of increasing and decreasing to each of the sources for Particles in Air.

References

- US Environmental Protection Agency (USEPA). March 2000. *National Air Pollutant Trends, 1900-1998*. http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf. Accessed 2/6/02.
- Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix B: Particulate Matter and Appendix E: Diesel Exhaust*. http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html. Accessed 2/6/02.

14. Pathogens in Water

Impact Categories: Human Health Noncancer Acute

Sources: Feedlots, Land-applied Manure, Land-applied Municipal and Industrial Byproducts, Municipal and Industrial Wastewater, Septic Systems

Disease-causing pathogens, such as giardia and cryptosporidium, have been found occasionally in public-water supplies and have caused illness in a large number of people in a few locations. Pathogens can enter our water from an animal source. Our assessment of contribution is based on number of illness incidents associated with pathogens.

Comparative Contribution of Sources

Feedlots: High contribution. Pathogens are an important component of runoff from animal feedlots, particularly open lots. There is little information on actual quantities of pathogens released to surface water, but runoff from open feedlots is considerable. Ground water beneath feedlots typically contains high concentrations of bacteria, but there are few studies of pathogens in ground water (http://www.cropsci.uiuc.edu/agronomyday/2000/filter-strips/; http://www.pca.state.mn.us/water/groundwater/gwmap/rpt-liquidmanurestorage-summary.pdf; http://www.hogwatch.org/html/rsccen/text/sos/rsccen__txtol_sos_sobsey.html; http://www.iwla.org/fishkill/Minnesota2000FactSheet.pdf).

Land-applied manure: Medium contribution. Manure contains high concentrations of pathogens, and the quantity of land-applied manure is high (http://www.nps.ars.usda.gov/programs/programs.htm?npnumber=206&docid=863; http://www.hogwatch.org/html/rsccen/text/sos/rsccen__txtol_sos_sobsey.html).

Septic systems: Medium contribution. Studies seem to indicate relatively low concentrations of bacteria in ground water under communities with septic systems. These are communities, however, where private wells typically occur, so that the potential exposure can be high in certain hydrologic settings (http://www.pca.state.mn.us/water/groundwater/gwmap/gwq-unseweredsub.pdf).

Municipal and industrial wastewater: Low contribution. Although large quantities of wastewater are discharged to surface water, this water requires treatment to remove pathogens. Where discharge of raw sewage occurs, high concentrations of pathogens may occur in surface water (http://www.pca.state.mn.us/water/basins/mnriver/bacteria.pdf; http://www.nebiosolids.org/qanda.html).

Land-applied municipal and industrial byproducts: Low contribution. Land-applied municipal and industrial byproducts typically does not contain pathogens (http://www.pca.state.mn.us/water/landapp.html).

Confidence Level

Feedlots: Moderately confidence. There is ample documentation that feedlots contribute pathogens to surface water, but health impacts are not well documented.

Land-applied manure: Moderately confident. We have information on the quantity of livestock in Minnesota, the amount waste that is likely produced as a result, pathogen contents in manure, and affects of management practices, such as composting, on pathogen concentrations. New feedlot rules contain information about land application of manure. Farmers in general, apply manure for nutrient value and thus should apply the manure in a manner that minimizes loss from runoff. There is little monitoring information about actual losses, however (http://www.mofga.org/mofgs00a.html; http://www.ecochem.com/t_cbpa_app.html; http://manure.unl.edu/adobe/v7n2_01.pdf).

Septic systems: Moderately confident. We have reliable information on the number of septic systems that occur in Minnesota and that septic systems contribute bacteria to drinking water. There is limited information about the fate of bacteria and the occurrence of pathogens from septic systems.

Municipal and industrial wastewater: Reasonable confidence. Most wastewater facilities are permitted and have effluent limits. We are therefore reasonably confident about the contribution from these facilities (http://www.pca.state.mn.us/water/wastewater.html).

Land-applied municipal and industrial byproducts: Somewhat speculative. We have limited information on the contribution from land-applied municipal and industrial byproducts. Not all of these wastes are permitted. Although there are requirements for wastes that are permitted, there is little environmental monitoring to determine the environmental fate of pathogens contained in the wastes (http://www.pca.state.mn.us/water/landapp.html; http://www.pca.state.mn.us/water/landapp.html).

Trends

There is little monitoring data available for contribution of health effects from pathogens. We therefore estimate trends based on trends in the sources.

Feedlots: No trend. There is no significant trend in the number of feedlots in Minnesota. More feedlots are becoming permitted with time, which should lead to improved management practices that decrease release of pathogens to surface water. Relative to the number of feedlots in Minnesota, however, these improvements are probably insignificant.

Land-applied manure: No trend. There is no significant trend in the number of livestock in Minnesota and, presumably, for manure that is applied to land.

Septic systems: Upward trend. There is an increasing trend in the number of septic systems in Minnesota. These systems are built in developing urban areas, where they may impact drinking water, and in lakeshore developments, where they may affect surface water.

Municipal and industrial wastewater: No trend. Most wastewater effluent has been regulated for several years, and there are no significant trends in emission from wastewater treatment facilities.

Land-applied municipal and industrial byproducts: No trend. We have poor information on the amount of land application that occurs in Minnesota. There does not appear to be an increase in the number of permits for application of wastes that contain pathogens, and many of these wastes are permitted through the Water Quality programs at the MPCA (http://www.pca.state.mn.us/water/landapp.html; http://www.pca.state.mn.us/water/landapp.html).

15. Phosphorus

Impact Categories: Aquatic Organisms, Quality of Life-Aesthetics
Sources: Agricultural Runoff, Feedlots, Municipal and Industrial Wastewater, Septic Systems, Urban Runoff

Phosphorus is generally the limiting nutrient contributing to the production of excess algae in surface waters and to lake eutrophication. Both point and nonpoint sources contribute to phosphorus, although nonpoint sources predominate. Nonpoint phosphorus is generally attached to sediment and closely related to soil erosion. Over the past 30 years, phosphorus levels have decreased at 75 percent of monitored stream sites, largely as a result of point source controls. The trend in phosphorus discharges from point sources has been relatively flat over the last five years, and was actually up slightly from 1999 to 2000. The MPCA is currently reviewing its phosphorus discharge standards to waters of the state and the outcome of this process may affect phosphorus discharges allowed from point sources in the future (http://www.pca.state.mn.us/water/phosphorus.html).

Comparative Contribution of Sources

Agricultural runoff: High contribution. Agricultural runoff includes overland loss of phosphorus from fertilizers and manure, and loss through tile lines. Overland loss is considerably greater than loss through tiles, since phosphorus is highly adsorbed to soil particles. Losses of phosphorus will thus occur primarily with eroded sediment. Annual phosphorus applied to Minnesota fields includes about 160 million pounds applied as inorganic fertilizer and an estimated 250,000 pounds applied with manure (assuming half of livestock manure is land applied)(http://www.ces.uga.edu/pubcd/c826-w.html; http://usda.mannlib.cornell.edu/data-sets/inputs/9X171/97171/agch0997.txt; http://www.bae.umn.edu/extens/manure/landapp/). These numbers greatly exceed all other sources of phosphorus.

Municipal and industrial wastewater: Medium contribution. The contribution of phosphorus from municipal and industrial wastewater discharges to waters of the state has been relatively stable over the past five years. Reported discharges from the 85 major treatment facilities comprising 27 industrial and 58 municipal sources have averaged about 1400 thousand kilograms over this time, according to Discharge Monitoring Reports (DMRs) submitted to the MPCA.

Feedlots: Medium contribution. Although there have been increased controls on the contribution of phosphorus from feedlot runoff and manure application to agricultural land in recent years, the size of feedlots and animals contained has increased, to some extent offsetting the effect of increased controls. Manure handling remains a critical concern in some areas of the state where large confined feedlot operations are concentrated.

Urban runoff: Medium contribution. Increased urbanization and use of fertilizers on lawns and plantings have been offset somewhat by better management practices for fertilizer application, implementation of runoff controls, and a ban on fertilizers containing phosphorus in some communities. Nevertheless, urban runoff is an important contributor to lakes and streams in urban areas (http://www.epa.gov/iwi/303d/02030101_303d.html; http://clean-water.uwex.edu/pubs/sheets/hiurban.pdf; http://www.chesapeakebay.net/info/stormwater.cfm; http://in.water.usgs.gov/nawqa/wr03006.htm; http://hermes.ecn.purdue.edu:8001/cgi/convertwq?8054; http://hermes.ecn.purdue.edu:8001/cgi/convertwq?8054; http://www.epa.gov/opptintr/fertilizer.pdf).

Septic systems: Low contribution. Contribution of phosphorus to water resources from a properly functioning septic system should be low. New construction and operation requirements, an increased enforcement presence at the local (county) level, and increased public awareness have led to a decreasing number of overloaded and failing septic systems in recent years, even as the number of systems has increased in near-urban areas not served by centralized treatment systems. Phosphorus can reach surface water from failing systems and from very old systems, but these amounts will be low compared to the sources discussed above (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-nonsewered.html).

Confidence Level

Our confidence level for the contribution of the above sources to phosphorus in our water resources is moderate to reasonable. We have reasonable confidence for municipal and industrial wastewater treatment plants, which are required to monitor and report phosphorus levels in their discharges. We also have reasonable confidence for agricultural runoff because of the large number of research studies illustrating loss of phosphorus from agricultural fields. A number of research studies have quantified the amount of phosphorus entering surface water as a result of runoff from agricultural tile lines (http://www.nemp.aus.net/dav20.htm; http://www.dnr.state.wi.us/org/water/wm/nps/waterquality.htm; http://www.ars.usda.gov/is/np/Phos&Eutro/phos&eutro.pdf; http://www.dnr.state.md.us/bay/czm/nps/npspollution.html). Runoff controls and some site-specific monitoring are required of larger feedlots and some septic systems. We have moderate confidence for septic systems, urban runoff, and feedlots, with the primary limitation being difficulties in quantifying losses from these sources.

Source Trends

Over the past 30 years, phosphorus levels have decreased at 75 percent of monitored stream sites, largely as a result of point source controls. In a recent five-year period (1996-2000), phosphorus from major point source discharges actually increased, but very slightly. The greatest threat to water resources from phosphorus is most likely from nonpoint sources that currently have only minimal monitoring. Examples include runoff from agricultural land, increasing urbanization, and increase in size and amount of animal waste generated from feedlot operations.

Agricultural runoff: No trend. An increasingly wetter climate in the last few decades has masked reductions in delivery of sediment and phosphorus to the Minnesota River due to improved crop and land management practices. While the wetter climate has actually increased sediment and phosphorus loads due to more frequent erosion-causing rainstorm events, producers have adopted better crop and land management practices that reduce erosion. After compensating for climate, there are about an equal number of surface water streams and rivers showing slightly increasing or decreasing trends in phosphorus load (http://www.soils.umn.edu/research/mn-river/doc/trends.html;). http://alfi.soils.wisc.edu/extension/FAPM/2002proceedings/porter.pdf).

Municipal and industrial wastewater. No trend. In a recent five-year period (1996-2000), phosphorus from municipal and industrial wastewater point source discharges increased very slightly, based on results from discharge monitoring reports

(DMRs) submitted to MPCA (http://www.pca.state.mn.us/hot/legislature/reports/2002/airwater/pdf).

Feedlots. No trend. There have been increased controls on the contribution of phosphorus from feedlot runoff and manure application to agricultural land in recent years, but the average size of feedlots and animals contained has increased, to some extent offsetting the effect of increased controls.

Urban runoff. Upward trend. Increased urbanization and the use of fertilizers on lawns and plantings have been offset somewhat by better management practices for fertilizer application and a ban on fertilizers containing phosphorus in some communities. Phosphorus from nonpoint sources is generally attached to sediment associated with urban runoff that is increasing with urban sprawl, despite tighter controls. It remains to be seen if recent bans on phosphorus in fertilizers sold for home use will have a measurable impact of phosphorus in runoff generated by relentless urbanization.

Septic systems. No trend. New construction and operation requirements, an increased enforcement presence at the local (county) level, and increased public awareness have led to a decreasing number of overloaded and failing septic systems in recent years, even as the number of systems has increased in near-urban areas not served by centralized treatment systems. Contribution of phosphorus to water resources from a properly functioning septic system is generally low, but the rapid rise in the number of systems being constructed, especially in the second and third-ring suburbs around major metropolitan areas such as the Twin Cities likely offsets this somewhat.

References

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- 2000 Minnesota Water Quality – Surface Water Section. http://www.pca.state.mn.us/publications/reports/305bfinalreport-2000.pdf

16. Temperature Increase/Climate Change

Impact Categories: Aquatic Organisms, Terrestrial Organisms, Human Health Noncancer Acute

Sources: Agriculture, Coal-fired Power Plants, Industry, On-road Vehicles, Permitted Waste Disposal, Power Plants (thermal discharge), Residential Fuel Combustion, Urban Runoff

Human health impacts from heat and severe weather and negative impacts on aquatic species from increases in water temperature are expected in the future as greenhouse gases accumulate in the atmosphere and contribute to increasing ambient temperatures. The sources of the greenhouse gases are listed below. Aquatic ecosystems may also be impacted by temperature changes associated with runoff in urban areas and direct thermal discharges from industry (http://www.ramas.com/therm.htm; http://h2osparc.wq.ncsu.edu/info/temper.html).

Comparative Contribution of Sources

Coal-Fired Power Plants: High contribution. Electricity generation, primarily from coal, is the largest source of carbon dioxide (CO_2), the principal greenhouse gas. Electric utilities are also a large source of NO_x.

On-Road Vehicles: High contribution. On-road vehicles are the second highest emitter of CO_2 behind electric utilities. They also emit significant amounts of methane and NO_x.

Agriculture: Medium contribution. Livestock are a source of methane and manure management is an important source of ammonia and other nitrogen compounds. Methane and nitrogen compounds are emitted from manure application and other crop practices.

Industry: Medium Contribution. Industrial fuel combustion is a large source of CO_2.

Permitted Waste Disposal: Medium Contribution. Landfills are the second largest source of methane behind livestock.

Residential Fuel Burning: Low Contribution. Residential burning of wood, natural gas, and other fossil fuels is a source of CO_2.

Urban Runoff: Medium Contribution. Impervious areas, such as parking lots and roof tops, absorb the sun's radiation and retain some of the heat. During a precipitation event, the heat is transferred to the runoff flowing over the impervious surface. This warm water is often discharged directly to a surface water body. The resulting temperature can directly affect aquatic organisms, but a more important effect may be on nutrient cycling and dissolved oxygen (http://h2osparc.wq.ncsu.edu/info/temper.html; http://wow.nrri.umn.edu/wow/under/parameters/temperature.html; http://www.surfrider.org/longbeach/descriptions.htm).

Power Plants (thermal discharge): Low Contribution. Many industries discharge effluent having elevated temperatures directly into surface water. The resulting increase in temperature may adversely impact aquatic habitats. These discharges are regulated, however, and effects are local (http://h2osparc.wq.ncsu.edu/info/temper.html).

Confidence Level

Coal-Fired Power Plants: Reasonable confidence. NOx emissions from power plants are well understood and CO2 emissions from combustion can be determined.

On-Road Vehicles: Reasonable confidence. Similar to power plants, NOx and CO2 emissions are tracked and can be determined.

Agriculture: Somewhat speculative. The emission of greenhouse gases during crop production and related processes is not well understood. Emissions of methane and NO_x from livestock and other agricultural practices are not as easy to determine as CO_2 emissions from fossil fuel combustion.

Industry: Reasonable confidence. Combustion-related CO2 emissions are well understood for industries where we have good data on fuel type and use.

Permitted Waste Disposal: Moderately confident. Determining methane emissions from landfills is more straightforward than calculating contributions of nitrous oxide but less so than estimated CO2 emissions from combustion processes.

Residential Fuel Burning: Reasonable confidence. The confidence in the contribution of residential fuel burning is similar to other fossil fuel combustion sources.

Urban Runoff: Somewhat Speculative. There is limited information that relates temperature effects to urban runoff.

Power Plants (thermal discharge): Reasonable confidence. Thermal discharges are regulated. Numerous studies also show the limited geographic area of thermal effects.

Source Trends

Coal-Fired Power Plants: Upward trend. Fossil fuel combustion (and therefore CO_2 emissions) associated with electricity generation is increasing.

On-Road Vehicles: Upward trend. Fossil fuel combustion (and therefore CO_2 emissions) associated with transportation is increasing.

Agriculture: Upward trend. N_2O emissions from agricultural soil management, the largest source of N_2O, is increasing. These emissions are created during bacterial nitrification processes, and are a function of available nitrogen. Nitrogen is added to the soil via commercial fertilizers, manure application, crop residues, and atmospheric deposition. Methane emissions from agricultural activities are also important, although to a lesser degree than N_2O emissions. Methane emissions from manure management are neither increasing nor decreasing, and methane emissions from livestock are decreasing.

Industry: No trend. CO_2 emissions from industrial combustion are level.

Permitted Waste Disposal: No trend. Methane emissions have decreased the 1980s levels but are stable over the last several years.

Residential Fuel Burning: No trend. CO_2 emissions from residential fuel combustion are stable.

Urban Runoff: Upward trend. The percent of land in urban use in Minnesota increased by more than 27 percent between 1982 and 1997 (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Power Plants (thermal discharge): No trend. The primary sources of heated effluent are industries that generate power, although other manufacturing industries, such as paper production, also generate heated effluent. There is no trend in these industries in Minnesota. We assume this means there is no trend in effluent generated by these industries.

References

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17. Toxic Chemicals – High Level Accidental Releases

Impact Categories: Human Health Noncancer Acute

Sources: Industry, On-road Vehicles, Pipelines, Residences, Tanks, Trains

This stressor involves various toxic materials that are released and cause immediately hazardous conditions. The comparative contributions of the sources are based on the database maintained by the PCA's Emergency Response program (as reported to us by Dorene Fier-Tucker in an e-mail on 9/6/01). The estimates are based on numbers of releases, not volume (which might result in different comparative contributions).

Comparative Contribution of Sources

On-Road Vehicles: High Contribution.
Trains: High Contribution.
Industry: Medium Contribution.
Residences: Low Contribution.
Tanks: Low Contribution.
Pipelines: Low Contribution.

Confidence Level

The confidence level for the comparative contribution of sources is considered "reasonable" for all the sources. This is based on the fact that, unlike most other stressors, we have an actual database to calculate numbers.

Source Trends

On-Road Vehicles: Upward.
Trains: No trend.
Industry: No trend.
Residences: No trend.
Tanks: Downward.
Pipelines: Downward.

These trends are based on the judgment of Steve Lee, Supervisor of Emergency Response program (in an e-mail dated 9/25/01).

18. Toxic Chemicals in Food

Impact Categories: Human Health Cancer, Human Health Noncancer Chronic
Sources: Coal-fired Power Plants, Industry, Mining, Municipal and Industrial Wastewater, Off-road Equipment, On-road Vehicles, Permitted Waste Disposal, Pesticide Use, Residential Fuel Combustion, Unpermitted Waste Disposal, Waste Incineration

A variety of toxic chemicals occur in food that humans consume. The primary chemicals of concern are persistent bioaccumulative toxics (pbts). These are chemicals that persist in the environment and accumulate in the food chain. Some pbts include PAHs, dioxin, some metals such as mercury, and chlorinated pesticides. PBTs are not the toxics of concern in the food chain, however. Many chemicals, including pesticides and metals, can be toxic but not bioaccumulate.

While toxics in food is not within the immediate regulatory authority of the MPCA, many of the sources of these toxics are regulated by the MPCA. This includes a variety of industries that discharge these toxics to the environment, permitted and unpermitted waste disposal, wastewater, and waste incineration.

Comparative Contribution of Sources

Residential fuel combustion: High contribution. The high contribution of residential fuel combustion is primarily attributed to burn barrels and wood burning, although a wide variety of persistent organic chemicals are released from other types of residential fuel combustion. While there are few of these sources compared to most other sources, these activities result in incomplete combustion and subsequent release of large quantities of PAHs and dioxins (http://ens.lycos.com/ens/jan2000/2000L-01-04-06.html; http://www.dnr.state.wi.us/org/caer/ce/ob/health.htm). Burn barrels, for example, are thought to contribute about 25 percent of the dioxins released annually to the atmosphere in the United States (EPA, 2000, Draft Dioxin Reassessment). Residential wood combustion is considered to contribute slightly more than a quarter of the total PAHs released annually to the atmosphere in the United States. These chemicals can be highly toxic and persistent in the environment (US EPA).

Pesticide Use: High contribution. The high contribution of pesticide use is attributed to the highly persistent nature of many pesticides, primarily chlorinated insecticides. While many of the chemicals have been banned, they were once widely used and still are found at levels of concern in the environment. Pesticides are found in food products due to improper, or in some cases, routine usage. (http://www.epa.gov/pesticides/food/risks.htm).

On-road vehicles: Medium contribution. While on-road vehicles are perhaps the largest contributor to air emissions, many of the chemicals emitted do not enter the food chain. PAHs and some metals, such as lead, are the primary concerns (US EPA).

Off-road equipment: Medium contribution. Off-road equipment contributes about one percent of the total PAHs and five percent of the lead released to the atmosphere annually in the United States (US EPA).

Unpermitted waste disposal: Medium contribution. Unpermitted waste disposal (e.g. unpermitted landfills) was once one of the most important contributors of persistent chemicals to the environment. The primary chemicals of concern were PCBs, chlorinated solvents, and dioxins. Because of programs such as Superfund, many of the largest sources have been cleaned up.

Mining: Medium contribution. Mining primarily contributes metals, such as cadmium, to the environment. Smelting operations, if included with mining, typically contribute 30 percent or more of the lead, cadmium, and arsenic released to the environment (US EPA).

Municipal and industrial wastewater: Medium contribution. Sewage and industrial wastewater contain a variety of chemicals, primarily metals such as cadmium, which are released to aquatic environments. These chemicals can accumulate in the environment and pass through the food chain to humans.

Coal-fired power plants: Medium contribution. Coal combustion contributes large quantities of mercury to the environment, perhaps as much as 25 percent of all mercury emissions in the United States (US EPA). Coal combustion also releases several other metals, such as lead.

Waste incineration: Medium contribution. Nationally, waste incineration is perhaps the largest contributor to chemicals that bioaccumulate in the environment. Incineration is an important source for PCBs, dioxins, and PAHs (US EPA). In Minnesota, impacts from waste incineration are less than nationally because much of the municipal and industrial waste is landfilled.

Industry: Medium contribution. Industry is a broad category that contains a wide variety of sources. Taken together, industries release large quantities of persistent chemicals. Examples include PCBs from industrial boilers (about eight percent of releases in the United States), mercury from chlorine production (five percent), lead from manufacturing (five percent), and dioxins from combustion processes (two percent) (US EPA).

Permitted Waste Disposal: Medium contribution. Permitted waste disposal (e.g. landfills) is an important contributor for mercury, accounting for about 15 percent of releases in the Great Lakes region (GLATEI, 1996).

Confidence Level

Our confidence in estimating relative contribution from the different sources that impact the food chain was somewhat speculative, with the exception of pesticides. Although there is reasonably good emission data for most of the major pollutant categories across the United States, there is limited information for Minnesota. Pesticide use is the exception, where we have good information on use and are therefore moderately confident of our estimates for comparative contribution. Another factor contributing to our uncertainty is the lack of documentation showing the connection between chemicals released to the atmosphere and those showing up in the food chain.

Source Trends

Trends for toxic chemicals in food are difficult to estimate. Recognition of pbts in our environment and potential linkages with toxics in food has resulted in some reductions in use of pbts. In spite of this, the number of advisories for fish consumption has increased in Minnesota in the past 10 years (http://www.epa.gov/pbt/fact.htm). It is likely that concentrations of some chemicals, such as chlorinated insecticides and PCBs, are decreasing, while concentrations of other chemicals, such as dioxin, are increasing. Consequently, many of the sources discussed here exhibit both upward and downward trends, because some chemicals emitted by the sources are decreasing while others are increasing in concentration.

Residential fuel combustion: No trend. Burning of trash is outlawed in most municipalities but is commonly practiced in rural areas. Although the number of people burning trash has probably decreased significantly in the past 10 to 20 years, the amount of dioxin released from burning may have increased over the same period, since trash now contains large quantities of plastics and papers that contribute to dioxin formation (http://www.co.carver.mn.us/EnviroServices/burnbarrel.htm).

Pesticide use: Downward trend. While overall pesticide use in the United States has remained steady or increased in the past 20 years, use of chlorinated insecticides has decreased (http://ceq.eh.doe.gov/nepa/reports/statistics/tab7x9.html). These are the chemicals of greatest concern, because they are persistent and bioaccumulate. Many insecticides have been banned, including DDT, chlordane, and dieldrin.

On-road vehicles: Up and down trend. Total vehicle miles driven have increased by more than 50 percent in the past 30 years in most parts of the United States. This has been somewhat offset by use of cleaner, more fuel-efficient cars. The 1970's and 1980's trend of decreasing overall fuel consumption in on-road vehicles appears to have reversed in recent years, however. This may be attributable to increased miles driven and use of less fuel efficient vehicles, such as SUVs (http://www.eia.doe.gov/aer/ep/motor.html).

Off-road equipment: Up and down trend. The up and down trend is attributable to many of the factors described for on-road vehicles. Although gasoline-powered engines are more fuel efficient and cleaner that they were 30 years ago, there are many more of them in use. Examples include lawn equipment, ATVs, and snowmobiles.

Unpermitted waste disposal: Downward trend. Unpermitted waste disposal sites continue to be cleaned up through programs such as Superfund and the Voluntary Investigation and Cleanup Program. RCRA and other legislation is designed to minimize unpermitted dumping. Consequently, impacts from unpermitted waste disposal are decreasing.

Mining: No trend. There is little data to suggest a trend in impacts from mining.

Municipal and industrial wastewater: No trend. There is some speculation that concentrations of pharmaceuticals and other household chemicals are increasing in municipal wastewater. There is little evidence to show that concentrations of these chemicals are increasing, although improved analytical detection methods confirm the presence of these chemicals in wastewater (http://recetox.chemi.muni.cz/PBTs/content.htm;).

Coal-fired power plants: No trend. Emissions from coal-fired power plants have not changed significantly in the past decade.

Waste incineration: Up and down trend. Wastewater treatment facilities (both municipal and industrial) are regulated through a permitting system. Through this permitting system and improvements in operation, environmental releases of metals to water bodies have diminished with time (http://www.pca.state.mn.us/water/wastewater.html). Similar trends have been observed in other areas of the country (http://www.wa.gov/puget_sound/Publications/workplan_01/MUNICPL.pdf; http://www.rice.edu/armadillo/Galveston/Chap6/ch6.html). This is tempered, however, by data that suggests increases in release of some pbts from waste incineration, such as dioxins and PAHs (http://www.epa.gov/opptintr/pbt/mercury.htm; http://recetox.chemi.muni.cz/PBTs/chapter7-2.htm; http://p2tools.utoledo.edu/PBTSyn.pdf).

Industry: Downward trend. Many industries have decreased emissions of certain pbts, such as dioxin from paper mills (http://recetox.chemi.muni.cz/PBTs/content.htm).

Permitted waste disposal: Up and down trend. While there continue to be efforts to limit the amount of toxic wastes disposed in municipal solid waste, the amount of solid waste generated by Minnesotans increased 33 percent between 1993 and 2001. Solid waste continues to be an important source of pbts
http://www.moea.state.mn.us/lc/score00.cfm;
http://recetox.chemi.muni.cz/PBTs/chapter10-3-5.htm;

http://www.epa.gov/pbt/pbtsandyou.htm; http://www.ecy.wa.gov/programs/hwtr/shoptalkonline/PDF_HTML_versions/Spring01.pdf).

19. Toxic Chemicals in Soil

Impact Categories: Human Health Cancer, Human Health Noncancer Acute, Human Health Noncancer Chronic

Sources: Industry, Land-applied Municipal and Industrial Byproducts, Pesticide Use, Spills, Unpermitted Waste Disposal, Lead Paint, Road Salt

Contaminants in soil affect human health through direct contact with soil, ingestion of soil particles in air, or ingestion of vapors released from soils. Our assessment of contribution is based on chemical mass, which may be somewhat misleading for sources that contribute small amounts of chemical but if exposures occur in heavily-populated urban areas.

Comparative Contribution of Sources

Pesticide Use: Medium to high contribution. Commercial application of pesticides requires a license. Actual use of pesticides is not strictly regulated, however. Over 10 million pounds of pesticide are applied annually in Minnesota (http://www.mda.state.mn.us/privapp/). Ambient concentrations of pesticides have not been determined in either urban or rural soils, but pesticides appear pervasive in other media. High contribution was assumed for cancer and chronic effects because of the widespread occurrence of pesticides in the environment and because of the likelihood for long-term exposure. The contribution for acute effects was considered moderate, since these effects will only occur in the case of chemical spills.

Industry: Medium contribution. Industrial contributions to soil are primarily through air deposition. Soils in urban areas contain much higher concentrations of chemicals such as lead and PAHs compared to natural background concentrations (http://www.state.nj.us/dep/dsr/soilrep.pdf).

Unpermitted Waste Disposal: Low to medium contribution. Most heavily contaminated sites have been identified and human exposure is controlled. There continues to be an upward trend in the number of Superfund sites where remediation activities have been completed. Although there may be level to upward trends in the number of new sites entering Superfund, these do not reflect new sites but rather sites that have existed for many years and are just now identified as being contaminated (http://www.epa.gov/children/indicators/land_contam.html). Future incidences of human exposure are limited as a result of property transfer programs, such the Voluntary Investigation and Cleanup Program. Programs such as RCRA limit the potential for exposure to hazardous chemicals that are improperly disposed, although some of this disposal continues to occur. Because of control programs, the likelihood of long-term exposure is low, and contribution for chronic health effects and cancer is low. The contribution for acute effects is moderate, since exposure to soil containing high concentrations of some chemicals, such as PCBs or chlorinated solvents, can result in immediate health effects.

Land-applied Municipal and Industrial Byproducts: Low contribution. Land application of biosolids (sewage sludge) is regulated through MN Rule Chap. 7041 and land application of industrial by-products is regulated through a permitting process (http://www.pca.state.mn.us/water/landapp.html). Most wastes are applied for beneficial use to crops and are thus not applied in quantities that will likely result in significant risk to human health (http://www.ext.vt.edu/pubs/compost/452-304/452-304.html; http://www.cfe.cornell.edu/wmi/Sludge/Recommends.html; http://www.gov.on.ca/OMAFRA/english/research/oascc/swa/biosol.htm).

Lead Paint: Low contribution. Lead paint has been banned in the United States since 1978. Much lead-based paint remains in older homes, but release of this is likely to be low. Training is required for people who handle lead-based paint (http://www.lgean.org/html/fedregsguide/ixb.cfm).

Road Salt: Low contribution. Although 320,000 tons of road salt were applied to Minnesota roads in 1999, and road salt contains cyanide, much of the cyanide is likely to end up in surface water or be degraded in the environment (http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html).

Spills: Low contribution. Although these may have an immediate impact on human health, they are usually detected quickly, thus preventing long-term exposure necessary for most cancers to develop (http://www.pca.state.mn.us/cleanup/ert.html). There is a potential for worker exposure to heavily contaminated soils resulting from poor waste management. This occurs primarily for small quantity generators such as salvage yards.

Confidence Level

Pesticide Use: Moderately confident. We have reasonable information on pesticide sales and assume this represents the amount of chemical released to the environment. There is little information on concentrations of pesticides in urban and agricultural soils. Most herbicides are likely to be quickly degraded from the parent compound, but the fate and toxicity of degradates are largely unknown.

Industry: Somewhat speculative based on lack of data for air deposition and lack of monitoring data. There is a large amount of data showing that deposition of contaminants occurs near some point sources, such as coal and nuclear plants. (http://www.econ.vu.nl/gis/education/Euphids/Pesticides.htm; http://www.metrokc.gov/health/hazard/vmdesign3.htm; http://recetox.chemi.muni.cz/PBTs/chapter10-8.htm; http://www.hanford.gov/docs/rl-98-33/section4.html).

Unpermitted Waste Disposal: Moderately confident. Most of the larger sites have been identified. There are likely to be few sites in residential areas. Exposure is thus limited to workers. Except for Very Small Quantity Generators, disposal of hazardous materials is controlled through RCRA.

Land-applied industrial and municipal byproducts: Moderately confident. We have good information on the amount of several industrial and municipal wastes that are land applied. These wastes are not hazardous and are applied for agronomic benefit, thus reducing their risk to humans.

Lead Paint: Moderately confident. Human health effects of lead paint are well understood. Lead paint has been banned in the United States since 1978 (http://www.lgean.org/html/fedregsguide/ixb.cfm). Combined, these two factors give us moderate confidence of the impacts to soil from lead paint.

Spills: Moderately confident based on the low exposure due to quick detection and relatively small volumes of most spills.

Road Salt: Somewhat speculative. The primary concern with road salt is cyanide. Cyanide is acutely toxic and quantities in road salt are relatively well understood. Impacts and exposure to humans is not well understood, however http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html).

Source Trends

Pesticide Use: No change in concentration with time. Quantities of pesticides applied over the past ten years have not increased or decreased (http://www.mda.state.mn.us/privapp/).

Industry: While there has been a downward trend in emissions of some criteria pollutants, data for particles are less certain. Particles are likely to be the largest contributor to soil contamination (http://www.pca.state.mn.us/air/aqemissions-trends.html).

Unpermitted Waste Disposal: Downward due to remediation of contaminated sites and regulation of hazardous wastes under RCRA.

Land-applied of industrial and municipal byproducts: Increasing trend. Quantities of lime, which includes industrial ash, have increased over the past ten years (http://www.mda.state.mn.us/lime/tonnagestats.pdf). Applications of biosolids have increased in the past 12 years (MPCA data).

Lead Paint: Lead was banned for use in paint in 1978. Since 1994, training is required for professionals who work with lead-base paint (http://www.lgean.org/html/fedregsguide/ixb.cfm). There is therefore a downward trend in contributions from lead-based paint.

Spills: No trend. Although spill prevention and preparedness have improved, the actual number of spills has remained unchanged in the past ten years.

Road Salt: No trend. Minnesota used 320,000 tons of road salt in 1999. Use has leveled off in recent years because of mild winter conditions (http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html).

20. Toxic Chemicals in Water

Impact Categories: Human Health Cancer, Human Health Noncancer Acute, Human Health Noncancer Chronic

Sources: Land-applied Municipal and Industrial Byproducts, Municipal and Industrial Wastewater, Pesticide Use, Spills, Tanks, Unpermitted Waste Disposal, Feedlots, Fertilizer Use, Septic Systems, Land-applied Manure

Toxic Chemicals in Water considers a wide range of chemicals that can have adverse health impacts when ingested with drinking water. Other effects, such as on aquatic organisms, are not considered. Although the discussion primarily focuses on and refers to ingestion of water, drinking water criteria also include other exposure routes for chemicals in water, such as dermal and inhalation.

Comparative Contribution of Sources

Pesticide Use: High contribution. Use of pesticides is not strictly regulated and over 10 million pounds of pesticide are applied annually in Minnesota (http://www.mda.state.mn.us/privapp/). Pesticides are not routinely sampled in most public water supplies and not at all in private water supplies (http://www.health.state.mn.us/divs/eh/dwp/pws/). Even in public water supplies sampled for pesticides, only a narrow range of parent compounds are analyzed. Data show that pesticide degradates are much more likely to occur in surface water and ground water compared to parent compounds (http://www.pca.state.mn.us/water/groundwater/gwmap/rpt-landuse-stcloud.pdf; http://www.pca.state.mn.us/water/groundwater/gwmap/rpt-gwq-cottage.pdf).

Tanks: Low to Medium contribution. Waste disposal sites are managed through programs at the MPCA. Contamination occurs on occasion and creates the potential for long-term exposure in some private wells. The chemical of greatest concern is benzene, which is a carcinogen. The contribution for cancer is thus medium, while the contribution for noncancer chronic is low (http://www.pca.state.mn.us/cleanup/ust.html; http://www.pca.state.mn.us/cleanup/ast.html; http://www.pca.state.mn.us/programs/lust_p.html; http://www.pca.state.mn.us/programs/vpic_p.html).

Unpermitted Waste Disposal: Medium contribution. Waste disposal sites are managed through programs at the MPCA. Contamination occurs on occasion and creates the potential for long-term exposure in some private wells. There is some evidence for widespread occurrence of VOCs in the environment, although concentrations appear to be below drinking standards (http://www.pca.state.mn.us/water/groundwater/gwmap/gw-baseline.html; http://www.pca.state.mn.us/waste/index.html).

Land-applied Industrial and Municipal Byproducts: Low contribution. Land application of biosolids (sewage sludge) is regulated through MN Rule Chap. 7041 and land application of industrial by-products are regulated through a permitting process (http://www.pca.state.mn.us/water/landapp.html). Most wastes are applied for beneficial use to crops and are thus not applied in quantities that will likely result in significant risk to human health (http://www.ext.vt.edu/pubs/compost/452-304/452-304.html; http://www.cfe.cornell.edu/wmi/Sludge/Recommends.html; http://www.gov.on.ca/OMAFRA/english/research/oascc/swa/biosol.htm).

Fertilizer Use: High Contribution. About 12 million short tons of nitrogen fertilizer are applied annually in the United States (http://www.tfi.org/Statistics/index.asp). About 0.58 million metric tons are applied annually in Minnesota (http://www.me3.org/issues/climate/gordon.pdf). Nitrate occurs widely in drinking water throughout Minnesota, often at concentrations exceeding drinking criteria. Effects are with infants under six months in age (http://www.pca.state.mn.us/water/groundwater/gwmap/index.html; http://www.ianr.unl.edu/pubs/water/g1369.htm).

Municipal and Industrial Wastewater: Low Contribution. Contributions are considered low since discharges to surface water are regulated and quantities are low relative to other sources (http://www.pca.state.mn.us/programs/inpdes_p.html; http://www.pca.state.mn.us/water/wastewater.html).

Septic Systems: Low to Moderate contribution. Many household wastes, including human excretions, contain chemicals that may represent a health risk, particularly nitrate and possibly pathogens. Wells typically provide drinking water in areas served by septic systems. In certain hydrologic environments, these wells may be at risk of contamination. The chemical of greatest concern is nitrate. Acute effects are therefore considered moderate, while chronic effects are considered low (http://www.pca.state.mn.us/water/groundwater/gwmap/gwq-unseweredsub.pdf; http://www.extension.umn.edu/extensionnews/1999/JP1052.html).

Spills: Low contribution. These may have an immediate impact on human health, but they are almost always detected quickly, thus preventing long-term exposure (http://www.pca.state.mn.us/cleanup/ert.html).

Feedlots: Low contribution. Nitrate is the chemical of concern for acute effects. Feedlots contribute low quantities of nitrate to ground water, except under certain conditions (http://www.pca.state.mn.us/water/groundwater/gwmap/rpt-liquidmanurestorage-summary.pdf).

Land-applied Manure: Medium contribution. Land-applied manure may contribute nitrate to drinking water, which can have acute effects on human health. Potentially, contributions from land-applied manure are high. Annually in the United States, 869 million tons of manure are generated from livestock (http://www.nhq.nrcs.usda.gov/land/RCAarchive/wp14text.html). It is difficult to gain good numbers on the quantity of manure applied in Minnesota, but the amount is probably considerable considering the livestock population in the state. Most of the nitrogen in land-applied manure is in the organic form and must therefore be converted to nitrate before it can leach to ground water. This likely limits the areas of concern to well-aerated, coarse-textured soils.

Confidence Level

Pesticide Use: Moderately confident. We have reasonable information on pesticide sales and assume this represents the amount of chemical released to the environment. There is some data on the occurrence and environmental fate of the more commonly used pesticides (Kolpin et al., 1997; Blanchard and Donald; 1997; USGS, 1998). The major uncertainty concerns pesticide degradates and pesticides entering the market in the past few years (Kalkhoff et al., 1998). Research suggests that most herbicides, which are the most extensively used pesticides, are detoxified quickly in the environment (Field and Thurman, 1996). Other pesticides, which are typically more persistent and toxic to humans than herbicides, generally have low mobility in the environment and are not likely to be found in ground water but often occur in surface water.

Tanks: Reasonable confidence. MPCA has programs designed to address contaminants associated with tanks. These programs have led to cleanup at several thousand tank sites, including both soil and ground water remediation. Future releases from tanks are diminished because of control programs that are now in place (http://www.pca.state.mn.us/cleanup/ast.html; http://www.pca.state.mn.us/programs/lust_p.html; http://www.pca.state.mn.us/cleanup/ust.html; http://www.pca.state.mn.us/programs/vpic_p.html).

Unpermitted Waste Disposal: Moderately confident. Public water supplies, on which 90 percent of Minnesotans rely, are routinely tested. Preventive measures, such as tank leak detection systems and RCRA, should limit new incidences of exposure. We have good information on the location and impact of existing sites, although there may be many unpermitted sites not identified (http://www.pca.state.mn.us/waste/index.html; http://www.pca.state.mn.us/cleanup/ast.html; http://www.pca.state.mn.us/programs/lust_p.html; http://www.pca.state.mn.us/cleanup/ust.html; http://www.pca.state.mn.us/programs/vpic_p.html).

Land-applied Industrial and Municipal Byproducts: Moderately confident. We have good information on the amount of several industrial and municipal wastes land applied. These wastes are not hazardous and are applied for agronomic benefit, thus reducing their risk to humans. We, however, have limited environmental data to verify this assumption (http://www.pca.state.mn.us/water/landapp.html).

Fertilizer use: Reasonable for acute effects, since incidence of blue-baby syndrome is well documented. We have good data describing the distribution of nitrate in the major aquifers in the state.

Municipal and industrial wastewater: Moderately confident. MPCA regulates wastewater discharges and sets effluent limits. There is little information about some chemicals in wastewater, however, such as pharmaceuticals (http://www.pca.state.mn.us/water/wastewater.html).

Septic systems: Moderately confident to Reasonable. We have good information on the number of septic systems, where they occur, and nitrogen loss from septic systems. Nitrogen is the chemical of greatest concern for acute impacts to human health. We have limited information for other chemicals that may have chronic impacts. We thus assigned moderate confidence for chronic impacts and reasonable for acute impacts.

Spills: Moderately confident based on the low exposure due to quick detection and relatively small volumes of most spills.

Feedlots: Moderately confident. We are moderately confident of our estimate of contribution from feedlots. We have good information on number of feedlots and the fate of nitrogen from feedlots. We do not have good information on the number of unpermitted feedlots, which may be an important contributor to nitrogen in ground water.

Land-applied manure: Moderately confident. We have some information on the amount of manure applied to agricultural soils and good information on livestock numbers. We have a good understanding of the fate of nitrogen in manure under certain field conditions.

Source Trends

Pesticide Use, Fertilizer Use: No change in concentration with time. Quantities of pesticides and fertilizer applied over the past ten years have not increased or decreased (http://www.mda.state.mn.us/privapp/).

Spills: stable to declining due to improved spill prevention and preparedness.

Land application of industrial and municipal byproducts: increasing trend. Quantities of lime, which includes industrial ash, have increased over the past ten years (http://www.mda.state.mn.us/lime/tonnagestats.pdf). Application of biosolids have increased in the past 12 years (MPCA data).

Tanks: because of MPCA and programs, there is a downward trend in number of new sites with leaking tanks. New tank sites are generally equipped with detection systems.

Unpermitted waste disposal: because of MPCA and local programs, there is a decreasing trend in the number of unpermitted waste disposal sites. New unpermitted hazardous waste sites are less likely because of RCRA. Sites continue to be cleaned up, and it is assumed that preventive programs will limit potential exposure from these sources.

S*eptic systems*: increasing trend. Prescription drug use and the number of septic systems continue to increase with time (http://www.extension.umn.edu/extensionnews/1999/JP1052.html)(http://www.house.gov/berry/prescriptiondrugs/Resources/nihcmreport.pdf).

Municipal and Industrial Wastewater: No trend. Assessing overall trends in wastewater contributions requires assessing a variety of wastewater sources. These range from industrial and municipal discharges to discharges of animal waste. Animal wastes decreased by approximately 3 percent between 1987 and 1997. Minnesota has limited information about other wastewater discharges (http://www.scorecard.org/ranking/). An original MPCA mission was to control point sources of contamination. Municipal and industrial wastewater treatment plants were targeted point sources and they have largely been brought into compliance. We therefore assume that impacts from wastewater discharge have decreased. This is countered, however, by evidence that chemicals such as pharmaceuticals are present in wastewater and may have impacts on human health. Concentrations of these chemicals in wastewater appear to be increasing (http://www.earthsky.com/2000/es000901.html; http://ag.arizona.edu/AZWATER/awr/july00/feature1.htm; http://toxics.usgs.gov/pubs/OFR-02-94/).

Land-applied Manure: No trend. There is little documentation about the amount of manure applied to agricultural fields. Since the number of livestock has not increased dramatically in the past ten years, and assuming farmers are not applying different quantities of manure than in the past, we estimated there was no trend in contributions from land-applied manure.

Feedlots: No trend. While the number of feedlots has decreased over the past ten years, the number of livestock has not changed during that same period. This reflects increasing size of operation. We based the assumption of no trend in contribution on the number of livestock, since the amount of waste produced has not changed in the past ten years (http://www.leg.state.mn.us/lrl/issues/feedlots.htm).

21. Toxic Metals

Impact Categories: Aquatic Organisms, Terrestrial Organisms

Sources: Coal-fired Power Plants, Industry, Mining, Municipal and Industrial Wastewater, Urban Runoff, Waste Incineration, Recreational Use (shooting ranges, fishing tackle)

Toxic metals include lead, mercury, cadmium, zinc, copper, chromium, and others. For this stressor, we consider effects of metals on aquatic and terrestrial organisms. These include impacts from exposure to sediments containing metals. Human health is also affected by metals in the environment, but these effects were considered under Toxic Chemicals in Soil, Toxic Volatile Chemicals in Water, Toxic Chemicals in Air, and Toxic Chemicals in Food.

Comparative Contribution

Coal-fired Power Plants: High Contribution. Coal contains a large number of metals. These may be emitted to air with particulates from coal-fired power plants. Mercury is a volatile metal and is emitted in its elemental form following coal combustion. These metals enter the aquatic ecosystem through air deposition. Coal combustion is the major source of mercury released to the environment (http://www.fetc.doe.gov/publications/proceedings/96/96jpfs/jpfs_pdf/toxics.pdf; http://www.pca.state.mn.us/air/mercury-about.html). Coal combustion accounts for less than 10 percent of air emissions for most metals, with the exception of arsenic, which is estimated at 19 percent, and mercury, which is estimated at about 25 percent (EPA 1998a; EPA 2000).

Urban Runoff: High Contribution. Urban runoff contributes large quantities of metals directly to ecosystems. The most recent National Water Quality Inventory reports that runoff from urban areas is the leading source of impairments to surveyed estuaries and the third largest source of water quality impairments to surveyed lakes (http://www.epa.gov/OWOW/NPS/facts/point7.htm). Automobile fluids are perhaps the most important source of metals. A study conducted by the MPCA in 1994 and 1995 showed that runoff from a 'typical' motor vehicle salvage facility greatly exceed aquatic life standards for cadmium, copper, lead, and zinc. Several other studies conducted outside Minnesota show direct ecosystem impacts from metal contamination associated with urban runoff (http://www.kristar.com/level2/info/infoG.html; http://www.epa.state.oh.us/dsw/documents/fs2eas2000.pdf; http://environment.prsc.qld.gov.au/waterquality.asp; http://www.auracom.com/~bofep/Publications/Fundy%20issues/contamin.htm).

Area Source combustion: Medium Contribution. Differences between area source contributions and industry are unclear. If we group smelting operations into area sources, then the contribution of area sources is medium. Smelting results in air emissions of lead, copper, cadmium, and arsenic. These chemicals may eventually be deposited in aquatic or terrestrial ecosystems. Smelting is a particularly important contributor of cadmium and arsenic (EPA 1999).

Municipal and Industrial Wastewater: Medium contribution. Concentrations of metals in some wastewater can be high (data from MPCA unpublished data base). Concentrations and metals of concern vary with the type of waste, since municipal and industrial wastewater covers a broad range of wastes. Effects of wastewater discharges on ecological ecosystems have been document (http://dnr.state.il.us/orep/c2000/MANAGE/dupage/ataglance.htm; http://marine.usgs.gov/fact-sheets/fs150-97/; http://www.ce.berkeley.edu/~sedlak/research_4.php; http://sfbay.wr.usgs.gov/access/Cloern.html#HDR1). Although effects can be severe, they also tend to be localized and associated with a particular point source of contamination.

Waste Incineration: Medium contribution. Nationally, waste incineration accounts for metal emissions to air that are similar in magnitude to coal combustion (EPA 1998a; 1999; 2000). Waste incineration is a significantly less important contributor in Minnesota, with only about 30 percent of the state's solid waste being incinerated (http://www.moea.state.mn.us/lc/DisposalAction.cfm).

Industry: Low contribution. Industry includes a large number of point sources that primarily contribute metals through air emissions. If smelting is not included under industry, then contributions of metals are relatively low. Metal finishing industries may contribute significant quantities of metal locally, particularly chromium (EPA, 1999).

Mining: Low contribution. Mining is not an important source of metals released to the atmosphere (discounting smelting operations)(EPA 1998a; 1999; 2000). Metals released to the environment will therefore occur locally. Contributions from mining are therefore considered low, although locally aquatic and terrestrial ecosystems can be impacted. Most studies of mining impacts on ecosystems and ecological organisms have occurred outside Minnesota (http://www.ainc-inac.gc.ca/pr/pub/nwr/li3_e.html; http://www.nrcan.gc.ca/mets/aete/factshte.htm; http://www.fisheries.org/Public_Affairs/Policy_Statements/ps_13.shtml).

Recreational use: Low contribution. A 15-year study, analyzing 222 dead loons from Minnesota and 17 other states, concluded that 10 percent died of lead poisoning. Half of those loons actually had lead fishing sinkers in their stomachs. In another study conducted by the Minnesota Pollution Control Agency, lead poisoning accounted for 17 percent of the dead loons sent to research centers for autopsy. In areas where loons breed – the Great Lakes region, northeastern United States, and eastern Canada – lead poisoning from sinkers or jigs may account for up to 50 percent of the dead adult loons found by researchers. Between 1980 and 1996, the University of Minnesota's Raptor Center reported lead poisoning in 138 of 650 eagles treated by the Center. Since 1996, 43 additional eagles were treated for lead poisoning including 22 last year. Most of the time, the source of the lead cannot be detected as the birds have cast the material out of their systems (http://www.moea.state.mn.us/reduce/sinkers.cfm). Because lead shot was banned in waterfowl production areas in the early 1990s, lead jigs and sinkers are a major source of ongoing lead poisoning.

Confidence Level

Coal-fired Power Plants: Reasonably confident. Coal-fired power plants are permitted. We therefore have information about releases.

Urban Runoff: Moderately confident. We have good data to indicate that population is increasing and the state is becoming more urbanized. We have good information that shows urban water quality contains toxic metals. We have limited information that supports our understanding of impacts from these metals on ecological organisms.

Municipal and Industrial Wastewater: Moderately confident. Most wastewater sources are controlled through a permitting process. Discharge quantities are therefore known. There is limited understanding of the environmental fate and impact from metals in wastewater.

Waste Incineration: Reasonably confident. Waste incinerators are permitted. We therefore have information about releases.

Industry: Somewhat speculative. Our low confidence is due to the large number of industries that potentially contribute metals to the environment.

Mining: Reasonably confident. If we eliminate smelting as a mining source, we have reasonably good information on mining contributions, since these operations require an NPDES permit.

Recreational Use: Intermediate confidence. Although studies suggest lead poisoning occurs in waterfowl and raptors, evidence linking the poisoning to use of lead in recreation is lacking. Lead sinkers have frequently been found in animals that have been poisoned (http://www.moea.state.mn.us/reduce/sinkers.cfm).

Trends

Coal-fired Power Plants: No trend. The primary metal of concern with coal-fired power plants is mercury. Emissions from power plants have increased about 25 percent in the past ten years as a result of increased energy demand. Concentrations of chemicals have not changed or decreased, however, partly because of decreasing emissions nationally (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf).

Urban Runoff: Upward trend. The upward trend is primarily a result of increasing population and an increase in the number of people living in urban areas (http://govpubs.lib.umn.edu/guides/census2k.phtml).

Municipal and Industrial Wastewater: No trend. Assessing overall trends in wastewater contributions to heavy metals in the environment requires assessing a variety of wastewater sources. These range from industrial and municipal discharges to discharges of animal waste. Animal wastes decreased by approximately 3 percent between 1987 and 1997. Minnesota has limited information about other wastewater discharges (http://www.scorecard.org/ranking/). An original MPCA mission was to control point sources of contamination. Municipal and industrial wastewater treatment plants were targeted point sources and they have largely been brought into compliance. We therefore assume that impacts from wastewater discharge have decreased significantly over the past 20 years, although current trends may be relatively flat.

Waste Incineration: Downward trend. Wastewater treatment facilities (both municipal and industrial) are regulated through a permitting system. Through this permitting system and improvements in operation, environmental releases of metals to water bodies have diminished with time (http://www.pca.state.mn.us/water/wastewater.html). Similar trends have been observed in other areas of the country (http://www.wa.gov/puget_sound/Publications/workplan_01/MUNICPL.pdf; http://www.rice.edu/armadillo/Galveston/Chap6/ch6.html).

Industry: No trend. Because of the large number of industries that could potentially contribute metals to the environment, it is difficult to assess trends. Overall, there are some industries with increasing emissions and some with decreasing emissions. Cumulatively, we took this to mean no trend (US Environmental Protection Agency. March 2000. *National Air Pollutant Trends, 1900-1998*. http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf; Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix B:*

Particulate Matter and Appendix E: Diesel Exhaust. http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html).

Mining: No trend. Data suggests a slight downward trend in the extent of mining in Minnesota, with a 14 percent decrease in the number of establishments between 1992 and 1997 and a 4 percent reduction in the number of employees. Value of shipments, however, has increased 17 percent over the same period. It is difficult to extrapolate these results to trends in environmental impacts from mining (http://www.census.gov/epcd/ec97/mn/MN000_21.HTM; http://www.census.gov/epcd/ec97sic/E97SUS.HTM).

Recreational use: No trend. There are no bans on lead jigs and sinker use in Minnesota, but tackle manufacturers, retailers, associations, sports enthusiasts and government are partnering to educate anglers about this issue and increase the use of environmentally friendly sinkers. Lead shot has been banned in Minnesota for several years (http://www.moea.state.mn.us/reduce/sinkers.cfm)

22. Toxic Organic Chemicals

Impact Categories: Aquatic Organisms, Terrestrial Organisms

Sources: Agricultural Runoff, Pesticide Use, Area Source Combustion, Municipal and Industrial Wastewater, Spills, Urban Runoff, Industry, Land-applied Municipal and Industrial Byproducts

Toxic organic chemicals include a wide range of chemicals. These include chemicals that have industrial, agricultural, and residential origins, and that vary widely in their persistence and toxicity. Only aquatic and ecosystem effects are considered in this discussion. Toxic organic chemicals that affect human health are included in discussions for Toxic Chemicals in Soil, Toxic Chemicals in Water, Toxic Volatile Chemicals in Air, and Toxic Chemicals in Food.

Comparative Contribution

Agricultural runoff: High contribution. Effects are on aquatic organisms. The primary organic chemicals of concern in agricultural runoff are pesticides. Occurrence of pesticides in surface waters and effects on aquatic organisms are well documented (http://www.ianr.unl.edu/pubs/water/g586.htm; http://www.ccohs.ca/headlines/text69.html; http://www.cotf.edu/ete/modules/waterq3/WQpollution3.html; http://www.epa.gov/ceisweb1/ceishome/atlas/nationalatlas/threats_to_health_of_us_waters.htm; http://www.pca.state.mn.us/water/groundwater/gwmap/gw-landuse.html).

Pesticide Use: High contribution. Effects are on terrestrial organisms. Many chlorinated insecticides, although banned or limited for use in the United States, continue to enter terrestrial ecosystems as a result of air deposition, since many of these chemicals are used in other areas around the world. Pesticide applications to forests, agricultural fields, and residential areas have immediate adverse impacts on terrestrial ecosystems near the application areas. Many pesticides are detected in rain water, although generally at low concentrations (http://ace.orst.edu/info/extoxnet/tibs/ecologic.htm; http://ice.ucdavis.edu/cehr/33.htm;

http://www.mst.dk/default.asp?Sub=http://www.mst.dk/udgiv/publications/2000/87-7944-325-7/html/indhold_eng.htm; http://www.mst.dk/default.asp?Sub=http://www.mst.dk/udgiv/publications/2000/87-7944-325-7/html/indhold_eng.htm; http://www.epa.gov/athens/staff/members/birdsandral/).

Area Source Combustion: Medium and High contribution. Effects on aquatic organisms are high. Effects on terrestrial organisms are moderate. The high contribution is primarily attributed to incomplete burning, which leads to release of PAHs and dioxin to the atmosphere (http://ens.lycos.com/ens/jan2000/2000L-01-04-06.html; http://www.dnr.state.wi.us/org/caer/ce/ob/health.htm). Burn barrels, for example, are thought to contribute about 25 percent of the dioxins released annually to the atmosphere in the United States (EPA, 2000, Draft Dioxin Reassessment). Residential wood combustion is considered to contribute slightly more than a quarter of the total PAHs released annually to the atmosphere in the United States. These chemicals can be highly toxic and persistent in the environment (US EPA). The effects are only medium in terrestrial ecosystems because soils typically bind and therefore limit mobility of PAHs and dioxins, whereas these chemicals are often cycled through sediments in aquatic ecosystems, thus increasing exposure of aquatic organisms.

Municipal and Industrial Wastewater: Intermediate and High contribution. Municipal and industrial wastewater contribution was high for aquatic organisms and medium for terrestrial organisms. The chemicals of greatest concern are pbts and endocrine-disrupting chemicals. Municipal and industrial wastewater contributes large quantities of these chemicals to aquatic ecosystems. Releases to terrestrial ecosystems occur through discharge to the atmosphere and subsequent deposition to terrestrial ecosystems, or locally due to direct discharge of organic chemicals. Atmospheric releases of pbts are considered less significant than from other sources (see Section 18).

Industry: Medium contribution. Industry encompasses a wide variety of sources for organic chemicals. The chemicals of greatest concern are pbts. Industry is considered to represent a significant source for these chemicals, but less than area sources (see Section 18).

Urban Runoff: Medium contribution. Urban runoff impacts both aquatic and terrestrial ecosystems. Impacts to aquatic ecosystems are evident and have been documented (http://www.afsc.noaa.gov/abl/Habitat/urbanPAH.htm; http://endocrine.ei.jrc.it/gedri/pack_edri.FullScreen?p_rs_id=262; http://www.usgs.gov/public/press/public_affairs/press_releases/pr457m.html; http://www.nwri.ca/talk-green/urban-runoff.html). Terrestrial organisms, such as waterfowl, are also impacted by organic contaminants that bioaccumulate.

Land-applied Municipal and Industrial Byproducts: Low contribution. Although municipal and industrial waste may contain organic contaminants, including pbts, applications are permitted and effects are generally local in nature (http://www.pca.state.mn.us/water/landapp.html).

Spills: Low contribution. Although spills can dramatically alter aquatic and terrestrial ecosystems, effects are generally local and spills are rapidly contained (http://www.pca.state.mn.us/cleanup/ert.html).

Confidence Level

Agricultural runoff: Moderately confident. Agricultural runoff of pesticides and presence of pesticides in surface water have been well documented.

Pesticide Use: Somewhat speculative. Although we have observed direct impacts to some organisms, such as raptors, there is limited information about rates of pesticide deposition to terrestrial ecosystems.

Area Source Combustion: Somewhat speculative. Emissions from the primary sources for area source combustion are not monitored, although we have general estimates of atmospheric discharge of some chemicals.

Municipal and Industrial Wastewater: Somewhat speculative and moderately confident. We are moderately confident for aquatic ecosystems since discharges of wastewater are regulated and effluent limits are established. We are somewhat speculative for terrestrial effects since we have limited information on atmospheric discharge from wastewater facilities.

Industry: Somewhat speculative. There are estimates of some pbts released to the atmosphere from some industries. Because of the wide variety of industries that may contribute organic chemicals to the environment, we rated our confidence as somewhat speculative.

Urban Runoff: Somewhat speculative. There are limited studies showing concentrations of organic chemicals released to the environment.

Spills: Moderately confident. MPCA and other agencies have Emergency Response programs that document and contain spills.

Land-applied Municipal and Industrial Byproducts: Moderately confident. This source is regulated through a permitting process.

Trends

Agricultural runoff: No trend. There has been no significant change in agricultural acres in the past 15 years. BMPs can diminish loss from agricultural fields, but there is little information about trends in use of BMPs. Some programs, such as the EQIP program, have been successful in getting farmers to implement BMPs, but the program is limited in scope (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41; http://wrc.coafes.umn.edu/EQIP/).

Area Source Combustion: No trend. There is limited information related to trends in chemical release from area sources. We can use information on discharge of pbts, which shows some chemical releases increasing and others decreasing. Overall, we assume there is no trend in environmental concentrations of organic contaminants.

Municipal and Industrial Wastewater: No trend. Wastewater is regulated through a permitting process. Quantities of wastewater have not changed significantly in the past 10 years.

Industry: No trend. Because of the large number of industries that could potentially contribute metals to the environment, it is difficult to assess trends. Overall, there are some industries with increasing emissions and some with decreasing emissions. Cumulatively, we took this to mean no trend (US Environmental Protection Agency. March 2000. *National Air Pollutant Trends, 1900-1998*. http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf; Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix B:*

Particulate Matter and Appendix E: Diesel Exhaust. http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html)

Urban Runoff: Upward trend. The percent of urban land in Minnesota increased about 27 percent between 1982 and 1997. Several studies have demonstrated negative impacts of urban runoff on aquatic organisms. The greatest concern is perhaps from PAHs, which are increasing in surface water sediments in urbanizing environments (http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://www.ocrm.nos.noaa.gov/pcd/6217.html; http://www.strategian.com/oct900.html#one; http://capita.wustl.edu/NEW/oconnor.html; http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Spills: No trend. Despite preventive efforts, spills still occur. There appears to be no trend in the occurrence of spills.

Land-applied Municipal and Industrial Byproducts: Upward trend. Land application of byproducts is increasing, partly due to improved markets for byproducts (http://www.tfhrc.gov/pubrds/fall94/p94au32.htm; http://www.ctre.iastate.edu/pubs/semisesq/session2/ghafoori/; http://www.p2pays.org/ref/03/02311.pdf).

23. Toxic Volatile Organic Chemicals in Air

Impact Categories: Human Health Cancer, Human Health Noncancer Acute, Human Health Noncancer Chronic

Sources: Industry, Off-road Equipment, On-road Vehicles, Residential Fuel Combustion

There are hundreds or thousands of different volatile chemicals released into the atmosphere from various industrial and commercial processes. For the sake of clarity and feasibility, it is necessary to define exactly which pollutants are described. In 1999, the MPCA's Staff Paper on Air Toxics identified ten 'pollutants of concern' in Minnesota based on modeling and monitoring (acrolein, benzene, 1,3-butadiene, formaldehyde, chromium, nickel, arsenic, ethylene dibromide, chloroform, and carbon tetrachloride). Follow-up work indicated that several pollutants may not be as large of a concern as previously thought. In the Environmental Information Report, the term air toxics refers to those pollutants identified by the MPCA to be near the relevant health benchmark: benzene, formaldehyde, 1,3-butadiene, acrolein, and acetaldehyde.

It should not be inferred that the other chemicals present in the air are known to cause no ill effects. Many of these pollutants are not tracked through modeling or monitoring and the information on health effects is incomplete or non-existent. In addition, the health impacts of mixtures of pollutants is not well understood; effects could be additive or synergistic.

Comparative Contribution of Sources

On-Road Vehicles: High Contribution. On-road vehicles emit large amounts of many volatile chemicals. According to Minnesota emissions inventory data, on-road vehicles are a primary source for benzene, formaldehyde, 1,3-butadiene, acrolein, and acetaldehyde.

Off-Road Equipment: Medium Contribution. The total contribution of off-road engines is less than that of on-road vehicles. The gasoline and diesel-powered engines are still significant sources of pollution, however.

Residential Fuel Burning: Medium Contribution. Residential burning of wood, natural gas, and other fossil fuels is a significant source of air toxics. Residential wood burning is a large source of benzene.

Industry: Medium Contribution. A variety of industrial operations emit volatile air pollutants. Although the cumulative emissions of cars, trucks, and other mobile sources are larger than the emissions for facilities, industrial emissions may adversely impact local communities.

<u>Confidence Level</u>

On-Road Vehicles: Reasonably confident. On-road gasoline and diesel vehicles are known to emit large amounts of many air pollutants. The specific emission rates are continually improved as EPA works to improve our understanding and formulate reduction strategies, but the contribution of on-road vehicles to air quality problems across the country is well documented.

Off-Road Equipment: Moderate confidence. Emission estimation procedures for the wide variety of off-road engines are constantly improved, but emission rates of specific engines and their contribution to local pollutant emissions are not as well understood as those for on-road vehicles.

Residential Fuel Burning: Somewhat speculative. Emission factors are available for wood and fossil fuel burning. Better activity data is needed (i.e., the amount of wood burned by households in Minnesota).

Industry: Reasonably confident. Minnesota does not require facilities to report air toxics emissions, but many large facilities work with the MPCA on emissions estimates. Most facilities are included in Minnesota's emissions inventory.

<u>Source Trends</u>

On-Road Vehicles and Off-Road Equipment: Up and Down. The on- and off-road vehicles categories contain a wide variety of vehicle and engine types powered by gasoline and diesel fuel. Different pollution control regulations apply to the different engines. Emissions from some sources are decreasing due to pollution control equipment while emissions from other engines are increasing due to increasing use. Some pollution control equipment may cause trade-offs (e.g., Some groups claim that burning gasoline blended with ethanol reduces emissions of some toxics, but increases aldehyde emissions).

Residential Fuel Burning: No Trend. Emissions trend information is not available for the ubiquitous residential combustion sources. The use of some fuels, such as wood, may be decreasing according to anecdotal evidence while others, like natural gas, may be increasing as the population of the region expands. Improved technology also plays a role in emissions.

Industrial Processes: Up and Down. Some industrial sectors and specific facilities are decreasing their emissions while the emissions from others are likely increasing.

References

- Minnesota Pollution Control Agency (MPCA). 2001. *1997 Minnesota Air Toxics Emissions Inventory.* http://www.pca.state.mn.us/air/toxics.html. Accessed 2/6/02.
- Minnesota Pollution Control Agency. 1999. *MPCA Staff Paper on Air Toxics.*
- Minnesota Pollution Control Agency. 2001. *Air Quality in Minnesota: Problems and Approaches. Appendix B: Air Toxics.* http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html. Accessed 2/6/02.

24. Transported Sediment

Impact Categories: Aquatic organisms, Quality of Life-Aesthetics
Sources: Agricultural Runoff, Construction, Municipal and Industrial Wastewater, Streambank Erosion, Urban Runoff

Transported sediment primarily affects aquatic organisms and can have negative aesthetic impacts for people who utilize surface water. There are few studies that allow comparison of the relative contribution of different source areas to suspended sediment in surface water (http://www.smm.org/SCWRS/sSchottler.php; http://nevada.usgs.gov/Activities/nv233.htm; http://wa.water.usgs.gov/ccpt/pubs/wrir-94-4215_abstract.html; http://www.cleanwaterclearchoice.org/documents/Construction/Appendix%20A.pdf; http://www.inforain.org/mapsatwork/rockrichardson/rockrichardson_page4.htm; http://www.pca.state.mn.us/water/basins/redriver/studies.html#usgs-sediment). Soil loss equations and other methods for estimating sediment loss typically include land use as a factor. The relative contribution from different land uses can therefore be compared using these estimation methods. Natural soil erosion is a process that averages 0.2 tons per acre. The loss rate is accelerated to 0.5 tons per acre for managed forests. The loss rate is accelerated to 1.5 to 20 tons per acre for pasture and cultivated lands. The loss rate is accelerated to 150 to 200 tons per acre for unprotected construction sites (http://www.engr.utk.edu/research/water/primer/erosionsediment/; http://www.dwaf.gov.za/IWQS/reports/slopes_olifants/sed_olif.htm).

Comparative Contribution of Sources

Municipal and Industrial Wastewater: Low contribution. Municipal and industrial wastewater contributes organic matter to surface waters, and may contribute phosphorus that leads to algae growth. The quantities of sediment are low however, and effects are typically localized.

Urban runoff: Medium contribution. Contributions from undisturbed urban areas are considered intermediate. These are primarily areas with established lawns and other vegetation. Sediment loss from disturbed soils are considered high unless soils are stabilized. These might include losses from industrial areas, such as salvage yards. Urban areas are considered to have dramatic impacts on lakes in urban areas (http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://clean-water.uwex.edu/pubs/sheets/hiurban.pdf;). Urban areas, however, make up less than 5 percent of Minnesota's land use, although that percentage is increasing (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41). Sediment loads are higher for urban areas relative to several other land uses, particularly forested and pastured areas (http://www.chesapeakebay.net/info/stormwater.cfm). In addition, average particle size for urban areas is smaller than other land uses. Smaller particle sizes are likely to increase loading of metals and organic pollutants, since these readily adsorb to small particles (http://www.hsrc.org/hsrc/html/rbriefs/RB7/rbrief7.html; http://wwwga.usgs.gov/edu/urbanrun.html).

Agricultural runoff: High contribution. Soils losses from agricultural land are considered intermediate in their severity. With more than 21 million acres of agricultural land in Minnesota, however, agriculture is a major contributor to suspended sediment. Much of this land is in row crop agriculture, which has a high erosion potential (http://www.ent.iastate.edu/ipm/icm/2000/7-24-2000/erosion.html). The US EPA suggests a high runoff potential for the southern half of Minnesota, which is where agriculture primarily occurs (http://www.epa.gov/iwi/1999sept/iv12_usmap.html). In addition to soil particles, agriculture contributes organic matter and phosphorus, which can result in algae growth (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41; http://www.ianr.unl.edu/pubs/water/g586.htm; http://www.soils.umn.edu/research/npsp/research/lower/hansen/abstract.htm).

Streambank erosion: Medium contribution. Streambank erosion is a natural process, but human activity can increase rates of sediment loss. These activities include increasing streamflow volumes and rates by paving areas and building storm sewers, straightening streams, building dams, and reducing vegetation in riparian areas. In many rivers, streambank erosion is perhaps the most important source of suspended sediment. Streambank erosion, however, may be related to other activities, such as construction, urban development, and agriculture (e.g. animal traffic, loss of riparian habitat). It is therefore difficult to separate streambank erosion from other sources of suspended sediment. We limited our definition to streambank erosion associated with alteration of water bodies, such as straightening and damming. This reduces the relative contribution of streambank erosion (http://www.nal.usda.gov/ttic/tektran/data/000012/45/0000124555.html; http://www.oacd.org/fs04ster.htm; http://www.niwa.cri.nz/pubs/no8/forestharvest1).

Construction: High contribution. For this source, we include most activities that result in land disturbance, such as building and road construction, mining, and timber production. We consider direct contributions of sediment, rather than modifications that later result in streambank erosion (see Streambank Erosion). Construction activities contribute large quantities of sediment per unit area (http://www.engr.utk.edu/research/water/primer/erosionsediment/; http://www.engr.utk.edu/research/water/primer/erosionsediment/).

Confidence Level

Municipal and Industrial Wastewater: Reasonably confident. Effluent limits exist for wastewater treatment facilities. Because of these limits, we have reasonable information about the quantity of organic matter and suspended material that is discharged (http://www.pca.state.mn.us/water/wastewater.html).

Urban runoff: Moderately confident. There is increasing evidence of urban impacts on sedimentation in surface waters. Impacts to aquatic are not well understood however. Specific sources of urban runoff are known, but the relative importance of each is not well understood (http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://www.epa.gov/OWOW/NPS/facts/point7.htm;).

Agricultural runoff: Reasonably confident. Most studies of erosion have occurred in agricultural areas. There are soil erodibility indices for many soils in agricultural areas. In addition, the sheer number of acres in agricultural production provide a reasonable certainty that agriculture is an important source of sediment to surface water, although perhaps not on a unit area scale compared to construction and streambank erosion.

Streambank erosion: Moderately confident. There is considerable information on rates of streambank erosion and effects of management activities designed to reduce sediment loss. Relating this information directly to sediment contributions from streambank erosion is difficult, however.

Construction: Moderately confident. Recent studies indicate that sediment losses from construction are extremely high. It is difficult to determine aquatic impacts associated with construction activity, however (http://www.engr.utk.edu/research/water/primer/erosionsediment/; http://www.cleanwaterclearchoice.org/documents/Construction/Appendix%20A.pdf).

Source Trends

Municipal and Industrial Wastewater: No trend. Effluent limits have been in place for many years. There is therefore no trend in sediment contributions from wastewater treatment (http://www.pca.state.mn.us/water/wastewater.html).

Urban runoff: No trend. Although the amount of urban land is increasing in Minnesota, there is increased awareness of impacts of urban land use on water quality. Implementation of Best Management Practices may counter some of the impacts of increased urbanization (http://www.state.tn.us/agriculture/nps/bmpu.html; http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41).

Agricultural runoff: No trend. There has been no significant change in agricultural acres in the past 15 years. BMPs can diminish erosion loss from agricultural fields, but there is little information about trends in use of BMPs. Some programs, such as the EQIP program, have been successful in getting farmers to implement BMPs, but the program is limited in scope (http://www.mnplan.state.mn.us/mm/indicator.html?Id=68&G=41; http://wrc.coafes.umn.edu/EQIP/).

Streambank erosion: No trend. There is limited information about trends in sediment loss from streambank erosion. Rates of damming and stream straightening do not appear to be changing. BMPs are typically implemented in forest and mining activities. Other BMPs may be implemented in developing areas. Consequently we assigned no trend to this source (http://www.epa.gov/OWOW/NPS/MMGI/Chapter2/ch2-2a.html; http://www.niwa.cri.nz/pubs/no8/forestharvest1; http://www.ieca.org/store/category.cfm?category_id=6).

Construction: No trend. Although urbanization and development are increasing, increased awareness of sediment losses from construction sites has resulted in development and implementation of BMPs, as well as increasing regulation of construction activity (http://www.ieca.org/store/category.cfm?category_id=6; http://www.epa.gov/OWOW/NPS/MMGI/Chapter4/ch4-3a.html; http://www.cleanwaterclearchoice.org/documents/Construction/Appendix%20A.pdf; http://www.pca.state.mn.us/water/stormwater-c.html)

Index for Appendix C: Documentation for Sources

Appendix D: Documentation/Background for Program Matrix

Note to readers: This appendix and others refer to reports and documents indicated as clickable internet links, which were live when the report was drafted. It is likely that some of these links are no longer live and current, as the MPCA cannot maintain those belonging to other organizations. If you are interested in a particular reference and cannot access it, please contact Michael Trojan at 651/297-5219.

This document summarizes information used to develop the Programs Matrix. During construction of the Program Matrix, we attempted to identify as much information as possible, primarily from the Internet. There was, however, limited input from experts within the various programs. Consequently, the information should not be construed as being complete.

The information focuses on sources rather than stressors. Sources align better than stressors with MPCA programs and activities. The reader should be careful to make sure they identify the stressors associated with particular sources. For example, Trains is a source listed in the Program Matrix. Trains are associated with two stressors: Explosive Flammable Materials – High Level Accidental Exposure, and Toxic Chemicals – High Level Accidental Exposure. Trains may affect other stressors, such as Particles in Air, but in the EIR, the contribution of trains to particles was not considered separately but was instead grouped with another source – Off-Road Vehicles. Within the following discussion, stressors are identified for each source.

There is no attempt to evaluate the effectiveness of any program or activity. We instead identify activity levels, which are a measure of how much activity exists within a particular source area. Three levels of activity are identified in the Program Matrix and these are described below.

Three levels of activity are identified in the Program Matrix and these are described below.

- ◻ Programs or activities do not exist
- ☐ Limited programs or activities exist
- ■ Well-established programs or activities exist

Four types of programs or activity are discussed:

Cleanup – A program dedicated to cleaning up or reducing exposure to pollutants that have been released to the environment.

Control - A program dedicated to controlling the release of pollutants through management practices or equipment rather than use of preventive strategies. Control programs include compliance or regulatory outreach and training, which should not be confused with education. Education is treated as a separate category in this document. Control programs also encompass most permitting activities, although certain aspects of permitting may relate to cleanup, education, or prevention.

Education – Programs or activities concerned with the interrelationships among components of the natural and human-made world, producing growth in the individual and leading to responsible stewardship of the earth (http://www.sru.edu/Depts/pcee/ProfDevInit/Resources/DEFINITION.html). Activities such as training, outreach, and technical assistance generally are not included under education but more typically are considered under control.
Prevention - Strictly speaking, "pollution prevention" means to reduce the quantity or toxicity of wastes or inputs at the source (source reduction) *Minn. Stat. § 115D and Executive Order 99-4.* Reusing wastes or products and recycling are other preventative approaches. These preventative practices contrast with treatment and disposal of wastes (commonly referred to as control, management or abatement methods). In addition to source reduction, the US EPA considers eliminating pollution through increased efficiency in the use of raw materials, energy and water, and the protection of natural resources by conservation to be pollution prevention. For more information, go to http://www.pca.state.mn.us/programs/p2-s/index.html#overview.[1]

We also distinguish between MPCA and external programs or activities. External entities include any non-MPCA organization or agency. These include federal, regional, state, or local government and non-government agencies or organizations.

A List of Abbreviations is included at the end of this document. The following outline indicates discussions for individual sources can be found.

[1] Prevention includes but is not limited to the following activities.

- Increase the efficiency in the use of raw materials, water, air or energy.
- Increase the useable life span of a product.
- Change procurement, consumption, or waste-generation habits for greater source reduction.
- Reduce volume of solid waste going to a landfill through recycling.
- Recycling process waters.
- Avoid cross media transfer.
- Use benign rather than toxic chemicals or energy-intensive remedies for site cleanup.
- Use natural systems (e.g., reclaimed/constructed wetlands) as part of cleanup remedies.
- Reuse salvageable materials recovered during deconstruction.
- Restore, replace or enhance habitat (e.g., Natural Resource Damages at Superfund sites).
- Prevent stormwater pollutants from entering lakes, streams or groundwater (e.g., low-impact development, integrated management practices).
- Support preventative approaches in environmental management systems or ISO 14001.
- Incorporate "Design for the Environment" or product stewardship.
- Promote high-performance building design, low impact transit, roadways, lighting and vegetation.

Note: This list is not comprehensive.

Discussion of Individual Sources

Agricultural Runoff

Stressors Impacted: Nitrogen, oxygen-demanding pollutants, phosphorus, toxic organic chemicals, transported sediments

Impact Categories: Aquatic Organisms, Quality of Life-Aesthetics

Agricultural runoff is excess water from rainfall and other precipitation that runs off the land. When uncontrolled, agricultural runoff removes topsoil, nutrients, pesticides, and organic materials and carries them to water bodies where they become pollutants (http://www.ianr.unl.edu/pubs/water/g586.htm#ar). Agricultural runoff includes sediments and chemicals associated with sediments and in solution. Most agricultural runoff is classified as nonpoint in origin. Impacts are to aquatic ecosystems. Additional information can be found in this document in sections on construction, feedlots, fertilizer use, land-applied manure, land-applied municipal and industrial byproducts, mining, and urban runoff.

Cleanup – There is no cleanup program associated with agricultural runoff, unless the source of runoff is regulated through a NPDES permit.

Control – Historically, nonpoint pollution has not been directly regulated, though implementation of Total Maximum Daily Loads (TMDLs) would alter this (http://www.epa.gov/owow/tmdl/). For each pollutant that causes a water body to fail state water quality standards, the federal Clean Water Act requires the MPCA to conduct a TMDL study. A TMDL study identifies both point and nonpoint sources of each pollutant that fails to meet water quality standards. Rivers and streams may have several TMDLs, each one determining the limit for a different pollutant. The Clean Water Act requires states to publish, every two years, an updated list of streams and lakes that are not meeting their designated uses because of excess pollutants. The list, known as the 303(d) list, is based on violations of water quality standards and is organized by river basin (http://www.pca.state.mn.us/water/tmdl.html#rulemaking). Minnesota has prepared a list of impaired waters (http://www.pca.state.mn.us/water/pubs/tmdl-list98.pdf). MPCA's innovation program seeks to promote greater use of Environmental Management Systems (EMSs) in agriculture. This is a two-pronged effort. On one track, the agency will be promoting and piloting EMS-based programs with producers and processors, and their associations and cooperatives. On the other track, MPCA seeks to strengthen market, lending, and insurance incentives for producers and processors to implement EMS, prevention, and sustainability approaches. With the Multi-State Working Group (MSWG) on Environmental Management Systems (http://www.iwrc.org/mswg/), the MPCA co-hosted a discussion of the potential for the expanded use of EMS and related tools in agriculture in March 2001. MPCA staff and MSWG members developed a survey of EMS-related activities in agriculture and agribusiness (http://www.iwrc.org/mswg/emsfac.doc). One of the activities outlined in the linked document above is the United Egg Producers initiative under EPA's Project XL. MPCA is working with some Minnesota facilities as part of the egg producers pilot (http://www.epa.gov/projectxl/uep/index.htm). Activities that would be included in EMS promotion include feedlots, fertilizer use, land application of manure, pesticide use, and streambank erosion. Some runoff is regulated indirectly through other programs, such as land application of manure. Some agricultural facilities, such as manufacturers of pesticides and fertilizers, are regulated through National Pollution Discharge Elimination System (NPDES) permits.

Prevention – MPCA's innovation program seeks to promote greater use of EMSs in agriculture (See discussion above under Control). The second phase of Clean Water Partnership (CWP) projects involve putting in place best management practices (BMPs), including sedimentation ponds, manure management, conservation tillage, terraces, new ordinances, wetland restoration, fertilizer management, education or other methods designed to reduce nonpoint-source pollution. Many of these BMPs are more correctly classified as control activities. FANMAP, a program administered through the Minnesota Department of Agriculture (MDA), is designed to educate farmers in sensitive hydrologic environments about assessing nutrient and pesticide needs (http://mrbdc.mankato.msus.edu/inventory/state/sbmp.html; http://www.mda.state.mn.us/appd/1999acpp.pdf). Preventive activities are described in sections on feedlots, fertilizer use, land-applied manure, pesticide use, and streambank erosion.

Education – MPCA's innovation program seeks to promote greater use of EMSs in agriculture (See discussion above under Control). Education activities are further described in sections on Fertilizer use and Land-applied manure.

Agriculture

Stressors Included: Habitat modification, Particles in air, Odorous chemicals from biological processes, Temperature increase/climate change

Impact Categories: Terrestrial Organisms, Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Quality of Life-Aesthetics

Agriculture includes a range of activities, including manure management, fertilizer and pesticide application, cultivation, crop management, etc. Many of these activities are discussed in other sections of this document (Agricultural runoff; Drainage and channelization; Feedlots; Fertilizer use; Land-applied manure; Pesticide use). These activities were combined because we felt it would be cumbersome to list each agricultural activity. Comments in EIR matrices may identify specific sources that are important for a particular stressor. The primary habitat impact from agriculture will be from crop growth. Because grasslands typically occur on well-developed soils and gentle terrain, they are prime spots for crop production. Sites that are not converted for crop production are highly desired as grazing land for livestock production. Crop production destroys grassland habitats while overgrazing degrades these habitats, allowing the invasion of exotic and early succession stage species. The net result is habitat that no longer supports the diversity of vertebrates that they once did (http://www.orst.edu/instruct/fw251/notebook/habitat.html). Agriculture affects wildlife by reducing and isolating natural habitat. Often all that remains of natural habitat in heavily farmed areas are scattered remnant patches, wet depressions, and linear strips lost in a sea of cropland (http://res2.agr.ca/london/gpres/report/rep19sum.html; http://www.sierraclub.org/habitat/report/habitatloss.asp). Another affect of crop production involves global climate change, which is primarily associated with release of nitrous oxide from fertilizer. The primary human health effects are related to air quality. A variety of agricultural activities impact air quality, including release of ammonia from manure and commercial fertilizers, release of fugitive dust (air particles), and release of pesticides associated with particles.

Cleanup – Minnesota Statute 116.07 subd. 7(p) requires that 75% cost-share funding be available before the Minnesota Pollution Control Agency (MPCA) may take enforcement action against any feedlot operation (http://www.mda.state.mn.us/feedlots/assessment.pdf). Other cleanup programs for agricultural activities occur within the Minnesota Department of Agriculture (MDA), although many of these programs are more accurately defined as affecting unpermitted waste disposal. These programs do not directly impact air emissions, although contaminated soils may act as sources for air releases (http://www.mda.state.mn.us/incidentresponse/default.htm).

Control – Chapter 7020.0200 governs the storage, transportation, disposal, and utilization of animal manure and process wastewaters and the application for and issuance of permits for construction and operation of animal manure management and disposal or utilization systems for the protection of the environment. This Chapter does not preempt the adoption or enforcement of zoning ordinances or plans by counties, townships, or cities (http://www.revisor.leg.state.mn.us/arule/7020/0200.html). Chapter 7020.2002 states that the owner of an animal feedlot is exempt from the state ambient air quality standards during the removal of manure from barns or manure storage facilities pursuant to the limitations in Minnesota Statutes, section 116.0713, paragraphs (b) and (c). Nothing in this part limits the emergency powers authority of the MPCA in Minnesota Statutes, section 116.11. The operator of a livestock production facility that claims exemption from the state ambient air quality standards shall notify the commissioner or county feedlot pollution control officer (http://www.revisor.leg.state.mn.us/arule/7020/2002.html). Chapter 7020.2010 discusses transportation of manure but does not specifically mention air quality (http://www.revisor.leg.state.mn.us/arule/7020/2010.html). Similar language exists for construction of manure storage structures, manure stockpiling, and land-applied manure (http://www.revisor.leg.state.mn.us/arule/7020/). Minnesota Statutes, Section 18C.121, regulate the design, construction, repair, alteration, location, installation, and operation of agricultural anhydrous ammonia systems with product used or intended for use as a fertilizer (http://www.revisor.leg.state.mn.us/arule/1513/0010.html). In December 1979, the MPCA adopted rules which allow counties to process MPCA feedlot permit applications for feedlots under 1,000 Animal Units (AU)(2,500 adult hogs). The county must forward applications to MPCA to process for feedlots over 1,000 AU (http://www.ctic.purdue.edu/Core4/Nutrient/ManureMgmt/Paper20.html). Many BMPs can be implemented to control odors, including use of odor over-riding chemicals and adsorption of odors (http://www.bae.umn.edu/extens/aeu/aeu8.html). Local ordinances may control release of odors or other agricultural air emissions. Minnesota Statutes 2000, Chapter 103C, describes powers of soil and water conservation districts. The Conservation Districts have broad authority regarding agricultural activities that may impact habitat modification (http://www.revisor.leg.state.mn.us/stats/103C/331.html).

Prevention – Wildlife diversity is diminished by agriculture, but a number of activities may decrease this effect. These include land application of manure or other organic matter, reducing field size and incorporating areas of noncultivated land, limiting grazing activities in noncultivated fields, reducing tillage, planting crops that are more desirable for birds, increasing edge habitat, promoting forest instead of herbaceous plants at field edges, decreased mowing and burning, conservation tillage, use of border fences and posts, a buffer zone for spraying adjacent to field edges, and use of timothy/clover instead of alfalfa (http://res2.agr.ca/london/gpres/download/rep1_9.pdf). Historically, conservation efforts in agricultural have focused on improving crop production. While some of these efforts improve wildlife diversity, increasing diversity is rarely an objective of agricultural management. USDA supports research to understand how community composition and structure relate to function and sustainability. Specific research needs are to understand the interaction of the biological community, including its environment, and to identify sustainable management practices for forest, range, crop, and aquatic ecosystems (http://www.usda.gov/oce/sdsf2/sdhome.htm; http://www.nnic.noaa.gov/CENR/agnew.html). Several references to prevention or reduction of odors from feedlots can be found at http://www.4cleanair.org/members/committee/agriculture/BMPs.PDF. Many odor-control BMPs qualify as controls, but some activities may be considered preventive. Examples of BMPs include proper maintenance of animal-holding structures, care of animals including dead animals, proper care of feed, use of manure pits beneath barns, dust suppression, and complete combustion for incineration activities. These activities reduce or prevent odors, but not the waste that generated the odor. The University of Minnesota (U of M) is the lead organization dealing with prevention of odors from manure operations (http://www.bae.umn.edu/extens/manure/odor/index.html; http://www.bae.umn.edu/extens/aeu/aeu8.html). The MPCA has established reduction goals for air particulates (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). Additional information about prevention efforts in agriculture can be found in this document in sections on drainage and channelization, agricultural runoff, fertilizer use, land-applied manure, and pesticide use. Activity that results in use of less chemical or reduction of erosion could be classified as prevention.

Education – There are many educational web sites that provide information on habitat destruction. Many of these do not directly relate to agriculture, but the activities and information provide students with tools for understanding environmental consequences of habitat modification (http://www.nwf.org/education/; http://www.usda.gov/news/usdakids/index.html; http://www.nwf.org/kids/; http://exchanges.state.gov/forum/journal/env1internet.htm; http://www.epa.state.il.us/kids/teachers/books.html; http://www.enc.org/resources/records/0,1240,013466,00.shtm). Other information about education efforts in agriculture can be found in sections on drainage and channelization, agricultural runoff, fertilizer use, land-applied manure, and pesticide use. We did not identify educational activities related to control of emissions from manure.

Aircraft

Stressors Included: Noise

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Quality of Life-Aesthetics

Aircraft contribute to off-road air emissions. They were considered a significant source of noise and added as a separate source for Noise.

Cleanup – none

Control – The Federal Aviation Administration (FAA) has source regulations for commercial jet engines. All commercial jet engines must meet noise emission criteria prior to being certified for flight. 14 CFR Part 150 provides a means for airports to accomplish comprehensive noise reduction goals. Part 150 is a federal program appropriating aviation-generating funds for the purpose of aircraft noise mitigation measures in communities surrounding an airport (including sound insulation). Currently Minneapolis-St. Paul (MSP) appropriates millions of dollars annually for the Residential Sound Insulation Program. However, the ability for an airport authority to use Part 150 funds or any aviation generated funds for the purpose of noise mitigation hinges upon completion and federal acceptance of approved noise mitigation measures proposed in a Part 150 study. The Part 150 Process provides airport operators with the procedures, standards and methodology governing the development, submission and review of airport Noise Exposure Maps (typically referred to as noise contours) and airport Noise Compatibility Programs. The PCA adopts standards describing the maximum levels of noise in terms of sound pressure level that may occur in the outdoor atmosphere. Standards give due consideration to such factors as the intensity of noises, the types of noises, the frequency with which noises recur, the time period for which noises continue, the times of day during which noises occur, and such other factors as could affect the extent to which noises may be injurious to human health or welfare, animal or plant life, or property, or could interfere unreasonably with the enjoyment of life or property (http://www.revisor.leg.state.mn.us/stats/116/07.html; http://www.pca.state.mn.us/programs/pubs/noise.pdf).

Prevention – The following measures comprise MSP's current approved Noise Compatibility Program (http://macavsat.org/noise_info/index.htm).

- Voluntary Noise Budget Program - The MAC has adopted a phased-in noise budget ordinance for MSP in April 1987.
- Voluntary Nighttime Limits on Flights
- Nighttime Powerbacks
- Engine Run-up Field Rule
- Training Restriction - The major carriers at MSP have agreed not to conduct training operations at MSP. No other carriers conduct training flights at MSP at this time.
- Operating Procedures agreed to by the major carriers at MSP.

Education - none

Area Source Combustion

Stressors Impacted: Particles in air, Ground-level ozone, Toxic organic chemicals, Nitrogen

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

We define area sources as a collection of similar emission units within a geographic area. Commonly, area sources have been defined at the county level, and most area source methods are designed to estimate area source emissions at the county level. Area sources collectively represent individual sources that are small and numerous and that have not been inventoried as specific point, mobile, or biogenic sources. Individual sources are typically grouped with other like sources into area source categories. These source categories are grouped in such a way that they can be estimated collectively using one methodology (http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii01_apr2001.pdf). Area source combustion includes prescribed burns, wildfires, residential open burning, wood combustion, solvent use, product storage and transport distribution (e.g. gasoline), light industrial sources, agriculture (feedlots and crop burning), waste management (landfills), and other small sources (http://www.tnrcc.state.tx.us/air/aqp/pollsource.html#Area). The contribution of each source is not well understood. Additional information on area sources can be found at http://www.epa.gov/ttn/chief/eiip/techreport/volume03/.

Cleanup – none identified, although limited cleanup may be conducted through programs that work within the sources contributing to area source combustion.

Control – There is no agency having a specific program that deals with just area sources. Some of the area sources are addressed through agency programs. The following discussion addresses individual area sources. The source of information for much of this is http://www.epa.gov/ttn/chief/eiip/techreport/volume03/. For most of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) affecting larger groups of facilities, such as Chrome, Halogenated Solvents, Printing (Litho and Flexo), Degreasing, Dry Cleaning, Styrene and Boatbuilding, there is an effort made by NESHAPs, Small Business Assistance Program (SBAP), Small Business Environmental Improvement Loan, and Pollution Prevention (P2) staff (coordinating with MnTAP) to conduct outreach and assistance before the implementation dates of the new standards. This effort seeks to get enough implementation to get sources out of the standard altogether, or if unavoidable, to enhance on-time compliance.

Wood burning: The Clean Air Act Amendments of 1990 required that all areas in the country achieve the National Ambient Air Quality Standards (NAAQS) for PM10 by December 31, 1994. The EPA published technical guidance for reasonably available control measures and Best Available Control Measures (BACM) for control of particulate matter (PM) from woodstoves to achieve this goal of reducing PM10 emissions. Those areas that do not achieve PM10 attainment by December 31, 1994, must apply BACM and develop a plan to meet the NAAQS by December 31, 2001. The only exceptions are those areas that were reclassified as serious after 1990; these areas must attain the NAAQS for PM10 no later than the end of the tenth calendar year after the area's designation as nonattainment. The best available control measure requirements include combinations of the following control measures: the use of new technology woodstoves, improvements in wood burning performance (e.g., control of wood moisture content, weatherization of homes), the use of "no burn" days, public awareness and education programs, replacement or installation of gas-burning equipment in fireplaces, and total banning of burning. The use of these BACM will reduce volatile organic compound (VOC), hazardous air pollutants (HAPs), carbon monoxide, and PM for measures that result in efficient wood combustion. Use of BACM will reduce nitrous oxide for measures that reduce the occurrence of combustion. The MPCA recently provided economic incentives to upgrade wood-burning stoves and fireplaces to newer, more efficient systems.

Dry Cleaning: Under the NESHAP program, the EPA has passed regulations that require the control of emissions for dry cleaning units using perchloroethylene. The NESHAP includes the required use of refrigerated condensers, leak detection, seal inspection programs, and monitoring and reporting requirements. Coin-operated dry cleaning units are exempt from all but the initial reporting NESHAP requirements. Dry cleaning with petroleum solvents was regulated under NESHAP beginning in 2000. NESHAP requirements are administered through the MPCA (http://www.pca.state.mn.us/air/index.html).

Architectural Surface Coating: The EPA is using regulatory negotiation to prepare a national rulemaking for controlling VOC emissions from architectural and industrial coatings. Currently, no federal EPA regulations are in place to limit VOC content or VOC emissions from architectural surface coatings.

Consumer and Commercial Solvent Use: In a March 23, 1995, Federal Register (FR) notice, the EPA identified 24 consumer product subcategories scheduled for development of federal regulations (60 FR 15264). As individual products and categories are further assessed, the EPA reserves the right to remove categories from or add categories to the list.

Solvent Cleaning: In 1994, a NESHAP was promulgated to regulate HAP emissions from halogenated solvent cleaning machines. The halogenated solvent cleaning NESHAP, promulgated in December 1994 (59 FR 61801, December 2, 1994), established standards for both area and major sources of solvent cleaners using HAP solvent.

Pesticide applications (agricultural and non-agricultural): Currently there are no federal or state regulations limiting air emissions from pesticide applications.

Gasoline Marketing: Stage I controls have been implemented in some areas, both attainment and nonattainment. Stage II controls are currently not widely implemented, but are required in some ozone nonattainment areas as defined by the 1990 Clean Air Act.

Municipal Landfills: Air quality standards and regulations that affect municipal solid waste landfill facility operations are New Source Performance Standards and Emissions Guidelines. The Standards of Performance for New Municipal Solid Waste Landfills, 40 Code of Federal Regulations (CFR) part 60, Subpart WWW are federal regulations affecting air emissions for new landfills or landfills that began construction, modification, or reconstruction on or after May 30, 1991. The Emission Guidelines required States to develop State plans to regulate existing landfills that began construction before May 30, 1991 and that have accepted waste since November 8, 1987, or have capacity to accept additional waste. The Emission Guidelines are contained in 40 CFR part 60 Subpart Cc. As of December 1999, existing landfills throughout the United

States were covered by either approved State plans that implement and enforce the Emission Guidelines, or by the Federal plan in 40 CFR part 62, Subpart GGG (see 40 CFR part 62 for a list of approved State plans). In late 2000, EPA expects to propose national emission standards for hazardous air pollutants from landfills. The proposed rule contains the same requirements as the Emission Guidelines and New Source Performance Standards.

Open burning: A variety of sources are included under open burning. Open burning is banned in many locations. Control in other areas are largely regulated to technologies designed to increase burning efficiency.

Residential and commercial coal combustion: This source category covers air emissions from coal combustion in the residential and commercial sectors for space heating or water heating. This category includes small boilers, furnaces, heaters, and other heating units that are not inventoried as point sources. Residential and commercial coal combustion sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and federal, state, and local government institutions (e.g., military installations, prisons, office buildings). No regulatory controls were identified.

Hexavalent Chromium: On January 25, 1995, the US EPA finalized regulations known as the NESHAP for Chromium Emissions from Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks (http://www.epa.gov/ttn/atw/chrome/chromepg.html). Major sources should already have submitted Part 70 air emissions permit applications. Area sources are currently deferred from Part 70 air emissions permit requirements. Permanent exemptions from Part 70 permits are granted for area sources with decorative chrome electroplating and chrome anodizing tanks that use fume suppressants, and decorative chrome electroplating tanks that use a trivalent chromium bath with a wetting agent incorporated into the bath (http://www.pca.state.mn.us/air/pubs/5-07.pdf).

Prevention – Prevention consists of decreasing the quantity or toxicity of materials used or generated in processes associated with these sources, or substituting less toxic inputs. MPCA's permitting process does not include incentives for prevention. Many businesses use prevention principles because they realize reduced regulatory burden with decreased volume or toxicity of regulated substances used or generated. MPCA SBAP provides regulatory and technical assistance to promote preventive approaches. MnTap works with private businesses to incorporate pollution prevention practices. Trivalent chrome can sometimes be used in place of hexavalent chromium. Water reuse can be maximized. Other additives can be reused or substituted to decrease toxicity or corrosivity of discharge to publicly owned wastewater treatment plants (http://www.mntap.umn.edu/). The MPCA has established reduction goals for air particulates and chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). Additional information on prevention can be found in this document in sections on agricultural sources, fertilizer use, land-applied manure, on-road vehicles, pesticide use, unpermitted waste disposal, and waste incineration.

Education – Education activities are associated with some area combustion sources. See sections on feedlots, fertilizer use, land-applied manure, on-road vehicles, pesticide use, unpermitted waste disposal, and waste incineration.

Coal-fired power plants

Stressors Included: Particles in air, habitat modification, ground-level ozone, nitrogen, toxic metals, temperature increase/climate change, other criteria pollutants in air, toxic chemicals in food, acid deposition.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Coal-fired power plants directly impact human health through the emission of toxic chemicals, particulate matter, and other chemicals such as sulfur dioxide. Coal-fired power plants also impact aquatic and terrestrial ecosystems by contributing to acid rain, air deposition of toxic chemicals, and climate change. Climate change, in turn, can result in habitat modification. Environmental impacts from coal-fired power plants were deemed significant enough to separate them from other industrial sources. This section discusses air quality aspects of coal combustion. Other aspects of coal combustion, such as generation of byproducts, including ash, and thermal discharge, are covered in other sections of this document.

Cleanup – none identified.

Control – Coal-fired power plants are not regulated as an individual entity, but are regulated through MPCA Air Quality programs. Air permits are required for coal-fired power plants, as specified in FCR, Title 40, Part 70 (http://www.revisor.leg.state.mn.us/arule/7007/0200.html). A permit includes a description of the source's processes and products (by Standard Industrial Classification Code or SIC Code), information about fugitive emissions, identification and description of each emission point in sufficient detail to verify the applicability of all applicable requirements, specification of the potential emissions from the source, emission limits that will be imposed on the source by applicable requirements, information on actual emissions for the preceding calendar year, actual emission rates of criteria pollutants, and actual emission rates of each hazardous air pollutant. The MPCA has authority to craft permit conditions to prevent pollution and to protect human health and the environment, although the requirements do not specifically exist in rule [Minn. Stat.§ 116.07, subd. 4a and Minn. R. 7007.0800, subp. 2.]. The general permitting rule also authorizes the MPCA to craft permit conditions that protect human health and the environment [Minn. R. 7001.0150, subp. 2.] (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-k.pdf). The primary MPCA activity that serves to reduce toxic emissions from a stationary source (e.g. coal-fired power plants) is the implementation of the federal NESHAP program. The MPCA has adopted 22 of the NESHAPs into state rule. For air particulates, Section 109 of the Clean Air Act defines primary NAAQS as allowing an adequate margin of safety to protect the pubic health. This is generally believed to mean that the standards would be set at a concentration below the threshold. However, the preamble of the final rule for the 1997 particulate matter standard (62

FR 38651) states that the Administrator isn't required to first identify a threshold and then set the standard somewhat lower than the threshold. In 1997, EPA selected 15 µg/m3 as the average annual PM2.5 NAAQS, in part, because solid evidence of a threshold lower than this did not exist. For criteria air pollutants, the EPA set NAAQS. Minnesota has, in some cases, established standards that are more stringent than EPA standards. The Clean Air Act also requires EPA to periodically review the state of the science for criteria pollutants and revise the standards if warranted. The ozone and PM2.5 standards were revised most recently (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-c.pdf).

Prevention – Possible MPCA activity in prevention could include promotion of demand side energy use reduction techniques and programs, and on the supply side, use of "clean" coal and coal cleaning techniques. The MPCA has established reduction goals for air particulates and chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items.

Education - The primary education tool for toxic chemicals is adoption of the NESHAPs into state rule. Coal-fired power plants, however, have not yet been included.

Construction

Stressors Impacted: Transported sediment.

Impact Categories: Aquatic Organisms, Quality of Life-Aesthetics

Construction activities result in erosion. Eroded sediment impacts aquatic ecosystems and aesthetic quality of surface waters.

Cleanup – Under the permitting process, permitted parties are required to take certain corrective actions when sediment is transported off a construction site (http://www.pca.state.mn.us/water/pubs/sw-cpermit.pdf).

Control – Minnesota Statutes Chapters 115 and 116, as amended, and Minnesota Rules Chapter 7001, provide a permitting process (Phase I) that establishes conditions for discharging storm water to waters of the state from construction activities which disturb five or more acres of total land area (http://www.pca.state.mn.us/water/pubs/sw-cpermit.pdf). Anyone conducting a construction activity, including clearing, grading and excavating, which results in the disturbance of five or more acres of land, is required to apply for coverage under the General Storm-Water Permit for Construction Activity. Such activities may include (but are not limited to) road building and construction of residential houses, office buildings, industrial or commercial buildings, landfills, airports, and feedlots. There are two main permit requirements that are important to successful erosion and sediment control on a project

1. The Temporary Erosion and Sediment Control Plan. The goal of this plan is to prevent erosion from occurring and keep sediment on site during active construction.
2. The Permanent Erosion and Sediment Control Plan. The goal of this plan is to minimize long-term erosion and manage storm-water runoff discharging from the project's ultimate impervious surface after construction is complete (http://www.pca.state.mn.us/water/stormwater-c.html). Local ordinances may exist.

The Phase II program expands the Phase I program by requiring operators of small construction sites, through the use of NPDES permits, to implement programs and practices to control polluted storm water runoff (http://www.pca.state.mn.us/publications/wq-sw1-02.pdf). Construction activity disturbing less than one acre, and any other storm water discharges, can be designated for coverage if the NPDES permitting authority or EPA determines that storm water controls are necessary. Site activities disturbing less than one acre are also regulated as small construction activity if they are part of a larger common plan of development or sale with a planned disturbance of equal to or greater than one acre and less than five acres (http://www.pca.state.mn.us/publications/wq-sw1-05.pdf).

Prevention – Although Phase I construction general permits and Phase II small construction permits require the development and implementation of a Storm Water Pollution Prevention Plan, the Best Management Practices (BMPs) employed are properly categorized as control measures, since they are intended to control loss of sediment. The objective is to minimize the discharge of pollutants from the site (http://www.pca.state.mn.us/publications/wq-sw1-05.pdf). Many municipalities implement a Good Housekeeping program. The goal is to prevent or reduce pollutant runoff from municipal operations, and typically involves municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning). Regulatory review, inspections and enforcement of these plans is limited. Further pollution prevention measures are found at http://www.pca.state.mn.us/water/pubs/swm-ch7.pdf. Other preventive activities include use of certain types of construction materials (to minimize erosion loss) and long-term maintenance after construction is completed (http://www.ieca.org/; http://128.241.229.74/public/articles/index.cfm?cat=24; http://es.epa.gov/ncer/final/grants/96/wwshed/reice.html).

Education – Education is considered a component of an NPDES Phase II permit, but few educational activities are currently practiced (http://www.pca.state.mn.us/water/pubs/sw-npdes2-01.pdf). Most activities described as educational are more accurately defined as preventive or control measures. Training is an example (http://128.241.229.74/public/articles/index.cfm?cat=24).

Drainage and channelization

Stressors Included: Habitat modification.

Impact Categories: Aquatic Organisms

Drainage includes any activity that results in removal of surface water. This definition makes no distinction between surface waters and therefore includes activities designed to remove temporary water. Considering impacts to the environment, drainage is most important for water bodies classified as public waters, as defined by the Minnesota Department of Natural Resources (DNR). Channelization includes a variety of activities that change the physical features of a surface water body.

Cleanup – Cleanup entails restoration of a water body. Chapter 354 of Minnesota Statutes provides for mitigation of drained or filled wetlands, allows local units of government administrative authority, and authorizes the Minnesota Board of Soil and Water Resources (BWSR) to adopt rules and acquire permanent easements for Type 1, 2, and 3 wetlands. The basis for civil restoration order is contained in Minnesota Statute 105.461 and 105.462. The basis for injunctive relief is contained in Minnesota Statute 105.55.

Control

General: Control of water bodies affected by drainage, channelization, or other modification are regulated by a variety of agencies, principally the Minnesota DNR, Army Corps of Engineers, and Board of Water and Soil Resources (BWSR). Environmental Impact Statements (EIS) and Environmental Assessment Worksheets (EAW) are required for a variety of projects and activities that potentially impact water bodies. These include activities related to drainage, channelization, or other modifications (http://www.revisor.leg.state.mn.us/arule/4410/). The Environmental Quality Board ultimately oversees implementation of this rule, although local government units have a large role in implementation. There are, however, numerous exemptions to these requirements. For example, any stream diversion or channelization within the right-of-way of an existing public roadway associated with bridge or culvert replacement is exempt (http://www.revisor.leg.state.mn.us/arule/4410/4600.html). The DNR's Water Permits Unit oversees the administration of the Public Waters Work Permit Program that regulates water development activities below the Ordinary High Water Level (OHWL) in public waters and public waters wetlands. Examples of development activities addressed by this program include filling, excavation, shore protection, bridges and culverts, structures, docks, marinas, water level controls, dredging, and dams (http://www.dnr.state.mn.us/waters/programs/water_mgt_section/pwpermits/progdesc.html).

Public waters (including wetlands): Under Minnesota Statute103G.245, Subdivision 1 (except as provided in Subdivisions 2, 11, and 12), the state, a political subdivision of the state, a public or private corporation, or a person must have a public waters work permit (application available under DNR Waters Forms) to do the following: 1) construct, reconstruct, remove, abandon, transfer ownership of, or make any change in a reservoir, dam, or waterway obstruction on public waters; or 2) change or diminish the course, current, or cross section of public waters, entirely or partially within the state, by any means, including filling, excavating, or placing of materials in or on the beds of public waters. No permit is required for beach sand blankets, rock riprap (for shore protection), streams with a watershed less than 5 square miles (3,200 acres), debris removal, repair of public drainage systems, seasonal docks and floating structures, permanent docks (on lakes only), privately owned boat ramps, publicly owned boat ramps, water level control structures (on streams only), low water ford crossings (on streams only), temporary bridges (on streams only), maintenance of storm sewers, agricultural drain tile, and ditch outlets, and installation of agricultural drain tile outlets. The basis for criminal prosecution is contained in Minnesota Statute 105.463 and 105.541 (http://www.dnr.state.mn.us/waters/programs/water_mgt_section/pwpermits/permit_requirements.html).

Wetlands: Public waters wetlands are protected under state laws governing all public waters. Under Minnesota Statutes Section 103G.005, Subd. 18, they are defined as "all types 3, 4, and 5 wetlands, as defined in United States Fish and Wildlife Service Circular No. 39 (1971 edition) . . . that are ten or more acres in size in unincorporated areas or 2-1/2 or more acres in incorporated areas. Public waters wetlands were inventoried during the 1980s by the DNR. The boundaries of such wetlands (and other water basins and watercourses like lakes and rivers) are set at the OHWL, as defined in Minnesota Statutes Section 103G.005. Wetlands protected under the Wetland Conservation Act are delineated according to the United States Army Corps of Engineers Wetland Delineation Manual (January 1987), pursuant to Minnesota Statutes Section 103G.2242, Subd. 2, except those which are public waters wetlands regulated under Minnesota Statutes Section 103G.005 Subd. 18 (http://www.dnr.state.mn.us/waters/wetlands/index.html). Exemptions apply for some types of land use and for wetlands smaller than the minimum regulatory requirements. Each Chippewa Band and Sioux Community makes its own land management decisions and policies on reservation lands, since their jurisdictions are separate from the State of Minnesota. In 1993, the legislature passed Chapter 175, which allowed counties or watersheds that had 80 percent or more of the presettlement wetlands remaining to mitigate for draining or filling on a 1-to-1 acre basis. The law created a deminimis exemption of up to 400 square feet of wetland area. In addition, BWSR adopted rules under the 1991 Wetland Conservation Act. In 1994, the legislature passed Chapter 627, which allowed local governments some flexibility in adopting a comprehensive wetland management plan that could substitute for parts of the BWSR rule on wetlands. It also allowed existing roadways to be upgraded to current construction and safety standards if wetland impacts were minimized and less than 2 acres of wetland was affected. In 1996, the legislature passed Chapter 462, which amended the Wetland Conservation Act to provide a more streamlined notification process. Exemptions were reformatted for easier interpretation with expansion of exemptions covering agricultural land, individual sewage treatment systems, wildlife habitat improvement projects, drainage, and deminimis. The 1996 amendments provided that local governmental units may develop Local Comprehensive Wetland Protection and Management Plans as an alternative to the state rules with flexibility in the application of sequencing standards, replacement standards, and certain exemptions. Changes in 1996 also amended the requirements for public road project replacement, including the provision that the BWSR will replace wetlands drained or filled from the repair, reconstruction, or rehabilitation of existing local government public roads. In 2000, the legislature passed Chapter 382 (Senate File 83) which amended parts of Minnesota Statutes 1998, section 103G in order to consolidate state wetland laws. The law was changed to maintain wetland protection to current standards, to better coordinate with federal wetland programs, and to simplify and make wetland regulation consistent for landowners. Specific details of the bill included the refinement of the Public Waters Inventory, established a consistent statewide definition of wetland, gave state conservation officers enforcement flexibility in pursuing Wetland Conservation Act and DNR violations, standardized wetland replacement/mitigation standards among state wetland agencies, and added an appeals process for landowners to challenge a wetland boundary or type determination.

Prevention – The 1976 public waters inventory included the establishment of a state Water Bank Program to compensate rural landowners who intended to drain wetlands for agricultural purposes. Under Minnesota Statutes, Section 105.492, a wetland qualified for compensation if drainage was lawful, feasible, and practical and, if drained, the wetland would provide high-quality cropland. In addition, the 1979 Minnesota Legislature enacted a system of wetland tax exemptions and credits to encourage wetland owners to maintain their natural wetlands (Laws of Minnesota, 1979, Chapter 303). The Minnesota Wetlands Conservation Plan was developed by several interested parties, in conjunction with several state agencies, to guide stewardship of wetlands. An important goal of this effort is to ensure wetland preservation (http://www.dnr.state.mn.us/fish_and_wildlife/wetlands/wetland.pdf).

Education - The Minnesota Wetlands Conservation Plan, developed by several interested parties in conjunction with several state agencies, developed a list of education goals and strategies for informing various audiences about wetlands (http://www.dnr.state.mn.us/fish_and_wildlife/wetlands/wetland.pdf). The Environmental Quality Incentives Program (EQIP), operated by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) in Minnesota and the University of Minnesota Extension Service (UMES), provides agricultural producers and agricultural professionals with education on conservation practices (http://www.extension.umn.edu/mnimpacts/impact.asp?projectID=1029). There are a wide variety of environmental education organizations that focus on wetlands, but not specifically on drainage and channelization (http://facweb.stvincent.edu/academics/environment/wetlandtours.html; http://www.lwv.org/where/protecting/webwalk/; http://www.montana.edu/wwwwet/;

http://www.montana.edu/wwwwater/publications/module.html; http://www.ducks.ca/edu/resource.html).

Dredging

Stressors Included: Habitat modification.

Impact Categories: Aquatic Organisms

The section of this document dealing with drainage and channelization provides a summary of activities related to modification of water bodies, including dredging. In general, EIS are required for most dredging operations. Regulatory authority is distributed among the Minnesota DNR, Army Corps of Engineers, and Minnesota BWSR.

Ethanol production

Stressors Included: Odorous chemicals from biological processes

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Quality of Life-Aesthetics

Ethanol is a gasoline additive that reduces air pollution. There are 14 ethanol plants in Minnesota. Residents near these plants occasionally comment on a distinctive yeasty odor, some reporting it as unpleasant. In 2001, Senators Tom Daschle (D-SD) and Richard Lugar (R-IN) introduced bipartisan legislation that would triple the nation's use of ethanol over the next decade, reducing the nation's dependence on foreign oil. Daschle's and Senate Agriculture Committee Chairman Lugar's bill increases demand for ethanol, a clean-burning renewable fuel, through the creation of a nationwide Renewable Fuels Standard (RFS), and it allows states to address serious groundwater contamination problems by phasing out MTBE – or methyl tertiary butyl ether – over the next four years. The bill will also reduce emissions of greenhouse gases, diversify our domestic liquid fuels production base, and promote investment and job creation in rural communities (http://www.senate.gov/~daschle/pressroom/releases/01/04/2001402515.html).

Cleanup – none

Control – An air quality permit is required before an ethanol plant begins production. The permit sets state and federal limits on the amounts of certain air pollutants that may be emitted from a facility (http://www.pca.state.mn.us/hot/gopherstate/). Minnesota had an "odor rule" until November 1996. The odor rule was repealed because it relied on an outdated test method and there was no better test method available. Although Minnesota Statutes mention odor (116.061), the statute's context is that of the responsibility of a business to notify the MPCA of "excessive" or "unpermitted" emissions that are "obnoxious" "public nuisance" and eliminate those emissions. There are no quantitative values to determine obnoxiousness or nuisance level. Since the odor rule was repealed, the MPCA's policy has been to refer cases of odor to cities to be handled as local nuisances under their regulatory authority, unless the MPCA can directly tie the odor to a violation of a standard or exceedance of a health risk level of a known chemical. MPCA can amend existing permits. Amendments fall into two categories: minor, which involve impact on the environment; and major, which involve more impact on the environment or make significant changes to an existing permit. Technological controls may alleviate odor problems associated with ethanol production, including eliminating drying wet corn and thermally oxidizing the odorous gases created during the drying process.

Prevention – Ethanol is intended to decrease the United State's dependency on foreign oil and will reduce consumption of fossil fuels and discharge of greenhouse gases. Use of ethanol is therefore a prevention mechanism in itself. Activities designed to control odors resulting from ethanol production are more appropriately labeled as control activities.

Education – None identified.

Feedlots

Stressors Included: Odorous chemicals from biological processes, toxic chemicals in water, ammonia, phosphorus, oxygen-demanding pollutants, nitrogen, pathogens in water, acid deposition.

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Animal feedlot means "a lot or building or combination of lots and buildings intended for the confined feeding, breeding, raising, or holding of animals and specifically designed as a confinement area in which manure may accumulate, or where the concentration of animals is such that a vegetative cover cannot be maintained within the enclosure. For purposes of these parts, open lots used for the feeding and rearing of poultry (poultry ranges) shall be considered animal feedlots. Pastures shall not be considered animal feedlots under these parts" (http://www.revisor.leg.state.mn.us/arule/7020/0300.html). Feedlots have a variety of impacts on the environment, including emission of gases that may impact health or create odors, nutrient and sediment loading of surface water, and ground water contamination. In this section, we include facilities that are regulated by the MPCA, MDA, or a local agency, plus animal manure storage facilities that are unregulated. Unregulated facilities may include a variety of feedlots having unpermitted manure storage systems, and open feedlots.

Cleanup – The MPCA does not administer cleanup at feedlots, but has a number of requirements for feedlot owners. In cases of a spill, feedlot owners are required to report, contain, and clean up the spill (http://www.exnet.iastate.edu/Publications/PM1859.pdf). In cases of feedlot abandonment, MPCA has closure requirements, including removal of contaminated soil and establishment of vegetation at the feedlot http://www.pca.state.mn.us/publications/wq-f6-50.pdf. In cases where a feedlot has high pollution potential, corrective actions may be required. Some feedlots with unpermitted manure areas are required to reconstruct the manure storage area or close and properly abandon the manure area (http://www.pca.state.mn.us/hot/feedlot-rulesataglance.pdf). County feedlot programs are responsible for the implementation of feedlot rules and regulations for feedlots with under 1000 animal units in 53 Minnesota counties, including most of the major feedlot counties (http://www.pca.state.mn.us/publications/wq-f6-51.pdf). A county feedlot program is established by the transfer of regulatory authority from the MPCA to the county. This transfer of authority is granted by statute and it allows the MPCA to "delegate" administration of certain parts of the feedlot program to counties. County feedlot programs have responsibility for implementing state feedlot regulations including registration, permitting, inspections, education and assistance, and complaint follow-up.

Control – Recently revised rules address control measures designed to reduce the risk of environmental contamination from feedlots. These include change of ownership, construction or expansion of feedlots (http://www.pca.state.mn.us/hot/pubs/fl-notice.pdf; http://www.pca.state.mn.us/publications/wq-f6-02.pdf; http://www.pca.state.mn.us/publications/wq-f6-22.pdf; http://www.pca.state.mn.us/publications/wq-f6-32.pdf), new requirements for open lots (http://www.pca.state.mn.us/hot/pubs/fl-cert2005-2010.pdf), operation and maintenance of feedlots (http://www.pca.state.mn.us/publications/wq-f6-21.pdf; http://www.pca.state.mn.us/publications/wq-f6-31.pdf), and requirements for NPDES permits (http://www.pca.state.mn.us/publications/wq-f3-05.pdf). There are also technical requirements established for land-applied manure (http://www.pca.state.mn.us/publications/wq-f8-04.pdf; http://www.pca.state.mn.us/publications/wq-f8-03.pdf), stockpiling of manure (http://www.pca.state.mn.us/publications/wq-f8-06.pdf), use of geosynthetic liners, feedlot management in karst areas, and general management of liquid manure (http://www.pca.state.mn.us/publications/wq-f8-04a.pdf). County feedlot programs are responsible for the implementation of feedlot rules and regulations in 53 Minnesota counties including most of the major feedlot counties (http://www.pca.state.mn.us/publications/wq-f6-51.pdf). A county feedlot program is established by the transfer of regulatory authority from the MPCA to the county. This transfer of authority is granted by statute and it allows the MPCA to "delegate" administration of certain parts of the feedlot program to counties. County feedlot programs have responsibility for implementing state feedlot regulations including registration, permitting, inspections, education and assistance, and complaint follow-up. The MDA licenses commercial animal waste application technicians (http://www.mda.state.mn.us/appd/cawt/default.htm). The MDA certifies manure testing laboratories (http://www.mda.state.mn.us/appd/manurelabs.htm.

Prevention – The role of preventive measures in agricultural operations are being explored, but most technologies and management strategies control contamination of air and water resources. The MPCA and external agencies have been involved in a limited amount of "prevention" activity, including promoting the use of anaerobic digesters which convert manure into electricity and reduce pathogens, composting (which kills pathogens and reduces manure volumes), reduction in concentrations of feed minerals which are not taken up by the animals' physiology ("pass-through"), and use of phytase in livestock diets to reduce phosphorus in excrements. MPCA recently approved a corrective action to reclaim a former prairie pothole that had been converted to a manure lagoon. These technologies are not a focal point of MPCA or county management strategies, which largely focus on controlling the likelihood of contamination. Individual farmers often land apply manure for agronomic benefit. Total confinement feedlots reduce the likelihood of pollution by controlling contact with soil and water, but they do not reduce the amount of waste generated. Dairy inspectors from the Dairy and Food Division of the MDA assist farmers in understanding the feedlot rules and provide them with information on resources for technical and financial assistance. The dairy inspectors and other MDA staff also work with MPCA and delegated county feedlot staff, soil and water conservation districts and other local partners to provide educational materials such as *The Minnesota Livestock Producer 's Guide to Feedlot Rules,* available at http://www.mda.state.mn.us/feedlots/feedlotrulesguide.pdf.

Education – Education is identified as a component of MPCA and county feedlot management. Most efforts labeled as education are training. The U of M, through its extension services, offers both training and education to feedlot owners and staff who work with management of feedlots (http://www.bae.umn.edu/extens/manure/). Similar efforts are conducted by dairy inspectors from the Dairy and Food Division of the MDA (http://www.mda.state.mn.us/feedlots/feedlotrulesguide.pdf).

Fertilizer Use

Stressors Included: Toxic chemicals in water, Nitrogen

Impact Categories: Human Health-noncancer acute, Terrestrial Organisms

Fertilizer use includes both agricultural and urban use. In this section, the primary concerns with fertilizer use are impacts to surface water and ground water.

Cleanup - The MDA is the lead agency for response to, and cleanup of, agricultural chemical contamination (pesticides and fertilizers) in Minnesota. These activities, however, are generally associated with unpermitted disposal or spills. There is no cleanup associated with routine use of fertilizers.

Control - Commercial applicators or authorized agents of applicators must maintain a record of fertilizer applications used on each site and for five (5) years after the date of application (Minnesota Statutes, Chapter 18B.37 and 18C.215) (http://www.mda.state.mn.us/../mdaforms/ag01353categorye.pdf). The Minnesota Fertilizer, Soil Amendment and Plant Amendment Law (Minnesota Statutes, Section 18C.001-18C.575) applies to fertilizer labeling, licensing, storage, facilities, mixing with other products, specialty fertilizers, genetically engineered fertilizers, chemigation, prohibited fertilizer activities, soil and manure testing laboratory certification, reporting, sampling, manure application and certification, and fertilizer distributors (http://www.revisor.leg.state.mn.us/stats/18C/). Minnesota Rules, Parts 1513.0010-1513.1100 apply to storage and handling of anhydrous ammonia (http://www.revisor.leg.state.mn.us/arule/1513/).

Prevention – Many programs exist that provide assistance (technical and financial) for minimizing environmental impacts from fertilizer use, including the Conservation Reserve Program (CRP) (http://www.mda.state.mn.us/crp/), Agricultural BMP loan programs (http://www.mda.state.mn.us/../agbmp/moreinfo.html), sustainable agriculture and integrated pest management programs (http://www.mda.state.mn.us/esap/), the Farm Nutrient Management Assessment Program (FANMAP) (http://www.mda.state.mn.us/appd/1999acpp.pdf), and various other programs funded through USDA, LCMR (Legislative Commission on Minnesota Resources), and wellhead protection (see Summary of Unit Activities section at http://www.mda.state.mn.us/appd/1999acpp.pdf). MPCA water quality permitting staff are collaborating with MnTAP to promote preventative approaches in Phosphorus Management Plans.

Education – Minnesota Statute 18C.432 states the commissioner shall develop, in conjunction with the UMES, innovative educational and training programs addressing manure applicator concerns, including water quality protection and the development of manure management plans. The commissioner shall appoint educational planning committees that must include representatives of industry (http://www.revisor.leg.state.mn.us/stats/18C/432.html). Educational efforts are often part of the programs identified above in the section on prevention. These education efforts are conducted in cooperation with the UMES and local cooperators. An example of a program that promotes education is the Environmental Quality Incentives Program (EQIP) (http://www.extension.umn.edu/mnimpacts/impact.asp?projectID=1029).

Fire extinguishers

Stressors Impacted: Excess UV radiation from stratospheric ozone depletion

Impact Categories: Human Health-cancer, human Health-noncancer chronic, Aquatic Organisms, Terrestrial Organisms

Fire extinguishers are a source of Halon 1211, which has about three times the ozone depletion potential of CFC-11 and CFC-12. Fire extinguishers are also a source of brominated organic chemicals that are listed as Persistent Bioaccumulative Toxics (PBTs).

Cleanup – MPCA has a mandate to provide for management of Household Hazardous Waste (HHW). It is accomplished through technical, financial, and regulatory support to counties. MPCA passes money through for the 13 regional county programs and they collect and dispose of all types of HHW including fire extinguishers. No business waste is accepted except for Very Small Quantity Generators (VSQGs).

Control – There are no requirements for disposal of halon-containing fire extinguishers, but MPCA's Stratospheric Ozone Protection Program works to reduce emissions from fire extinguishers (http://www.pca.state.mn.us/programs/cfc_p.html).

Prevention – halon fire extinguishers are banned.

Education – none identified

Fugitive Dust

Stressors Impacted: Particles in air

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Quality of Life-Aesthetics

Fugitive dust is the largest single source of primary PM-2.5 emissions in the U.S. (http://www2.mriresearch.org/ae/abstract.html). There are several important sources of fugitive dust, including vehicle traffic, mining, landfills, construction (including highway construction), industry, and erosion from agricultural activities. Dust from roads, erosion, and agriculture account for about 80 percent of all emissions (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-b.pdf). Other sources are discussed at http://www.tfhrc.gov/hnr20/recycle/waste/evenvir.htm.

Cleanup – Several cleanup programs indirectly impact fugitive dust releases by requiring removal of sources, such as stockpiles. Some of these programs are discussed in under Unpermitted waste disposal. Many of these programs are administered at the county or other local level.

Control – Minnesota Rule Chapter 7035 states municipal solid waste combustor ash must be stored in a manner that minimizes the emission of fugitive dust (http://www.revisor.leg.state.mn.us/arule/7035/0700.html). Under Chapter 7855, which applies to fuel conversion facilities, coal slurry or coal liquids pipelines, nuclear fuel processing facilities, and nuclear waste storage or disposal facilities, applicants shall provide data on wastes and emissions associated with construction or operation of the facility, including: … locations that may be sources of fugitive dust and the nature of each source (http://www.pca.state.mn.us/water/pubs/fdust.pdf). Permit applications for demolition debris land disposal facilities must include … procedures to control fugitive dust (http://www.iet.msu.edu/environmental/laws/regstate/mnwaste.htm) (Chapter 7041, Minnesota Rules). Minnesota Rules Ch. 7011 establishes air quality standards for stationary sources of air emissions and includes control of fugitive dust (http://www.dnr.state.mn.us/waters/czm/feis/part5_ch3_c.html#1). The Indirect Source Permit rules, found in Minn. R. 7023.9000 through 7023.9050, provide information on conditions relating to fugitive dust emissions from large development or highway projects (http://www.pca.state.mn.us/publications/aq2-08.pdf). EAWs include a section that addresses dust and fugitive emissions (http://www.soils.agri.umn.edu/academics/classes/soil4021/doc/eawsht.htm). Many industries that emit PM 10 and PM 2.5 particles require an air permit. There is a national ambient air quality standard for PM 2.5 particles, but this standard does not specifically control release of particulate matter from sources (http://www.pca.state.mn.us/hot/legislature/reports/2001/at-appendix-b.pdf).

Prevention – Prevention activities focus on reducing erosion loss. The MPCA has established reduction goals for air particulates, although these largely apply to industrial, transportation, and energy-related emissions (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). Some of the discussion under Agricultural runoff, Fertilizer use, and Pesticide use apply to reducing erosion losses from agricultural activities.

Education – Some educational activities are discussed in sections on Fertilizer use, Land-applied manure, Land-applied municipal and industrial byproducts, Permitted waste disposal, Pesticide use, and Unpermitted waste disposal.

Industry

Stressors Included: Toxic volatile chemicals in air, Toxic chemicals in soil, Toxic metals, excess UV radiation from stratospheric ozone depletion, Toxic chemicals in food, Toxic organic chemicals, Noise, Particles in air, Other criteria pollutants in air, Toxic chemicals-high level accidental release, Explosive/flammable material-high level accidental release, Ground-level ozone, Habitat modification, Temperature increase/climate change.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Environmental impacts from industry include effects from air emissions and noise. Industry is a broad category that includes a variety of sources. For air emissions, these may include major industries that act as point sources, such as wastewater treatment facilities, smaller industries that act as area sources (for example, gasoline stations), or a group of activities that may be treated as an industry (for example, the feedlot industry). These sources impact all media, although many of the pollutants of concern are initially released to air. Consequently, there are many programs to consider. The term Industry is used in the environmental matrices when there are many industries that contribute somewhat equally to a stressor, or when a specific source cannot be identified. The following discussion divides these programs by media.

Cleanup

Air – There are few cleanup programs within the air medium.

Water – There are few cleanup programs directly associated with water (see section on spills). Many programs affect water resources, primarily ground water, because they result in cleanup of sources to water (see sections on agriculture, construction, feedlots, mining, permitted waste disposal, tanks, and unpermitted waste disposal).

Land – Many traditional Agency cleanup programs primarily affect land. These include Superfund, the VIC Program, and storage tank programs (see section on unpermitted waste disposal). For information on other cleanup programs, see sections on agricultural sources, construction, feedlots, mining, permitted waste disposal, and tanks.

Control

Air - facilities that have the potential to emit (also known as PTE) any regulated pollutant, in greater than specific threshold amounts, must obtain a total facility permit. In addition, some federal regulatory programs require facilities to apply for permits regardless of how much air pollution they could potentially cause. Besides total facility operating permits, another general class of permits that the MPCA issues are construction permits. Construction permits are issued for the construction of a new facility whose PTE is over the federal or state thresholds, or the modification of an existing facility (http://www.pca.state.mn.us/air/aboutpermits.html#who). Consequently, a large number of industries are regulated through the air permitting process. For more information on control programs for industries that impact air, see sections on coal-fired power plants, mining, refrigerants, and waste incineration.

Water – MPCA has a variety of programs designed to control industrial releases to water. These include the programs identified for cleanup (see above). In addition, there are programs designed to minimize impact from wastewater treatment plants and other, more general, industries (e.g. feedlots, land application). In addition to the programs described under cleanup for water and land (see above), control programs are further discussed in sections on land-applied municipal and industrial byproducts, municipal and industrial wastewater, and pesticide use.

Land – Land programs that control release of chemicals include those discussed under cleanup (see above).

Noise - The PCA adopts standards describing the maximum levels of noise in terms of sound pressure level that may occur in the outdoor atmosphere (http://www.revisor.leg.state.mn.us/stats/116/07.html; http://www.pca.state.mn.us/programs/pubs/noise.pdf).

Prevention – A large number of prevention activities are used to combat these sources. These are discussed in various sections of this document, including sections on area source combustion, mining, municipal and industrial wastewater, and unpermitted waste disposal. The MPCA has established reduction goals for air particulates and chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the OEA and MPCA to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. Businesses that realize regulatory, economic or marketing benefits conduct voluntary prevention efforts that focus primarily on source reduction or elimination of air emissions, which has been somewhat effective for industries using toxic chemicals.

Education – As with cleanup and control programs, there are a large number of education activities. These are discussed in various sections of this document, including Unpermitted waste disposal. In general, the majority of and best-organized education programs are for land. The UMES has been very active in educational efforts. Education activities are described in sections on fertilizer use, land-applied manure, and pesticide use of this document. MPCA has limited education efforts.

Land-applied manure

Stressors Included: Nitrogen, toxic chemicals in water, pathogens in water
Impact Categories: Human Health-noncancer acute, Terrestrial Organisms

Manure is typically applied by farmers as a means of managing wastes and as a nutrient supplement to agricultural fields. Land-applied manure may impact surface water through runoff of organic matter, pathogens, and nutrients; and ground water through leaching of nitrogen and pathogens.

Cleanup – since manure should be applied at agronomic rates, cleanup is unnecessary.

Control - All Minnesota feedlot permits require a manure management plan that accounts for all manure produced by the operation, including land application. There are state requirements for some aspects of land application, such as setback distances from surface waters. Many counties have local ordinances that apply to land-applied manure (http://www.mda.state.mn.us/DOCS/AGDEV/AgLandUse/animalordinancesummary.pdf). Commercial applicators of manure must be licensed (http://www.mda.state.mn.us/appd/cawt/). Training is available for commercial applicators. Manure and process wastewater must not be applied to land in a manner that will result in a discharge to waters of the state during the application process. In addition, manure and process wastewater must not be applied to land in a manner that causes water pollution due to manure-contaminated runoff (Minn. R. chap. 7020.2225 subp. 1, item A). Manure and process wastewater application rates must be limited so that the estimated plant-available nitrogen from all nitrogen sources does not exceed expected crop nitrogen needs for non-legume crops and expected nitrogen removal for legumes (Minn. R. 7020.2225 subp. 3, item A). Manure in storage areas produced from more than 100 animal units must be tested for nitrogen and phosphorus content a minimum of once every four years (Minn. R. Ch. 7020.2225 Subp. 2). Additional protective measures are required for application in special protection areas (7020.2225 Subpart 6). Records must be kept of manure application activities and soils must be tested at larger facilities (http://www.pca.state.mn.us/publications/wq-f8-04.pdf).

Prevention – Prevention activities focus on applying manure to agronomic fields at appropriate agronomic rates. This reduces the amount of commercial fertilizer required and provides a means of utilizing waste, although utilization of waste may not be considered preventive. Manure in storage areas produced by more than 100 animal units must be tested by the feedlot facility owner for nitrogen and phosphorus content (see Minn. R. Ch. 7020.2225 Subp. 2). Many programs exist that provide assistance (technical and financial) for minimizing environmental impacts from manure (fertilizer) use, including the CRP (http://www.mda.state.mn.us/crp/), Agricultural BMP loan programs (http://www.mda.state.mn.us/../agbmp/moreinfo.html), sustainable agriculture and integrated pest management programs (http://www.mda.state.mn.us/esap/), the FANMAP (http://www.mda.state.mn.us/appd/1999acpp.pdf), and various other programs funded through USDA, LCMR (Legislative Commission on Minnesota Resources), and wellhead protection (see Summary of Unit Activities section at http://www.mda.state.mn.us/appd/1999acpp.pdf).

Education - Minnesota Statute 18C.432 states the commissioner shall develop, in conjunction with the UMES, innovative educational and training programs addressing manure applicator concerns, including water quality protection and the development of manure management plans. The commissioner shall appoint educational planning committees that must include representatives of industry (http://www.revisor.leg.state.mn.us/stats/18C/432.html). Educational efforts are often part of the programs identified above in the Prevention section. These education efforts are conducted in cooperation with the UMES and local cooperators.

Land-applied municipal and industrial byproducts

Stressors included: Toxic organic chemicals, toxic chemicals in soil, pathogens in water, toxic chemicals in water

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Terrestrial Organisms

Industrial and municipal wastes often have agronomic value as a fertilizer or soil amendment. They are frequently applied to agronomic fields. They can potentially impact drinking water supplies by leaching to ground water or through transport to surface water. Industrial and municipal byproducts are administered under two separate programs at the MPCA, although we combine them in this document. Industrial byproducts are increasingly being used in other applications, including roadbase, concrete, landfill cover, and flowable fill. These applications are not considered in this document (http://www.pca.state.mn.us/water/landapp.html. For more information, see Chapter 14 in http://www.pca.state.mn.us/water/nonpoint/nsmpp-toc.pdf).

Cleanup – No cleanup program exists for land application, since byproducts are applied at agronomic rates and cleanup is not required.

Control - Land application of biosolids (sewage sludge) is regulated through Minnesota Rule Ch. 7041, while land application of industrial by-products are regulated through a permitting process (http://www.pca.state.mn.us/water/landapp.html). The permitting program established for land application of industrial byproducts requires further development. Questions have arisen which cannot be answered using the existing permitting criteria. Mandatory certification of operators managing land application of biosolids and industrial byproducts is an important program element. Courses are offered yearly for continuing education credits for operators managing land application. This training program is essential for relaying information on management and rule requirements to the people land applying these materials and for maintaining good communication with operators and inspectors (http://www.pca.state.mn.us/news/training/). Staff estimate about 10 percent of their time is spent on training and education (personal communication). Some local agencies may regulate land application activities (http://www.co.ramsey.mn.us/PH/eh/reg_sw_ord_1_9.htm).

Prevention – No program identified. Land application programs deal with material that has been produced rather than with reducing quantities of pollutants, although staff from the Minnesota Office of Environmental Assistance (MOEA) maintain contact with MPCA staff working with land application. The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items.

Education – No program identified. Activities labeled as education are actually training activities that focus on applicators and on proper application of byproducts. The U of M occasionally offers courses related to land application, but it is unclear if these are training or true educational activities.

Lead paint

Stressors Included: Toxic chemicals in soil.

Impact Categories: Human Health-noncancer acute, Human Health-noncancer chronic

Lead is toxic to humans. Children under the age of six years are especially sensitive to lead poisoning. The lead hazard occurs primarily from exposure to dust containing lead-based paint. When lead-based paint deteriorates, paint dust containing lead is released. This paint dust can be inhaled and eaten by the people living and working in buildings painted with lead-based paints.

Cleanup – none

Control – The MPCA has developed regulations with procedures that owners of steel structures or contractors must follow in removing lead paint from exterior surfaces of the structures. The regulations affect almost everyone who removes lead paint from steel structures such as bridges, water tanks, fuel tanks, grain storage bins, railcars and pipelines (http://www.pca.state.mn.us/air/leadpaint.html; http://www.revisor.leg.state.mn.us/arule/7025/). In 1991, the Minnesota Legislature passed laws requiring reduction of lead in specified products (Minn. Stat. Sec.115A.9651). The law applies to an estimated 1,000 products made or sold in Minnesota, including inks, dyes, paints, pigments and one fungicide (http://www.pca.state.mn.us/waste/listedmetals.html; http://www.revisor.leg.state.mn.us/stats/115A/9651.html). "… no manufacturer or distributor may sell or offer for sale or for promotional purposes in this state packaging or a product that is contained in packaging if the packaging itself, or any inks, dyes, pigments, adhesives, stabilizers, or any other additives to the packaging contain any lead, … that has been intentionally introduced as an element during manufacture or distribution of the packaging" (http://www.revisor.leg.state.mn.us/stats/115A/965.html).

Prevention – Since use of lead paints has been largely controlled, prevention now centers on reducing exposure to lead paints that occur in the environment. MPCA provides tips for reducing the risk of lead exposure in the home on it's website (http://www.pca.state.mn.us/air/lead.html#tips). New regulations that affect the sale or lease of almost all residential buildings constructed prior to 1978 were adopted by the Federal Department of Housing and Urban Development and the EPA. The regulations took effect on September 6, 1996 for the owners of more than four residential dwellings, and will take effect on December 6, 1996 for the owners of all residential dwellings. The new regulations require certain disclosures about lead-based paint and establish stiff penalties for failure to comply (http://www.perkinscoie.com/resource/real/paint.htm). On August 29, 1996, the Agency published a final rule for the certification and training of lead-based paint professionals (61FR 45778)(http://www.epa.gov/lead/leadcert.htm). The EPA clarified that contractors can manage residential lead-based paint waste as household waste, thus ensuring that lead paints can be removed in an affordable manner (http://www.epa.gov/lead/fslbp.htm). Section 406 of TSCA directed EPA to develop requirements for renovators to distribute a lead hazard information pamphlet to housing owners and occupants before conducting renovations in pre-1978 housing. EPA published a final rule on June 1, 1998. The rule became effective on June 1, 1999 (http://www.epa.gov/lead/leadrenf.htm). Several additional regulations are under development (http://www.epa.gov/opptintr/lead/regulation.htm). EPA has published several materials regarding lead paint (http://www.epa.gov/opptintr/lead/leadpbed.htm). In Minnesota, it is illegal to dispose paint containing lead in the trash (http://www.moea.state.mn.us/res/consumertips.cfm#paint). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of

Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items.

Education – none identified

Mining

Stressors Included: Habitat modification, toxic metals, toxic chemicals in food

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Some of the environmental effects of mining include deposition of hydraulic-mining debris in stream channels and on fields, accelerated introduction of heavy metals into streams and reservoirs, and production of acidic water. Many of the metals released to the environment are classified as PBTs. Mining is generally not regulated as a separate industry. Mining activities potentially impact soil, air, and water. A variety of wastes are produced from mining. Consequently, a number of MPCA programs are involved in regulation of the mining industry.

Cleanup – The Minnesota DNR, through the Division of Lands and Minerals, administers the Mineland Reclamation Act (Minn. Stat. §§ 93.44-93.51, rules adopted 1980), which requires reclamation implementation of a variety of measures to stabilize all areas disturbed by mining, minimize the impact on water resources, and ensure that the land fulfills a future land use such as forestry, wildlife, or recreation activities. Included in the rules are requirements for lift heights and benches, sloping and revegetation. Because of the program, over 6,600 acres of tailings basins, stockpiles and pit walls have been reclaimed since the program began in 1980 (http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch13.pdf). Minnesota Rules, Chapter 298.223, created a fund called the taconite environmental protection fund. The fund was created for the purpose of reclaiming, restoring and enhancing those areas of northeast Minnesota located within a tax relief area defined in section 273.134 that are adversely affected by the environmentally damaging operations involved in mining taconite and iron ore and producing iron ore concentrate and for the purpose of promoting the economic development of northeast Minnesota.

Control – The Minnesota DNR, through the Division of Lands and Minerals, administers the Mineland Reclamation Act (Minn. Stat. §§ 93.44-93.51, rules adopted 1980) which requires that all facilities operating after 1980 obtain a permit to mine. This permit requires reclamation of the entire facility and requires the implementation of a variety of measures to stabilize all areas disturbed by mining, minimize the impact on water resources, and ensure that the land fulfills a future land use such as forestry, wildlife, or recreation activities. Included in the rules are requirements for lift heights and benches, sloping and revegetation (http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch13.pdf). A Permit to Mine Peat is required of all peat mining operations exceeding 40 acres in size and for those operations less than 40 acres where there is potential for significant environmental effects. The Minnesota DNR administers this permit under the authority of the Mineland Reclamation Act (Minn. Stat. §§ 93.44-93.51) and the rules adopted under that Act relating to the reclamation of mined peatlands (Minn. R. Ch. 6131). The DNR Division of Waters also regulates the mining industry through permits for appropriating surface and ground water and for working in the beds of public waters. Appropriation permits are issued to regulate the taking of water, usually for processing or for dewatering pits. Each application triggers an evaluation to identify and mitigate impacts associated with taking or discharging the water. All appropriation permits are normally issued in concert with MPCA's discharge permit. Protected Waters permits are issued to regulate mining activities that alter the course, current or cross-section of a protected water basin or wetland. Provisions are included which require specific engineering design, construction, or reclamation to mitigate identified impacts. The Wetland Conservation Act, passed in 1991, required that all wetlands impacted by mining operations be replaced. MPCA is the lead agency for regulating ground water quality and surface water. MPCA responsibilities include establishing and enforcing effluent limitations, water quality standards, and compliance monitoring. The MPCA administers the NPDES and State Disposal System (SDS) permit program for mining facilities in Minnesota. Under this program, individual water quality permits are issued to all of the state's large iron and peat mines, as well as all clay mines. Individual NPDES/SDS permits are also required for any mine pit dewatering or process water surface discharges, such as occur at many crushed stone and construction sand and gravel mines and quarries. Mine and quarry operations that do not have an individual NPDES/SDS permit are required to be covered by a general industrial NPDES/SDS storm water permit. Local units of government, such as counties, townships and cities, have the lead responsibility for mineland reclamation oversight at crushed stone, dimension stone, industrial sand, clay and construction sand and gravel mines and quarries throughout Minnesota. Specific reclamation requirements vary considerably, depending on location. The DNR and the MPCA at times have provided technical assistance to local units of government. Abandoned iron mine lands, which include all areas disturbed prior to the adoption of the Mineland Reclamation Rules 1980, are handled by the Iron Range Resources and Rehabilitation Board (IRRRB). Founded in 1978 and supported by a tax on taconite production, the IRRRB has completed about 250 projects. Some of these have been recreation-oriented, such as the development of campgrounds and sliding hills, but others have focused on stabilizing old areas of mine waste. Over three million trees have been planted and about 1,000 acres of abandoned mine lands have been reclaimed. Operations requiring a NPDES permit are regulated under the Clean Water Act, as amended, (33 U.S.C. 1251 et. seq.), 40 CFR 122,123, and 124, as amended, et. seq.; Minn. Stat. Chs. 115 and 116, as amended, and Minn. Rules Ch. 7001. Mining waste disposal must conform with existing regulations for disposal of solid waste in permitted landfills (see Section 18, of this document – Permitted Waste Disposal). Mining wastes do not qualify as a mixed municipal solid waste and are therefore landfilled as a separate waste stream. The MPCA has developed a new general water quality permit to cover most gravel and hot mix operations. This permit is an optional replacement for MPCA water quality multiple permit coverage. The permit covers storm water runoff from gravel mines and stone quarries and pit dewatering from gravel mines (http://www.pca.state.mn.us/water/pubs/asphalt.pdf). The DNR has compiled several fact sheets describing BMPs for mining operations (http://www.dnr.state.mn.us/minerals/minpubs3.html). The 1990 amendments to the Clean Air Act involved many significant changes to the federal air quality programs that, in turn, caused a major overhaul of Minnesota's existing air permitting program. Two of the larger changes included the way hazardous air pollutants are addressed, and the addition of the Title V (or Part 70) operating permitting program. Title V refers to the section of the Clean Air Act, and Part 70 the part of Title 40 of the Code of Federal Regulations, which include the requirements for this program. Minnesota's air rules were revised in October 1993, in response to these changes. Companies who were required to apply for Title V operating permits had to submit their Title V permit applications to the MPCA between 1995 and 1996 (depending on the industry category). In general, facilities who have the potential to emit (also known as PTE) any regulated pollutant, in greater than specific threshold amounts, must obtain a total facility permit (http://www.pca.state.mn.us/air/aboutpermits.html). This includes mining facilities. All facilities that are required to obtain an air emission permit are required to submit an annual emission inventory (http://www.pca.state.mn.us/air/emissionfaq.html).

Prevention – Storm water permits require mining operations, which include the majority of Minnesota's construction sand and gravel mines, to develop pollution prevention plans and implement best management practices (BMPs) to control their storm water and to protect ground water quality. These BMPs are more appropriately classified as control activities, however, since they are designed to control pollution at mining facilities. The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items.

Education – The Minnesota Minerals Education Workshop consists of a daylong series of classroom sessions followed by a day and a half-day of geology field trips and tours of mining operations. Topics covered include general geology, rock and mineral identification and mineland reclamation. Classes are taught by geologists, educators, and minerals and mining industry professionals (http://www.dnr.state.mn.us/minerals/mmewrpt.html).

Municipal and Industrial Wastewater

Stressors Included: Nitrogen, dissolved solids, particles in air, toxic chemicals in water, transported sediment, toxic metals, pathogens in water, phosphorus, toxic organic chemicals, toxic chemicals in food, oxygen-demanding pollutants, ammonia

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

This section describes programs and activities related to environmental impacts associated with wastewater. Consequently, surface water is the primary media affected.

Cleanup – MPCA responds to spills and leaks that involve municipal and industrial waste and wastewater (http://www.pca.state.mn.us/cleanup/pubs/6_1.html). Other cleanup activities are limited. An example is removal of mercury from sewers prior to pretreatment.

Control – MN Rules 7077.0100 provides MPCA administration of financial assistance programs for the construction of municipal wastewater treatment systems. Facilities that process wastewater from domestic sanitary sewer sources (sewage) are considered municipal facilities. These include city wastewater districts treatment, sanitary districts, wayside rest areas, national or state parks, mobile home parks, and resorts. NPDES permits regulate wastewater discharges to lakes, streams, wetlands and other surface waters. SDS permits regulate the construction and operation of wastewater disposal systems, including land disposal (http://www.pca.state.mn.us/programs/inpdes_p.html). For Minnesota industrial facilities, the MPCA strives to issue these permits as consolidated water quality management permits. An individual NPDES/SDS permit for an industrial facility may cover a number of different waste types and activities, including industrial process wastewater, contact and non-contact cooling water, storm water, contaminated ground water pumpouts, water supply treatment backwash, and wastewater treatment sludges. The Industrial Pretreatment Program seeks to control the discharge of industrial (and other) wastes into the sanitary sewer. This is done through many kinds of controls. The POTW (publicly owned (wastewater) treatment works)(i.e. the municipal sewage treatment plant and the authority who operates it) is inherently the primary control authority. Therefore, most of the actual regulatory work of pretreatment is carried out by POTWs. Several general NPDES/SDS permits also are available. NPDES/SDS permit requirements may include monitoring, limits, and management practices designed to protect surface and ground water quality. Municipal wastewater is subject to similar regulations regarding discharge. Major facilities are regulated through the US EPA NPDES program (http://cfpub1.epa.gov/npdes/). Minnesota's point source revolving loan program provides loans to municipalities for planning, design and construction of wastewater and stormwater treatment projects (http://www.pca.state.mn.us/water/wpcrf-psource.html). MPCA has incorporated its Phosphorus Strategy into the NPDES process (http://www.pca.state.mn.us/water/pubs/phos-npdes.pdf).

Prevention – For the Minnesota River Basin, permit writers and engineers promote P2 initiatives to protect smaller municipal treatment systems from toxics and phosphorus loading through P2 implemented at upstream contributors. The

Pretreatment Program has promoted P2 outreach as a standard part of service from the state's larger municipal treatment systems that operate their own pretreatment programs. This initiative is a collaboration between MPCA and MnTAP. The Nonpoint Source side of water quality protection has several efforts under way that promote pollution prevention. MPCA's Minnesota River staff are teaming with MnTAP to work on priority point sources (particularly phosphorus loading), whether they contribute to municipal systems or direct discharges (http://www.mntap.umn.edu/). The MPCA has established reduction goals for air particulates (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. In the broadest definition of wastewater, any activity designed to reduce municipal and industrial waste qualifies as a prevention program. There are a multitude of these programs, although they typically address specific wastes or waste generators (http://www.pca.state.mn.us/programs/p2-success.html; http://www.moea.state.mn.us/reduce/index.cfm).

Education – MPCA's Phosphorus Strategy includes educational components (http://www.pca.state.mn.us/hot/legislature/factsheets/phosphorus-00.pdf). In the broadest definition of wastewater, any educational activity designed to inform about waste and waste reduction qualifies as an education program. There are many educational programs and much educational information related to wastewater (http://www.extension.umn.edu/water/; http://www.metrocouncil.org/environment/PollutionPrevention/P2_Home.htm; http://metrocouncil.org/environment/Kids/Slide__1.htm; http://www.epa.gov/owow/monitoring/nationswaters/). It is unclear if these resources are widely used.

Off-road equipment

Stressors Included: Particles in air, other criteria pollutants in air, acid deposition, noise, nitrogen, toxic volatile chemicals in air, toxic chemicals in food, ground-level ozone

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Off-road equipment affects noise levels, air quality, aquatic ecosystems, and terrestrial ecosystems. In the case of air quality, emissions are the primary concern. For terrestrial and aquatic ecosystems, nitrogen and acid deposition are the primary concerns. Off-road equipment includes a variety of equipment and vehicles, including lawn mowers, all-terrain vehicles, farm equipment, diesel locomotives, etc.

Cleanup – none identified
Control
Emissions: The MPCA has limited regulatory authority for controlling emissions from off-road equipment.
Noise: The PCA adopts standards describing the maximum levels of noise in terms of sound pressure level that may occur in the outdoor atmosphere (http://www.revisor.leg.state.mn.us/stats/116/07.html; http://www.pca.state.mn.us/programs/pubs/noise.pdf). The Minnesota DNR has source standards for snowmobiles, motorboats, personal watercraft and off-highway vehicles(http://www.pca.state.mn.us/programs/pubs/noise.pdf; http://www.dnr.state.mn.us/information_and_education/water_safety/bg-equ07.html).
Prevention – See On-road vehicles.
Education – See On-road vehicles.

On-road vehicles

Stressors Included: Particles in air, other criteria pollutants in air, acid deposition, heat/severe weather, temperature increase, noise, nitrogen, toxic volatile chemicals in air, toxic chemicals in food, ground-level ozone

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

On-road equipment affects noise levels, air quality, aquatic ecosystems, and terrestrial ecosystems. In the case of air quality, emissions are the primary concern. For terrestrial and aquatic ecosystems, nitrogen and acid deposition are the primary concerns. On-road vehicles include automobiles, vans, SUVs, trucks, and other machines that are permitted to be driven on roads and highways.

Cleanup – none identified
Control
Emissions: The MPCA has limited regulatory authority for controlling emissions from on-road vehicles.
Noise: The PCA adopts standards describing the maximum levels of noise in terms of sound pressure level that may occur in the outdoor atmosphere. Most highways subject to Federal funding and new highways are exempt "provided that all reasonably available noise mitigation measures are employed to abate noise" Public roads in St. Paul and Minneapolis are also exempt. Most noise abatement efforts conducted by MNDOT, such as use of sound barriers, would be considered control measures (http://www.revisor.leg.state.mn.us/stats/116/07.html; http://www.dot.state.mn.us/metro/tps/htms/noise/mndot_noise_policy.html; http://www.pca.state.mn.us/programs/pubs/noise.pdf).
Prevention – Numerous organizations conduct prevention for air emissions by promoting activities that reduce fuel consumption (and therefore emissions) from on-road vehicles. The MPCA has established reduction goals for air particulates and chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). Some links

to websites dealing with prevention are found at http://www.dot.state.mn.us/sti/telework.html and at http://www.pca.state.mn.us/air/mvpollution.html#faq. The MPCA conducts limited efforts at prevention (http://www.pca.state.mn.us/programs/p2-components.html#smartgrowth; http://www.pca.state.mn.us/air/pubs/2-10.pdf; http://www.pca.state.mn.us/programs/p2-components.html#cleanair). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. There are limited prevention efforts for noise and habitat destruction or modification.

Education – There is limited educational activity at the MPCA related to environmental impacts from on-road vehicles. Numerous environmental education efforts focus on lifestyle adaptations to minimize environmental impact. Vehicle use is a component of some of these efforts. Examples of environmental education resources and lessons can be found at http://www.nceet.snre.umich.edu/.

Permitted waste disposal

Stressors Included: Toxic chemicals in food, temperature increase/climate change

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms

The MPCA is actively involved in regulating Minnesota's landfills. MPCA has two programs for cleaning up and closing Minnesota landfills, including unpermitted landfills (see Unpermitted waste disposal). The primary concern with landfills is release of chemicals that may enter the food chain (PBTs).

Cleanup – The purpose of the Minnesota Landfill Cleanup Program (Minn. Stat. Ch. 115B.441 - 115B.445) is to ensure the proper closure and postclosure care at 106 closed, permitted municipal sanitary landfills in the state. Any MPCA-permitted mixed-municipal solid waste landfill that stopped accepting mixed municipal solid waste by 4/9/94 , and demolition debris before 5/1/95, can qualify for application to this program. After the owners/operators enter an agreement with the MPCA and complete the requirements set forth in that agreement, the owner/operators are issued a Notice of Compliance. The MPCA assumes responsibility for any remaining cleanup work, closure construction, and long-term care of the landfill. In some cases, past cleanup costs can be reimbursed to owner/operators (http://www.pca.state.mn.us/programs/landfill_p.html). The primary customers are the owners and operators of the municipal sanitary landfills in Minnesota. The MDA has responsibility for cleanup of pesticides. Information of MDA pesticide cleanup programs can be found under Cleanup in the section on pesticide use.

Control – Minn. Stat. Ch. 115B.441 - 115B.445 give MPCA regulatory authority to manage wastes at permitted municipal sanitary landfills in the state (http://www.revisor.leg.state.mn.us/stats/115B/39.html). Mixed municipal solid waste (http://www.revisor.leg.state.mn.us/arule/7035/2815.html), demolition debris (http://www.revisor.leg.state.mn.us/arule/7035/2825.html), municipal solid waste combuster ash (http://www.revisor.leg.state.mn.us/arule/7035/2885.html), and compost (http://www.revisor.leg.state.mn.us/arule/7035/2836.html) facilities are specifically covered under Minnesota Rule 7035. The Agency has authority to ensure the proper closure and postclosure care at 106 closed, permitted municipal sanitary landfills in the state. An indirect control measure that relates to landfills is reuse of municipal and industrial byproducts, which decreases the amount of material entering landfills. These are control activities if they do not decrease the quantity of pollutants generated but decrease the potential for environmental degradation associated with landfills. Section 17 of this document describes land application of reuse products. The MPCA does not promote reuse through a specific program, but reviews reuse cases on an individual basis. Other agencies, such as MOEA, promote reuse (http://www.pca.state.mn.us/cleanup/pubs/c8-01.pdf). The Resource and Conservation Recovery Act (1976) and the Pollution Prevention Act (1990) are the primary federal laws that regulate disposal of hazardous wastes (http://www.enviroliteracy.org/hazardous_waste.html).

Prevention – Preventive activities, as they relate to landfills, primarily focus on waste reduction. The Pollution Prevention Act of 1990 and Minnesota Toxic Pollution Prevention Act (TPPA) of 1990 (Minn. Stat. § 115D) and Executive Order 99-4, "Providing for the Implementation of Pollution Prevention and Resource Conservation By State Government", mandate the use of preventive actions to reduce waste (http://www.revisor.leg.state.mn.us/stats/115D/; http://www.epa.gov/opptintr/p2home/p2policy/act1990.htm). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. For more information, see the section on unpermitted waste disposal). Some landfill activities, such as recovery of wastes for beneficial purposes, can be labeled as prevention activities. An example would be recovery of methane for energy use.

Education – See Unpermitted waste disposal.

Pesticide use

Stressors Included: Toxic chemicals in water, toxic chemicals in soil, toxic chemicals in food, toxic organic chemicals.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Terrestrial Organisms.

Pesticides impact drinking water through leaching to ground water and discharge to surface water. Surface water discharge includes overland transport of storm water runoff and contributions from tile drains. Although aquatic ecosystems are not identified above as an impact category, they are included under agricultural runoff, which is a broad source category that does impact aquatic ecosystems.

Cleanup – The MDA is the lead agency for response to, and cleanup of, agricultural chemical contamination (pesticides and fertilizers) in Minnesota. These activities, however, are generally associated with unpermitted disposal or spills. There is no cleanup associated with routine use of fertilizers.

Control – Licenses are required for commercial application of pesticides. The UMES provides pesticide applicator training (http://www.extension.umn.edu/pesticides/pat/mnpat.html) and some other pesticide training (http://www.extension.umn.edu/pesticides/index.html).

Prevention : MDA operates a voluntary BMP program (http://www.mda.state.mn.us/appd/BMPs/BMPs.htm; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch10.pdf). Some BMPs are preventive, including reducing pesticide application, utilizing alternatives to pesticides, changing formulations, and using less toxic chemicals (http://www.mcstoppp.org/pesticides.htm; http://wbln0018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/$File/71_pestf.pdf). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items.

Education – FANMAP, a program administered through MDA, is designed to educate farmers in sensitive hydrologic environments about assessing nutrient and pesticide needs (http://mrbdc.mankato.msus.edu/inventory/state/sbmp.html; http://www.mda.state.mn.us/appd/1999acpp.pdf). Another example of a program that utilizes education is EQIP (http://www.extension.umn.edu/mnimpacts/impact.asp?projectID=1029). Additional information is available on the internet (http://www.cehn.org/cehn/resourceguide/ncamp.html: http://www.epa.gov/opptintr/kids/hometour/index.htm).

Petroleum storage and transfer

Stressors Included: Ground-level ozone

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Terrestrial Organisms, Quality of Life-Aesthetics

Much of the discussion under Solvent utilization applies to petroleum storage and transfer. Many of the activities for petroleum storage and transfer that lead to release of ozone-depleting chemicals are unregulated or have been given relatively low priority for prevention. These include vapor loss associated with fueling vehicles or transferring volatile chemicals.

Cleanup – none identified.

Control – MPCA requires air permits for some facilities involved in storage and transfer, but many activities are not considered.

Prevention – Most of the prevention activities discussed for Solvent utilization are not applicable. Prevention activities may include more efficient methods for transfer of volatile chemicals. The MPCA has established reduction goals for chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf).

Education – none identified.

Pipelines

Stressors Included: Explosive/flammable materials-high level accidental release, toxic chemicals-high level accidental release.

Impact Categories: Human Health-noncancer acute

Cleanup – The Minnesota Pollution Control Agency regulates pipelines associated with petroleum storage tanks, and has similar regulatory authority for contamination from pipelines associated with other cleanup programs, such as Superfund. The MPCA has no formal regulatory authority for other types of pipelines. The US EPA has broad regulatory authority under Title 40 CFR.

Control – The Minnesota Pollution Control Agency regulates pipelines associated with petroleum storage tanks, and has similar regulatory authority for contamination from pipelines associated with other cleanup programs, such as Superfund (http://www.pca.state.mn.us/cleanup/ast.html; http://www.pca.state.mn.us/programs/lust_p.html; http://www.pca.state.mn.us/cleanup/ust.html). The MPCA has no formal regulatory authority for other types of pipelines. The Minnesota Office of Pipeline Safety provides training on issues related to pipeline safety (http://www.dps.state.mn.us/pipeline/), and has authority to inspect underground pipelines and conduct other activities related to ensuring the safety of underground pipelines (http://www.revisor.leg.state.mn.us/arule/7530/). The US EPA has broad regulatory authority under Title 40 CFR. Minnesota Rules Chapter 6135 provides DNR with authority to regulate licensing of utility crossings, including pipelines, across public lands and waters.

Prevention – The US EPA has broad regulatory authority for Oil Pollution Prevention under Title 40 CFR Part 112 (http://www.epa.gov/earth1r6/6sf/sfsites/oil/prgother.htm). Activities, however, relate to drilling, production, gathering, storage, processing, refining, transferring, distribution, or consumption of oil and oil products. These cannot be clearly defined as pollution prevention activities

Education – none identified

26. Power plants

Stressors Included: Temperature increase/climate change

Impact Categories: Aquatic Organisms

This section provides information on thermal discharge (cooling water) to surface water. Potential impacts are to aquatic ecosystems.

Cleanup – none identified

Control – Congress included section 316 in the Clean Water Act for the express purpose of regulating thermal discharges and addressing the environmental impact of cooling water intake structures. Sections 316(a) and (c) provide for relief in certain circumstances from the thermal effluent standards applicable to point source discharges of pollutants. Section 316(b) does not focus on controlling the discharge of pollutants. Rather, it addresses the environmental impact of cooling water intake structures. Section 316(b) is the only provision in the Clean Water Act that focuses exclusively on water intake. These regulations are administered at the state level by the MPCA through the NPDES program (http://www.pca.state.mn.us/water/permits/index.html#cooling; http://www.pca.state.mn.us/water/permits/nccoolng.pdf). There may also be local rules that apply to specific water bodies. One example is surface water within the Lake Superior Basin (http://www.revisor.leg.state.mn.us/arule/7052/0300.html).

Prevention – none identified

Education – none identified

Recreational use (shooting ranges, fishing tackle)

Stressors Included: Toxic metals.

Impact Categories: Terrestrial Organisms

The primary environmental concern with recreational activity is use of lead shot or tackle. Lead poisoning has been documented, particularly in raptors and waterfowl, such as swans and loons (http://www.raptor.cvm.umn.edu/content.asp?page=7006; http://species.fws.gov/bio_swan.html; http://www.michiganloons.org/lead.htm; http://www.uswaternews.com/archives/arcquality/1leause4.html).

Cleanup – Cleanup of sediments in lakes and wetlands is generally discouraged because the cleanup activities result in extensive environmental damage. The MPCA may work with local entities to clean contaminated soils.

Control – The United States banned the use of lead shot for hunting migratory waterfowl in 1991 (http://www.michiganloons.org/lead.htm). Upland game hunters hunting on federal Waterfowl Production Areas (WPAs) are required to use non-toxic shot (http://www.great-lakes.net/lists/glin-announce/1998-08/msg00013.html). No person may use lead shot to take—or have lead shot in possession while taking—geese, ducks (including captive-reared mallards), mergansers, coots, or moorhens. This restriction includes muzzleloading shotguns. Only these types of shot may be used: steel; copper-, nickel-, or zinc-plated steel; bismuth-alloy; tungsten-iron; tungsten-nickel-iron; tungsten-polymer; tungsten-matrix; or other nontoxic shot approved by the director of the U.S. Fish and Wildlife Service (http://www.dnr.state.mn.us/fish_and_wildlife/regulations/hunting/waterfowl_regs.pdf). The U.S. Fish and Wildlife Service has asked all national wildlife refuges to document waters frequently used by recreational anglers as well as habitat used by common loons. Those areas where the two overlap will be designated "lead-free fishing areas." Lead-free fishing areas would be phased in during a 2-year period.

During the first year, the refuge would alert anglers to the impending lead-free fishing area and educate anglers about the benefits of non-toxic sinkers and jigs for wildlife. During the second year, refuges with lead-free fishing areas would also offer anglers the opportunity to trade in their lead sinkers and jigs for non-toxic substitutes. After the second full year, the use of lead sinkers and jigs in lead-free fishing areas would be prohibited (http://www.fws.gov/r9extaff/pr9908.html).

Prevention – The DNR, University of Minnesota Raptor Center, the Minnesota Office of Environmental Assistance (OEA), retailers such as Target Stores and Wal-Mart, and tackle manufacturers such as Water Gremlin and Bullet Weights are partnering to educate anglers about this issue. These organizations, and others, promote use of environmentally friendly, non-lead sinkers (http://www.moea.state.mn.us/media/03-26-99-1.cfm; http://www.lpleader.com/Opinion/DNR.html).

Education – Several organizations provide information about the environmental effects of lead from shot or fishing tackle (http://www.learner.org/jnorth/tm/loon/SteelSinkers.html; http://www.moea.state.mn.us/media/03-26-99-1.cfm; http://www.leadfreesinkers.com/lead2.html). Many of these efforts are passive, providing information only. There are some attempts, however, to bring this information into the classroom or directly to the recreationists.

Refrigerants

Stressors Included: Excess UV radiation from stratospheric ozone depletion.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Aquatic Organisms, Terrestrial Organisms

Air conditioners include any machinery containing refrigerants and designed for cooling. This would include home and vehicle air conditioners, refrigerators, and freezers.

Cleanup – No cleanup program exists.

Control – The MPCA requires technician certification for persons servicing and disposing of appliances containing refrigerant and the servicing, and in some cases, disposal of motor vehicle air conditioners (http://www.pca.state.mn.us/industry/ts-links.html#airconditioning). Proper disposal of Chlorofluorocarbon (CFC)-containing refrigerants is required (http://www.pca.state.mn.us/air/cfc.html). Anyone who sells or distributes ozone-depleting refrigerant must retain invoices that indicate the name of the purchaser, the date of sale, and quantity of refrigerant purchased.

Prevention – CFC's have been banned from use in refrigerants.

Education – No educational programs exist.

Residences

Stressors Included: Explosive/flammable materials-high level accidental release, toxic chemicals-high level accidental release.

Impact Categories: Human Health-noncancer acute

This section considers accidental releases of toxic chemicals or explosive/flammable materials. While MPCA programs do not directly address households, MPCA activities apply, in many cases, to residential homes.

Cleanup – The MPCA ERT members are responsible for organizing the MPCA's efforts for oil and hazardous material emergencies (http://www.pca.state.mn.us/cleanup/ert.html).

Control – Minnesota Statutes 2000, 115.061, requires notification for petroleum spills greater than five gallons (http://www.revisor.leg.state.mn.us/stats/115/061.html). Minnesota Statutes 2000, 115E.02, states "A person who owns or operates a vessel or facility transporting, storing, or otherwise handling hazardous substances or oil or who is otherwise in control of hazardous substances or oil shall take reasonable steps to prevent the discharge of those materials in a place or manner that might cause pollution of the land, waters, or air of the state or that might threaten the public's safety or health" (http://www.revisor.leg.state.mn.us/stats/115E/02.html). Local agencies may have similar requirements.

Prevention – Internal and external spill prevention and preparedness is an important part of the MPCA ERT's strategic plan and is carried-out through pro-active community planning, fire department training, exercises and drills, and enforcement (http://www.pca.state.mn.us/cleanup/ert.html).

Education – none identified.

Residential fuel combustion

Stressors Included: Temperature increase/climate change, other criteria pollutants in air, toxic chemicals in food, toxic volatile chemicals in air, habitat modification.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms

Residential fuel combustion is included in some subcategories of Area source combustion. These include wood burning and residential coal combustion.

Cleanup – none identified

Control – The Clean Air Act Amendments of 1990 (CAAA) required that all areas in the country achieve the (NAAQS) for PM10 by December 31, 1994. The EPA published technical guidance for reasonably available control measures and BACM for control of PM from woodstoves to achieve this goal of reducing PM10 emissions. Those areas that do not achieve PM10 attainment by December 31, 1994, must apply BACM and develop a plan to meet the NAAQS by December 31, 2001. The only exceptions are those areas that were reclassified as serious after 1990; these areas must attain the NAAQS for PM10 no later than the end of the tenth calendar year after the area's designation as nonattainment. The BACM requirements include combinations of the following control measures: the use of new technology woodstoves, improvements in wood burning performance (e.g., control of wood moisture content, weatherization of homes), the use of "no burn" days, public awareness and education programs, replacement or installation of gas-burning equipment in fireplaces, and total banning of burning. The use of these BACM will reduce VOC, HAPs, and carbon monoxide along with PM, for measures that produce more complete combustion of wood; for measures that reduce the occurrence of combustion, nitrous oxides will also be reduced. The MPCA recently provided economic incentives to upgrade wood-burning stoves and fireplaces to newer, more efficient systems. Residential and commercial coal combustion covers air emissions from coal combustion in the residential and commercial sectors for space heating or water heating. This category includes small boilers, furnaces, heaters, and other heating units that are not inventoried as point sources. Residential and commercial coal combustion sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and federal, state, and local government institutions (e.g., military installations, prisons, office buildings). No regulatory controls were identified for coal combustion (See Area Source Combustion in this document for web sites).

Prevention – No specific program was identified. The MPCA has established reduction goals for chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. There are unorganized efforts by various agencies and groups to decrease home use of fuels.

Education – No specific program was identified. There are unorganized efforts by various agencies and groups to increase awareness about environmental impacts from home use of fuels.

Road salt

Stressors Included: Toxic chemicals in soil.

Impact Categories: Human Health-noncancer acute

In Minnesota, a tremendous amount of salt is used each year to melt ice from roads, parking lots and sidewalks. From 1984 to 1994 average salt usage was approximately 157,000 tons per year. Over 1989 to 1994 usage increased to an average of 181,000 tons per year. Because it is extremely soluble, almost all salt applied ends up in surface or ground water (Pitt, 1995). If the concentration of chloride becomes too high, it can be toxic to many freshwater organisms. There have been many cases of surface and ground water contamination caused by runoff from inadequately protected stockpiles of salt and sand-salt mixtures (Blaha and Cherryholmes, unpublished MPCA data)(http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch11.txt). Aquatic effects from road salt are included in urban and agricultural runoff. We consider soil effects in this section. Cyanide is the primary chemical of concern in road salt.

Cleanup – none

Control – Some industrial facilities may require an NPDES permit (http://www.pca.state.mn.us/water/stormwater-i.html).

Prevention – Facilities that need a permit must develop and implement a Storm Water Pollution Prevention Plan under this program. This plan must be tailored to specific site conditions and designed with the goal of controlling and minimizing the amount of pollution in storm water that leaves the site. This is accomplished with BMPs selected for site-specific conditions (http://www.pca.state.mn.us/water/stormwater-i.html). A variety of prevention activities exist to reduce impacts from road salts (http://www.cwp.org/Cold%20Climates/CHAPT8%20-%20POLLUTION%20PREVENTION.pdf). In general, prevention activities are largely voluntary and not extensively implemented.

Education – There are limited efforts to educate the public about environmental effects of deicing salt (http://www.captus.com/information/tac.htm; http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html)

Septic systems

Stressors Included: Toxic chemicals in water, pathogens in water, ammonia, phosphorus, nitrogen, oxygen-demanding pollutants

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Quality of Life-Aesthetics

Septic systems include individual sewage treatment systems (ISTS), cesspools, community systems, and other systems designed to treat human waste, excluding municipal treatment systems.

Cleanup – There is no organized effort at cleaning up environmental impacts from septic systems or for bringing noncompliant systems into compliance, with the exception of failing systems, which must be brought into compliance. Numerous local communities have begun conducting septic inventories in the past ten years to determine the number of noncompliant systems (http://www.bwsr.state.mn.us/news/2001March.pdf). Some restoration projects have resulted in repair of septic systems (http://www.epa.gov/owow/NPS/Section319II/MN.html).

Control - The goal of the agency's ISTS program is to protect the public health and the environment by adequate treatment and disposal of sewage from dwellings or other establishments not serviced by a publicly-owned treatment facility. The agency is charged to do this by Minnesota statutes 115.55 and 115.56 and through Minnesota Rules Chapter 7080. Statutes §§ 115.55 and 115.56. MN Stat. § 115.55 describe the administrative requirements of the program including rule requirements; local ordinance requirements; and permitting, inspection and upgrade requirements. MN Stat. § 115.56 describes the statewide licensing program for septic system professionals (http://www.pca.state.mn.us/programs/ists/index.html#information). Minnesota Rules, Chapter 7080, provides requirements for managing septage solids (http://www.revisor.leg.state.mn.us/arule/7080/0175.html). Septage pumpout waste may be land-applied or sent to a wastewater treatment facility. State law requires homeowners, when selling a home with a septic system, to disclose everything they know about the system to the buyer. The state also requires that if a county, township or city is going to have their own ordinance governing septic systems, it cannot be less restrictive than the state rules. Local units of government are required to adopt Chapter 7080 to set standards for septic systems. Because of unique local conditions, local ordinances may be slightly more or less restrictive than the state rules (http://www.extension.umn.edu/extensionnews/1999/JP1054.html). ISTS requirements are adopted and enforced locally and requests for assistance or complaints are first be directed to the local authority (county, city, and township). The Minnesota Department of Health has building codes, plumbing codes and well codes. The DNR has the Shoreland Act and the BWSR has wetland rules. All of these codes impact septic systems (http://www.pca.state.mn.us/programs/ists/rules.html. Inspections are required for all new septic system construction and replacement. Existing systems must be inspected when there is a bedroom addition permit request (if the local government unit has a permitting program for bedroom additions). Existing systems must also be inspected when any building permit or variance is requested for systems located in a shoreland area. Local ordinances or lending institutions may require inspections at other times, such as at property transfer (http://www.pca.state.mn.us/programs/ists/technical.html#inspections). Additional state rules and statutes exist, such as for state financing of septic systems. In addition to maintaining septic systems, managing lot size, installing sewers, properly locating septic systems with respect to drinking water receptors, and utilizing new technologies are control methods for reducing exposure risk from septic systems. These may be implemented at the local level, but generally not in response to reducing potential impacts to drinking water receptors.

Prevention – Preventive activities for reducing impacts from septic systems include managing the quantity and types of waste discharged through septic systems, maintaining septic systems, and utilizing new technologies (http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/SepticSystemControls.htm; http://www.cepp.cc/; http://www.dep.state.pa.us/dep/deputate/enved/enviroed/Can_Do/p2home.htm). The latter two activities do not reduce waste at the source (the septic tank), but may lead to destruction of pollutants near the source. The MPCA does little to promote these activities. There appears to be greater prevention activity at the local level, although there is likely to be a wide range in activity level between different localities (http://www.co.dakota.mn.us/environ/links.htm; http://www.extension.umn.edu/county/dakota/Environment/nonpt.html). Implementation of prevention activities is likely to be a function of economics, personal preference, and convenience, rather than an effort to control pollution from septic systems. It is unclear if there is an environmental advantage to community septic systems for situations where houses are completed on small lots (http://www.extension.umn.edu/extensionnews/1999/JP1057.html). A community system probably does not affect the extent of environmental impacts, but it may be easier to define impacted areas.

Education – Most education is conducted through agencies other than the MPCA. There are numerous fact sheets and manuals intended to educate owners of septic systems (http://www.hometimes.com/HowTo/septic.html; http://www.bae.umn.edu/~septic/; http://www.pca.state.mn.us/water/pubs/istsfact.pdf). Included are efforts to educate about water use and types of wastes that may be disposed, such as anti-bacterial soaps, household cleaners, dairy product/food residue, oil, paint, and solvents (http://www.extension.umn.edu/distribution/naturalresources/DD7439.html;

http://www.hometimes.com/HowTo/septic.html; http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/SepticSystemControls.htm; http://www.dakotaswcd.org/newsnotes/1999win/nnw9901a.htm; http://thurston.wsu.edu/Resource%20Library/water_quality_library.htm#groundwater). There appear to be many outreach efforts, primarily at the local level and often in response to specific needs. For example, there have been outreach efforts directed at shoreline property owners. Consequently, these efforts do not provide well-rounded education, since they are narrowly focused. It is unclear how extensive these efforts are and what the environmental effects of these efforts have been.

Silvaculture

Stressors Included: Habitat modification.

Impact Categories: Terrestrial Organisms, Quality of Life-Aesthetics

Silvaculture is a branch of forestry dealing with the development and care of timber. Severe habitat destruction can result from forestry activities. Effects of silvaculture are therefore primarily on terrestrial ecosystem health. Forestry has been identified as one of Minnesota's four major sources of nonpoint source pollution. Pollutants from forestry operations include sediment, nutrients, organic debris, pesticides, petroleum products; water temperature increases are also of concern (http://www.epa.gov/OWOW/NPS/Success319/MN.html). These affects on aquatic ecosystems are included under urban or agricultural runoff. State and federal forest lands are managed through government programs, but most regulations do not extend to private forest land.

Cleanup – none

Control – The commissioner of the DNR manages the forest resources of state forest lands according to the principles of multiple use and sustained yield (http://www.revisor.leg.state.mn.us/stats/89/002.html). This includes forest extraction (i.e. silvaculture). The DNR is directed to enact rules to reach this objective, including provision for sale of all timber species by both the informal and the auction sale method; and maintaining reasonable proportions of volume in each method of sale (http://www.revisor.leg.state.mn.us/stats/90/02.html). The United States Forest Service manages federal forested lands.

Prevention – Since forests are a renewable resource, the primary objective of prevention activities is to conduct silvaculture activities that have the least effect on habitat destruction. Each year the DNR commissioner strives to assure that (1) reforestation occurs annually on an acreage at least equal to the acreage harvested that year on all forest lands under the authority of the commissioner; (2) additional reforestation is accomplished on areas previously harvested but not adequately reforested so that the backlog of reforestation work can be eliminated; and (3) poorly stocked forest land, or forest land damaged by natural causes, shall be returned to a state of productivity (http://www.revisor.leg.state.mn.us/stats/89/002.html). Under Section 319 of the Clean Water Act, the MINNESOTA DNR has authority to identify nonpoint pollution sources and develop BMPs for controlling environmental effects from these activities (http://www.dnr.state.mn.us/waters/czm/feis/part6.html). The

MPCA has a minor role to play in 319 and Clean Water Partnership projects that focus on implementation of BMPs in forested lands. The Minnesota DNR has established a statewide goal of encouraging 50% of private landowners with holdings over 20 acres in size to participate in the development of a private Forest Stewardship Plan with the assistance of a qualified forester, by the year 2005 (http://www.dnr.state.mn.us/forestry/aitkin/98press13.html). If the landowner wishes to sell timber as part of a private Forest Stewardship Plan, consulting foresters can set up a timber sale contract to ensure that all parties are satisfied and protected. This contract will contain a specific set of guidelines to ensure that proper management is accomplished and that all applicable laws are followed (http://www.dnr.state.mn.us/forestry/aitkin/98press13.html). The Sustainable Forestry Initiative (SFI) program is a dynamic and comprehensive system of objectives and performance measures that guide the responsible management of our forests. Several counties in Northeast Minnesota are active licensees of this program (http://www.minntrees.org/asp/default.asp?PageID=89).

Education - Minnesota uses Section 319 funds to determine the effectiveness of BMPs and to what extent they are being used in forestry operations throughout the state. The MPCA has a minor role in these activities. Minnesota has developed a field audit process to evaluate how extensively silvaculture BMPs are used in forest management operations on state, federal, county, private industrial, and nonindustrial private (small properties) forest lands. The audit process has been tested in Aitkin County. The field audits provide valuable information to the MPCA, the Minnesota DNR, and the forest community on the degree to which BMPs are being employed. Audit results provide a focus for educational efforts and technical assistance and identify practice deficiencies so that the state can clearly target corrective measures to improve compliance. Field audits began in the fall of 1991. The field audit forms used to evaluate forest management sites were based on the BMPs identified in Water Quality in Forest Management: Best Management Practices in Minnesota, the state-approved forestry BMP guidebook.

Solvent utilization

Stressors Included: Ground-level ozone.

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Terrestrial Organisms, Quality of Life-Aesthetics

Nonmethane VOCs are a principal component in the chemical and physical atmospheric reactions that form ozone and other photochemical oxidants. Nearly half (47.9 percent) of the 20.7 million metric tons of NMVOC emissions during 1995 came from industrial processes, of which solvent use was the largest source (http://www.eia.doe.gov/oiaf/1605/gg97rpt/chap6.html). The primary effect of solvent utilization is on production of ground-level ozone (http://www.bea.doc.gov/bea/an/0300are/table5.htm)

Cleanup – none identified.

Control – The MPCA requires air permits from individuals or industries that emit or have the potential to emit pollutants, including VOCs. The threshold for VOCs is 100 tons per year (http://www.pca.state.mn.us/air/aboutpermits.html#who).

Prevention – The Pollution Prevention Act (42 U.S.C. 13101 and 13102, s/s et seq.; 1990) focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use (http://www.epa.gov/region5/defs/html/ppa.htm). The Act states "… Congress hereby declares it to be the national policy of the United States that pollution should be prevented or reduced at the source whenever feasible (http://www4.law.cornell.edu/uscode/unframed/42/13101.html; http://www4.law.cornell.edu/uscode/unframed/42/13103.html). The Minnesota Toxic Pollution Prevention Act of 1990 states "…. [to] protect the public health, welfare, and the environment, the legislature declares that it is the policy of the state to encourage toxic pollution prevention. The preferred means of preventing toxic pollution are techniques and processes that are implemented at the source and that minimize the transfer of toxic pollutants from one environmental medium to another (http://www.revisor.leg.state.mn.us/stats/115D/12.html). Pollution prevention fees are collected from individuals producing hazardous waste. Emissions from solvent utilization declined in the 1990's because of the substitution of products and improvement of technologies (http://www.eia.doe.gov/oiaf/1605/gg97rpt/chap6.html; http://www.cleanairprogress.org/studies/summary.htm). There is information that describes alternatives for use of solvents for parts cleaning and degreasing (http://clean.rti.org/; http://www.ehsfreeware.com/p2comp.htm). The MPCA has established reduction goals for chemicals that lead to formation of ground-level ozone (http://www.pca.state.mn.us/hot/legislature/reports/2001/aq-report.pdf). Some organizations focus on proper disposal of solvents, particularly in the household (http://www.moea.state.mn.us/p2week/schools-paints.cfm; http://www.pca.state.mn.us/waste/hhw.html).

Education – none identified.

Spills

Stressors Included: Toxic chemicals in soil, toxic chemicals in water, oxygen-demanding pollutants, toxic organic chemicals.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

The MPCA's Emergency Response Team (ERT) members are responsible for organizing the MPCA's efforts for oil and hazardous material emergencies. Chemical fires, train derailments, pipeline breaks, tanker truck accidents and petroleum vapors in a sewer are examples of environmental and public health emergencies that the MPCA's ERT members respond to. The MDA is the lead agency for responses to agricultural chemical emergencies.

Cleanup – One of the goals of MPCA's ERT is to respond to environmental releases and support public safety protection and achieve cleanup (http://www.pca.state.mn.us/cleanup/ert.html; http://www.revisor.leg.state.mn.us/stats/115/061.html). The MDA Emergency Response Spills Team is responsible for directing and assisting with the response and cleanup of emergency agricultural chemical incidents (http://www.mda.state.mn.us/incidentresponse/99gd02.htm).

Control – Two goals of the ERT are preventing unpermitted releases of pollutants and ensuring emergency preparedness and planning (http://www.pca.state.mn.us/cleanup/ert.html; http://www.pca.state.mn.us/cleanup/pubs/ertpubs.html). Emergency Response Plans have been developed for some areas of Minnesota. Counties and services may have spill response plans through environmental services, waste management programs, etc.

Prevention – no program or activity identified.

Education – no program or activity identified.

Streambank erosion

Stressors Included: Transported sediment.

Impact Categories: Aquatic Organisms, Quality of Life-Aesthetics

Streambank erosion is a natural process in surface water, but human activities often accelerate the rate of erosion. Streambank erosion affects aquatic ecosystems.

Cleanup – none identified

Control – MN Statute, Chapter 103G.245 requires a permit prior to any alteration of Protected Waters and Wetlands, as identified by the Minnesota DNR. Other agencies may also have regulations for streambank or shoreline modification, including local government units, Soil and Water Conservation Districts, and the Army Corps of Engineers (http://www.shorelandmanagement.org/quick/faqpdf/spfaq.pdf; http://www.dnr.state.mn.us/waters/publications/lakeshim.pdf). The UMES provides information useful for controlling streambank erosion. This is most appropriately categorized as a control component since most of the recommended techniques involve technological ways of decreasing the potential for erosion (http://www.extension.umn.edu/distribution/naturalresources/components/DD6946g.html). Other organizations, such as the Minnesota Lakes Association, provide similar information (http://www.mnlakesassn.org/Main/Resources/ShorelandManagement/index.cfm).

Prevention – Leaving the natural shoreland undisturbed is often the best and least expensive protection against erosion. This preventive activity maintains shoreline in a natural condition without relying on technological solutions to maintain erosion protection. Methods for managing natural shoreland are promoted by the UMES and other local or private groups (http://www.extension.umn.edu/distribution/naturalresources/components/DD6946g.html).

Education – Education efforts are often linked with prevention efforts and are therefore conducted by the UMES, local agencies, and private groups (http://www.extension.umn.edu/distribution/naturalresources/components/DD6946g.html; (http://www.mnlakesassn.org/Main/Resources/ShorelandManagement/index.cfm).

Tanks

Stressors Included: Toxic chemicals in water, Explosive/flammable materials-high level accidental release, toxic chemicals-high level accidental release

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute

The primary effect of leaking tanks is on drinking water supplies, but leaking tanks have the potential to impact soil and aquatic ecosystems. This discussion focuses on impacts to drinking water supplies and human health risk associated with release of toxic or flammable chemicals. Tanks include both above- and below-ground tanks and all associated appurtenances, such as piping.

Cleanup

- LUST (Leaking Underground Storage Tank Program): The LUST program mission is to investigate petroleum releases from petroleum tanks, and to evaluate and remove risks to human health and the environment resulting from those releases. The risks targeted are those posed by petroleum contamination that has impacted ground water and may affect human health, led or may lead to dangerous conditions due to petroleum vapors, or affected or may affect surface water quality. Free product recovery to the extent practicable is required. Where pathways linking contaminant sources to receptors exist, risk removal efforts might include: replacement of the water supply wells or providing municipal water; long-term point-of-use treatment of contaminated ground water; or active remediation of petroleum contaminated soil and ground water (http://www.pca.state.mn.us/programs/lust_p.html#search).
- VPIC (Voluntary Petroleum Investigation and Cleanup) Program: The VPIC Program provides technical assistance and liability assurance needed to expedite and facilitate the investigation and cleanup of property that is contaminated with petroleum. MPCA approves corrective actions required under the Petroleum Tank Release Cleanup Act (Minn. Stat. 115C) (http://www.pca.state.mn.us/programs/vpic_p.html;).
- Aboveground Storage Tank (AST) Program: Cleanup procedures within the AST generally follow guidelines specified through the LUST Program, with a few exceptions that are described at http://www.pca.state.mn.us/cleanup/pubs/c1-17.pdf. The AST Program typically refers to large facilities. Smaller facilities are dealt with through the LUST Program. Smaller facilities are required to develop a spill response plan that describes procedures for cleanup of leaking tanks and spills (http://www.pca.state.mn.us/cleanup/pubs/2_12.pdf).

Control

- UST (Underground Storage Tank) Program: All regulated UST systems must have spill protection, overfill protection, corrosion protection, and leak detection to comply with state and federal requirements. However, regulated USTs that receive less than 25 gallons of product at a time are only required to have corrosion protection and leak detection (http://www.pca.state.mn.us/cleanup/ust.html#regulations). The Storage Tank Compliance and Assistance Program provides storage tank owners and operators with the information they need to prevent spills and leaks at their facilities. Program staff offer underground storage tank owners technical assistance about tank requirements and spill prevention. Technical assistance is available through tank inspectors, workshops, the tanks help line, the agency's tank newsletters, fact sheets, and a web page. The program also evaluates compliance of tank facilities with state statutes and rules through inspections and investigations and determines appropriate enforcement actions when violations are discovered. Regulated underground storage tanks must be installed, upgraded or removed by a certified supervisor (that is a certified contractor or a person employed by a certified contractor). This program operates a certification program for underground storage tank contractors and supervisors (http://www.pca.state.mn.us/programs/tanks_p.html).

- AST: Facilities that have more than one million gallons capacity must obtain an individual permit from the MPCA (Minnesota Rules Chapter 7001.4205-4250). These facilities must create a standard for safe operation of aboveground storage tank facilities. In addition, these facilities are required to use industry standards for tank construction and maintenance activities. Facilities storing less than one million gallons of liquid substances shall follow Minnesota Rules Chapter 7151. Tanks that are greater than 500 gallons in capacity and less than or equal to 1,100 gallons in capacity and located within 500 feet of a Class 2 Surface Water must meet the labeling and secondary containment requirements only. Owners of ASTs larger than 110 gallons must notify the MPCA of the existence of these tanks. In addition, tank owners are required to notify the MPCA within 30 days of a change of product or change of status of ASTs. All ASTs must have a secondary containment area surrounding the tank that can hold 100 percent of the contents of the largest tank located within the containment area. Tanks at existing sites must have a continuous dike surrounding the tanks. Secondary containment for ASTs must be impermeable to the materials being stored. All tanks must be routinely monitored to ensure they are not leaking. ASTs must have corrosion protection for the floor of the tank. Areas where substances are transferred must be equipped with spill containment. All regulated tanks must be equipped with overfill prevention equipment. Regulated AST owners of tanks larger than 1,100 gallons are required to keep records about the system design, containment area evaluation, tank monitoring, and tank inspections (http://www.pca.state.mn.us/cleanup/ast.html). The Aboveground Petroleum Storage Act of 1990 requires owners and operators of AST's to file a storage statement with the State Water Resources Control Board and implement spill prevention measures by developing and utilizing a Spill Prevention Control and Countermeasure (SPCC) Plan that is specific for the site (http://www.sbcfire.org/ofm/field_services/ast.shtml; http://www.epa.gov/oilspill/spcc/).
- Agriculture: The MDA guidance on rules for facilities that store, handle or use anhydrous ammonia are available at http://www.mda.state.mn.us/appd/nh3/nh3rules.pdf. The storage of pesticides is regulated by the MDA under Minnesota Ch. 18B, Pesticide Control Law (http://www.revisor.leg.state.mn.us/stats/18B/). The storage of fertilizers is regulated by the MDA under Minnesota Ch. 18C (http://www.revisor.leg.state.mn.us/stats/18C/).

Prevention – A Toolkit for Enhanced Opportunities for P2 and Sustainable Activities at Remediation Sites helps MPCA staff and program users identify and implement enhanced opportunities for P2 and sustainable activities at remediation sites. Some of the Toolkit guidelines may be applicable to tank sites, but it has not been widely used within the tank programs (http://www.pca.state.mn.us/programs/p2-s/remediation/toolkit.html).

Education – no program or activity identified

Trains

Stressors Included: Explosive/flammable materials-high level accidental release, toxic chemicals-high level accidental release.

Categories Impacted: Human Health-noncancer acute

See discussions under Residences and Spills.

Treatment/settling ponds

Stressors Included: Odorous chemicals from biological processes

Impact Categories: Human Health-noncancer chronic, Human Health-noncancer acute, Quality of Life-Aesthetics

Treatment and settling ponds includes a variety of activities that result in odor and associated health problems. Manure management is probably the most important of these activities, but most activities that utilize treatment and settling ponds for organic chemicals generate odors. These include activities associated with management of petroleum, vegetable and fruit processing, or waste management.

Cleanup – none identified

Control – The MPCA regulates feedlots and wastewater treatment facilities, although wastewater treatment is addressed under Municipal and industrial wastewater (http://www.pca.state.mn.us/hot/feedlots.html; http://www.pca.state.mn.us/water/wastewater.html; http://www.pca.state.mn.us/water/wastewater-engineering.html). Local agencies may administer regulations or programs related to management of these wastes. A variety of BMPs may be implemented to reduce odor problems (http://www.bae.umn.edu/extens/manure/odor/; http://www.cahe.nmsu.edu/pubs/_m/m-106.html; http://www.united-tech.com/aq_ProdLn.html; http://www.epa.state.il.us/p2/fact-sheets/hog-facts.html; http://www.betzdearborn.com/customer_successes/customersuccesses.asp?CS_ID=264).

Prevention – Some of the activities included in the above references for control may also be classified as prevention, particularly if the waste is utilized and odor and health effects are controlled.

Education – none identified

Unpermitted waste disposal

Stressors Included: Toxic chemicals in soil, toxic chemicals in water, excess UV radiation from stratospheric ozone depletion, toxic chemicals in food.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Human Health-noncancer acute, Aquatic Organisms, Terrestrial Organisms

Unpermitted waste disposal includes wastes that are not incinerated, reused, land applied, or landfilled at permitted facilities. Municipal and industrial wastewater treatment is a permitted activity, but many of the wastes treated through this activity may be improperly disposed (for example, household hazardous waste dumped down the sink). These wastes, although they pass through municipal and industrial wastewater treatment plants, are addressed in this section of the document.

Cleanup

- MERLA : Superfund (http://www.pca.state.mn.us/programs/superf_p.html; http://www.revisor.leg.state.mn.us/stats/115B/) and the VIC Program (http://www.pca.state.mn.us/cleanup/vic.html#intro; http://www.pca.state.mn.us/cleanup/vic.html) contain or eliminate human exposure to toxic chemicals. These programs conduct a variety of land and ground water cleanups. Metro District Site Remediation continues to investigate potential contaminant sources for inclusion in the Superfund program.
- RCRA Corrective Action : RCRA covers a wide variety of programs dealing with waste management including a program involved in cleanup of improperly managed hazardous wastes referred to as RCRA Corrective Action (http://www.epa.gov/epaoswer/hazwaste/ca/index.htm). RCRA was amended by the 1984 Hazardous and Solid Waste Amendments (HSWA), which include RCRA Corrective Action. A variety of land and ground water cleanups are conducted under RCRA Corrective Action. Two types of sites are subject to RCRA Corrective Action: 1-Hazardous Waste Treatment, Storage, or Disposal Facilities, commonly referred to as TSDs. These facilities have RCRA permits allowing the treatment, storage and or disposal of hazardous wastes; and 2-Interim Status Hazardous Waste Treatment, Storage, or Disposal Facilities, commonly referred to as Interim Status Facilities. These facilities at one time applied for a RCRA treatment, storage and or disposal permit, but did not complete the permitting process. Although the permitting process was never completed, by applying for the permit, such facilities were allowed to conduct business as a Hazardous Waste Treatment, Storage, or Disposal Facility operating under interim status. Hazardous Waste Generators, usually referred to as Generators, are not subject to RCRA Corrective Action as defined in the 1984 HSWA. However, releases or potential releases from these sites are required to be properly investigated and if necessary remediated in accordance with other hazardous waste management rules found in Minn. Rules Chapter 7045 that are administered by the MPCA RCRA and remediation programs. Generators include all entities that generate a hazardous waste and include all very small, small, and large quantity generators. While conducted under different rules and authorities, investigation and remediation at Generator sites often follow the phased Corrective Action process. The Hazardous Waste Treatment, Storage, or Disposal Facilities enter the RCRA corrective action program through the permitting process. Interim Status Facilities enter the RCRA Correction Action Program through a negotiated process initiated by the MPCA. Hazardous Waste Generators usually enter the RCRA remediation program through evidence of suspected releases to soil and or ground water

from improper management of hazardous wastes or hazardous constituents uncovered during hazardous waste inspections conducted by state, county or city inspectors (http://www.pca.state.mn.us/cleanup/rcra.html).

- Landfill Program (see also Permitted waste disposal): Because of potential contamination from old, abandoned, unpermitted dumps, the Minnesota Legislature in 1999 appropriated one million dollars for a two-year environmental assessment program, looking at old dumps in the state. In 2001, the MPCA will report to the Legislature on which dumps may pose a threat to public health or the environment (http://www.pca.state.mn.us/cleanup/pubs/c8-01.pdf).
- MPCA's Pretreatment Program does limited cleanup, such as removal of mercury from sewers.
- Fertilizers: The MDA is the lead agency for response to, and cleanup of, agricultural chemical contamination (pesticides and fertilizers) in Minnesota. These activities are generally associated with unpermitted disposal or spills. This lead role was an outcome of the 1989 Minnesota Groundwater Protection Act which provided the MDA authority for agricultural chemical contamination under the Minnesota Environmental Response and Liability Act (MERLA – the Minnesota "Superfund") and created a reimbursement fund for the partial reimbursement of agricultural chemical cleanup costs (Agricultural Chemical Response and Reimbursement Account - ACRRA). The program operates under the primary authorities of Minnesota Chapters: 115B (MERLA); 18B (Pesticide Control Law); 18C (Fertilizer Law); 18D (Agricultural Chemical Liability, Incident, and Enforcement Law); and, 18E (ACRRA). The MDA agricultural chemical incident response program has four major program areas: 24 hour emergency response; comprehensive facility investigations; the Voluntary Cleanup and Technical Assistance Program (AgVIC); and, the Agricultural Chemical Response and Reimbursement Account (ACRRA) (http://www.mda.state.mn.us/incidentresponse/default.htm#Overview).
- Pesticides: The MDA is the lead agency for response to and cleanup of agricultural chemical contamination (pesticides and fertilizers) in Minnesota. This role was an outcome of the 1989 Minnesota Groundwater Protection Act which provided the MDA authority for agricultural chemical contamination under the Minnesota Environmental Response and Liability Act (MERLA – the Minnesota "Superfund") and created a reimbursement fund for the partial reimbursement of agricultural chemical cleanup costs (Agricultural Chemical Response and Reimbursement Account – ACRRA). The program operates under the primary authorities of Minnesota Chapters: 115B (MERLA); 18B (Pesticide Control Law); 18C (Fertilizer Law); 18D (Agricultural Chemical Liability, Incident, and Enforcement Law); and, 18E (ACRRA). The MDA agricultural chemical incident response program has four major program areas: 24 hour emergency response; comprehensive facility investigations; the Voluntary Cleanup and Technical Assistance Program (AgVIC); and, the ACRRA. The incident unit also is a contact point for agricultural chemical incident and facility database searches (http://www.mda.state.mn.us/incidentresponse/default.htm).

Control

- RCRA : The RCRA was enacted in 1976 to address the issue of how to safely manage and dispose of the huge volumes of municipal and industrial waste generated nationwide. The RCRA program is administered by EPA's Office of Solid Waste. Subtitles C and D of RCRA set forth the framework for EPA's comprehensive waste management program. RCRA Subtitle C establishes the regulatory structure for managing hazardous waste from the time it is generated until its ultimate disposal. RCRA Subtitle D establishes a system for managing solid (primarily nonhazardous) waste, such as household waste (http://www.epa.gov/epaoswer/hotline/rcra.htm; http://www.pca.state.mn.us/cleanup/rcra.html). A variety of other wastes are covered through various rules (http://www.pca.state.mn.us/waste/sw_mnrules.html). The above rules are generally successful in controlling the majority of solid waste discharged to the environment. Unknown quantities of waste are released from very small quantity generators (VSQG), households, and from people or industries that do not comply with the rules. Under the federal program, VSQGs are called conditionally exempt generators and are exempted from most of the provisions of RCRA (Federal hazardous waste rules) provided the waste is not spilled and is disposed at an acceptable facility. Under the federal program, an acceptable facility may be either a hazardous waste facility or a permitted solid waste facility (landfill or incinerator). In Minnesota, these generators have been regulated under the hazardous waste rules since the start of the hazardous waste program in the 1970's. Although they are excluded from certain minor parts of the Minnesota hazardous waste rules, most VSQGs are still required to meet hazardous waste storage and disposal standards, obtain a license, manifest their waste shipments and pay hazardous waste generator fees. In the metropolitan area, county level hazardous waste programs conduct many of the VSQG licensing, manifest, and inspection activities. The county programs do not have civil enforcement authority, therefore, they refer civil cases and clean ups to the MPCA for resolution. In Greater Minnesota, the average amount of VSQG waste is 1.5 % of the total waste volume generated, but in more sparsely populated areas, this proportion will increase. For example, in the Lake Superior Basin, VSQGs generate 23 percent of all the hazardous waste produced in the region.
- Landfill Program (see also Permitted waste disposal): The MPCA Landfill program is responsible for permitting active landfills (http://www.pca.state.mn.us/waste/pubs/sw-execsum.html#perpetual).
- Non-MPCA : MN Statute (473.811, subd. 5b) requires that the metropolitan counties have a hazardous waste program and an ordinance that "may not be inconsistent... and must be at least as stringent as the agency *(MPCA)* hazardous waste rules." Each Metro county administers a hazardous waste program (http://www.pca.state.mn.us/programs/bau_p.html). Eighty-seven counties in Minnesota operate household hazardous waste programs (http://www.pca.state.mn.us/waste/hhw.html). Several counties operate various environmental service programs, including waste management

(http://www.pca.state.mn.us/waste/hhw.html#program). Some cities operate collection systems for specific types of wastes (http://www.ci.fridley.mn.us/serv/monthlydrop.html)

- The Industrial Pretreatment Program seeks to control the discharge of industrial (and other) wastes into the sanitary sewer. This is done through many kinds of controls. The POTW (publicly owned (wastewater) treatment works)(i.e. the municipal sewage treatment plant and the authority who operates it) is inherently the primary control authority. Therefore, most of the actual regulatory work of pretreatment is carried out by POTWs.
- Agriculture: Pesticide Response Plans include emergency response in cases of spills or leaks. MDA's Waste Pesticide Collection Program helps farmers, small businesses, households, and other pesticide users to properly dispose of unwanted and unusable pesticides (http://www.mda.state.mn.us/appd/wastepest/default.htm). The amount of pesticide collected through the Waste Collection Program has increased from 34100 pounds in 1991 to 236500 pounds in 1995 and 410718 pounds in 1999 (http://www.mda.state.mn.us/appd/wastepest/pounds.htm).

Prevention – MN Rules, Chap. 155D states "To protect the public health, welfare, and the environment, the legislature declares that it is the policy of the state to encourage toxic pollution prevention. The preferred means of preventing toxic pollution are techniques and processes that are implemented at the source and that minimize the transfer of toxic pollutants from one environmental medium to another … The legislature intends that the programs developed under sections 115D.01 to 115D.12 shall encourage and lead to a greater awareness of the need for and benefits of toxic pollution prevention, and to a greater degree of cooperation and coordination among all elements of government, industry, and the public in encouraging and carrying out pollution prevention activities. A review of MPCA prevention activities shows a wide diversity of programs. These programs are generally not coordinated. Many activities labeled as prevention activities would more accurately be defined as control programs, since they do not have the primary goal of reducing waste at the source (http://www.pca.state.mn.us/water/stormwater-i.html). The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. Examples of prevention efforts are discussed below.

- Although P2/S is not commonly included as part of the cleanup process, successful examples exist (http://www.pca.state.mn.us/programs/p2-success.html). Once cleanup is underway, an existing business or redevelopment plan can incorporate P2 measures. A Toolkit for Enhanced

Opportunities for P2 and Sustainable Activities at Remediation Sites helps MPCA staff and program users identify and implement enhanced opportunities for P2 and sustainable activities during cleanup, ongoing business and redevelopment at remediation sites on a voluntary basis in the Superfund, VIC, and RCRA corrective action programs. (http://www.pca.state.mn.us/programs/p2-s/remediation/toolkit.html; http://www.pca.state.mn.us/programs/inpdes_p.html).

- Project XL is a voluntary state and federal pilot program. Project XL supports regulated parties that demonstrate excellence and leadership (XL) in protecting the environment who are willing to undertake new initiatives that go beyond the existing requirements of state and federal law. In exchange for their superior environmental performance, these parties will receive increased operational flexibility and reduced environmental-management costs (http://www.pca.state.mn.us/programs/projectxl/index.html#background). Minnesota pilot projects are summarized at http://www.pca.state.mn.us/programs/projectxl/xlprojects.html.
- MnTAP, operated through the U of M, helps businesses prevent pollution and better manage waste. MnTAP provides assistance to a wide range of industry sectors. A variety of outreach efforts are coordinated through MnTAP (http://www.mntap.umn.edu/).
- The MOEA provides information, assistance, grants and loans in the areas of waste and pollution prevention, recycling, reuse, environmental education, sustainable communities, and resource conservation to protect Minnesota's environment and assure a sustainable economy (http://www.moea.state.mn.us/).
- There are a large number of organizations at the national, state, and local level, including a variety of public and private organizations and nonprofit organizations, dedicated to incorporating prevention into waste reduction (http://www.mntap.umn.edu/ see Links).

Education – The MPCA and external agencies operate various programs designed to train people who manage wastes, but few of these programs are geared toward education. Numerous fact sheets have been prepared and are available on the web, but there appears to be little outreach associated with getting this information to potential users. Minnesota has many organizations involved in environmental education. They are not well coordinated and the focus is not necessarily on waste reduction (http://www.moea.state.mn.us/reduce/index.cfm). The MPCA does not have coordinated education programs.

Urban runoff

Stressors Included: Toxic metals, transported sediment, toxic organic chemicals, temperature increase/climate change, oxygen-demanding pollutants, dissolved solids, phosphorus, nitrogen.

Impact Categories: Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Urban runoff includes overland discharge to receiving water bodies, infiltration or injection of stormwater collected in retention basins, and leakage from sewers. The primary contaminants include phosphorus, nitrogen, ammonia, metals, and organic materials. The effects of urban runoff are on aquatic and terrestrial ecosystems. The most recent National Water Quality Inventory reports that runoff from urban areas is the leading source of impairments to surveyed estuaries and the third largest source of water quality impairments to surveyed lakes (http://www.epa.gov/OWOW/NPS/facts/point7.htm). Improperly functioning sewer systems can result in ground water contamination, which in turn may affect aquatic ecosystems. Additional information for this section can be found in this document under Construction. Short summaries are provided below.

Cleanup – Most large municipalities in Minnesota have Public Works departments that are charged, in statute, with repairing and maintaining sewer systems (http://www.ci.stpaul.mn.us/code/lc081.html; http://www.ci.eagan.mn.us/water_resources/3_07.htm). Corrective actions may be required for activities that result in off-site transport of sediment or chemicals.

Control

Sewers: MN Rules 7077.0100 provides for the MPCA's administration of financial assistance programs for … the combined sewer overflow program for grants awarded on or after July 1, 1990, under Minnesota Statutes, section 116.162 (http://www.ci.stpaul.mn.us/code/lc081.html). EPA has issued a national policy statement entitled "Combined Sewer Overflow (CSO) Control Policy." This policy establishes a consistent national approach for controlling discharges from CSOs to the Nation's waters through the National Pollutant Discharge Elimination System (NPDES) permit program (http://www.epa.gov/owm/csopol.htm). This policy provides guidance to permitees with CSOs, NPDES authorities and State water quality standards authorities on coordinating the planning, selection, and implementation of CSO controls that meet the requirements of the Clean Water Act and allow for public involvement during the decision-making process. Implementation of storm sewer separation has occurred in much of the Twin Cities Metropolitan Area (http://www.kyeqc.net/minutes/2000/nkuminutes.htm). Many municipalities implement storm sewer maintenance and repair, though not by statute (http://www.newulm.com/city/publicworks.html; http://www.ci.hammond.in.us/sewer/paper.html).

Storm water: The 1987 Amendments to the Clean Water Act required the US EPA to develop regulations for stormwater discharges associated with construction and industrial activity. NPDES permitting authority was given to the MPCA to administer this federal program (http://www.pca.state.mn.us/water/stormwater.html). Phase I of the US EPA's storm water program relies on NPDES permit coverage to address storm water runoff from "medium" and "large" municipal separate storm sewer systems (MS4s), construction activities disturbing five or more acres of land, and ten categories of industrial activity. The Storm Water Phase II expands the Phase I program by requiring additional operators of MS4s in urbanized areas and operators of small construction sites (1 to 5 acres), through the use of NPDES permits, to implement programs and practices to control polluted storm water runoff. Nonpoint contributions of pesticides from agricultural and, to a lesser extent, urban land use are addressed through a variety of non-regulatory programs. Nonpoint programs focus on education, training, and consequently, voluntary controls for stormwater. MDA operates a voluntary BMP program for pesticides (http://www.mda.state.mn.us/appd/BMPs/BMPs.htm; http://www.pca.state.mn.us/water/nonpoint/nsmpp-ch10.pdf).

Prevention – As of January, 1999, 45 cities in Minnesota collected fees based on stormwater runoff volume and pollution. In the Twin Cities Metro Area, over 23 million dollars in stormwater utility fees were collected in 1997. Most of this money, however, goes toward maintenance and repair of existing infrastructure. http://www.me3.org/sprawl/envlfin.pdf states "… the *Smart Growth Scenario* specifies that households sited according to that plan will create 53 percent fewer transportation-related site imperviousness acres … compared to the site plan for the *Sprawling Scenario*." There are a variety of other prevention activities. New developments can maintain the volume of runoff at predevelopment levels by using structural controls and pollution prevention strategies. Plans for the management of runoff, sediment, toxics, and nutrients can establish guidelines to help achieve both goals. Management plans are designed to protect sensitive ecological areas, minimize land disturbances, and retain natural drainage and vegetation. Existing urban areas can target their urban runoff control projects to make them more economical. Runoff management plans for existing areas can first identify priority pollutant reduction opportunities, then protect natural areas that help control runoff, and finally begin ecological restoration and retrofit activities to clean up degraded water bodies. Citizens can help prioritize the clean-up strategies, volunteer to become involved with restoration efforts, and help protect ecologically valuable areas. The control of nutrient and pathogen loading to surface waters can begin with the proper design, installation, and operation of onsite disposal systems (OSDSs). These septic systems should be situated away from open waters and sensitive resources such as wetlands and floodplains. They should also be inspected, pumped out, and repaired at regular time intervals. Household maintenance of septic systems can play a large role in preventing excessive system discharges (http://www.epa.gov/OWOW/NPS/facts/point7.htm; http://www.epa.gov/OWOW/NPS/roads.html; http://www.epa.gov/OWOW/NPS/runoff.html). The second phase of Clean Water Partnership (CWP) projects involve putting in place best management practices (BMPs), including sedimentation ponds, manure management, conservation tillage, terraces, new ordinances, wetland restoration, fertilizer management, education or other methods designed to reduce nonpoint-source pollution. FANMAP, a program administered through MDA, is designed to educate farmers in sensitive hydrologic environments about assessing nutrient and pesticide needs (http://mrbdc.mankato.msus.edu/inventory/state/sbmp.html; http://www.mda.state.mn.us/appd/1999acpp.pdf). MPCA water quality permitting staff are collaborating with MnTAP to promote preventative approaches in Phosphorus Management Plans.

Education - The United States Congress enacted Section 319 of the federal Clean Water Act in 1987, establishing a national program to control nonpoint sources of water pollution. There are educational activities associated with Section 319 funds (http://www.bae.umn.edu/annrpt/1996/outreach/exten15.html; http://www.pca.state.mn.us/water/nonpoint/mplan.html). Fact sheets and manuals have been written with Section 319 or other funds, but it appears little outreach is associated with many of these publications (http://www.pca.state.mn.us/water/pubs/sw-bmpmanual.html). The CWP program was created in 1987 to address pollution associated with runoff from agricultural and urban areas. The program provides local governments with resources to protect and improve lakes, streams and ground water. Educational components are built into both phases of a CWP effort. Both Section 319 and CWP program focus on improving a water resource that has been polluted by land-use-related activities. FANMAP, a program administered through MDA, is designed to educate farmers in sensitive hydrologic environments about assessing nutrient and pesticide needs. The Nonpoint Education for Municipal Officials (NEMO) program is an educational program for local land use officials that addresses the relationship of land use to natural resource protection. There are multiple NEMO projects in Minnesota, most focusing on the Great Lakes (http://nemo.uconn.edu/; http://nemo.uconn.edu/edprog.htm; http://www.seagrant.umn.edu/water/nemo.html; http://nemo.uconn.edu/newnatl/stateprograms/mi-wi.html).

Urban development

Stressors Included: Habitat modification

Impact Categories: Aquatic Organisms, Terrestrial Organisms, Quality of Life-Aesthetics

Urban development has a wide variety of environmental effects, including consumption of fossil fuels associated with sprawl; runoff; and management of wastes, such as with septic systems. Some of these are discussed in other sections. We discuss urban development in terms of environmental effects on habitat modification. These occur through wetland drainage, deforestation and loss of natural areas, and fragmentation. Urban development, however, can occur in a manner that minimizes these environmental effects, or, in the case of abandoned or blighted properties, enhances development of habitat. A variety of urban development strategies can be utilized to redevelop properties and make them more "habitat-friendly". These include watershed protection (targeting growth to areas outside of sensitive aquifer recharge areas or watersheds), urban growth boundaries (a regulatory strategy for limiting urban development by creating a geographical boundary for new development), in-fill development (a strategy to direct development within previously developed areas), brownfield redevelopment (turning idle and possibly contaminated urban properties into productive use, versus "greenfield" development on previously undeveloped land), and open space protection (strategy to protect undeveloped or agricultural land)(http://www.marinenv.com/pg2.pdf). MPCA's authority is limited in the arena of urban development. The primary tool available to MPCA is through its cleanup programs, which can decrease urban sprawl and, when conducted properly, encourage habitat development in otherwise abandoned or blighted areas. Beyond these activities, partnership with other governmental and non-governmental organizations is necessary to affect urban development activities that impact environmental quality (http://intranet.pca.state.mn.us/programs/smartgrowth/actionfinal.pdf). The MPCA identified four leverage areas where smart growth can be incorporated into Agency activities. These include providing data and information, education and outreach, planning assistance, financial assistance and incentives, and regulation. Many local agencies are concerned with environmental affects of urban development. Like MPCA, these agencies are limited in their ability to manage urban development.

Cleanup – Brownfields are abandoned, idled, or underused industrial and commercial properties where expansion or redevelopment is complicated by actual or suspected environmental contamination. By investigating and cleaning up brownfield sites, many of which are abandoned or blighted properties in inner-city areas, redevelopment can take place without fear of environmental legal liabilities. This benefits Minnesota communities by bringing new businesses, jobs and an improved tax base to areas where brownfield sites have been unused and unproductive. Brownfield sites in Minnesota are addressed by programs at both the state and local level. The MPCA has several programs that work on investigating and cleaning up brownfield sites. The individual MPCA program that works with a particular site is based on the types of contaminants present or the circumstances under which the contamination occurred (http://www.pca.state.mn.us/cleanup/brownfields.html). The VIC Program can encourage development in areas that are already developed (in-fill development). While the focus of this program is to improve environmental quality through cleanup actions, activities can be conducted in a manner that is favorable for habitat development. Information on regulatory authority for the various programs can be found under Tanks and Unpermitted waste disposal.

Control – Under Minnesota State Statute 115.07, subdivision 3, permits are required for extensions of sanitary sewers. The MPCA can use traditional regulatory authorities (rules, standards, enforcement, etc.), as appropriate, to discourage practices and behaviors for which education, planning assistance, and financial assistance and incentives are insufficient motivators for achieving "smarter" growth and development. The MPCA can work with the MDH and local agencies and organizations to protect areas with vulnerable resources. Examples include development in areas where wild and scenic rivers exist, wellhead protection areas, or sole-source aquifer areas (http://www.health.state.mn.us/divs/eh/dwp/swp/whp_mn2.html). The Metropolitan Council can develop policies that affect urban development, such as development of municipal water and sewer lines (http://www.metrocouncil.org/sgtc/news_events.htm; http://www.metrocouncil.org/).

Prevention – Brownfield development can be conducted or encouraged in a manner that is "habitat-friendly". Examples include establishing guidelines for planting, care, maintenance and removal of trees, shrubs and any other plantings in public areas; making provisions for lots that are contiguous with or directly adjoin an intermittent or perennial stream or river; and encouraging development of greenways (http://www.sustainable.doe.gov/codes/napaord.shtml; http://www.sustainable.doe.gov/codes/santaros.shtml; http://www.sustainable.doe.gov/codes/sttrees.shtml#12.28.010). Although little of this activity currently exists in Minnesota, the MPCA can align financial assistance and incentive programs to promote development decisions and projects that are more environmentally protective in the long-term (http://www.pca.state.mn.us/programs/smartgrowth/). The business operations and redevelopment options promoted in MPCA's Toolkit for P2 and Sustainable Activities at Remediation Sites also apply to non-contaminated sites. This toolkit has not been fully integrated into MPCA service delivery programs.

Education – The MPCA can provide education and outreach to local officials, state and regional agencies, and members of the public on the environmental impacts of growth and development. Areas in which education can be implemented include wastewater, storm water, brownfields redevelopment, air quality/transportation, and basin management efforts. Other potential educational areas include researching areas of knowledge gaps, compiling and organizing existing information into more useable forms by decision-makers and the public, gathering program staff who are currently working on issues in focus areas into intra-agency working groups that meet cooperatively with local communities to carry out these Action Directions, and participating in the Governor's Local Solutions Alliance pilot program to develop similar collaborative approaches at an interagency level, as well. There are many educational activities conducted by a variety of organizations. Lesson plans and numerous links to educational materials are available on the web. Colleges and universities offer degrees and programs in sustainable development and land use planning (http://www.planning.org/kidsandcommunity/; http://www.sustainable.doe.gov/efficiency/educ/educatn3.shtml; http://www.sustainable.doe.gov/landuse/luedtoc.shtml).

Waste incineration

Stressors Included: Toxic chemicals in food, toxic metals.

Impact Categories: Human Health-cancer, Human Health-noncancer chronic, Aquatic Organisms, Terrestrial Organisms

Waste incineration is a source of PBTs, which may enter the food chain. Waste incineration also releases chemicals that may affect human health through inhalation, but these activities are discussed under Industry.

Cleanup – MPCA and MDA operate cleanup programs that deal with hazardous wastes, although it is difficult to ascertain what their role would be in the case of air deposition from waste incineration.

Control – The Clean Air Act (42 USC 7412) provides the regulatory authority and framework for regulating air releases from waste incineration. The US EPA has jurisdiction over incineration involving PCBs and hazardous waste from Superfund sites (http://books.nap.edu/books/030906371X/html/184.html#pagetop). All hazardous waste incinerators are currently required to control particulate emissions to 0.08 grains per dry standard cubic foot of air emissions (40 CFR 264.343) (http://www.crwi.org/textfiles/partem.htm). The Omnibus Mercury Emissions Reduction Act of 1998 amends the Clean Air Act to require new standards for mercury emissions from solid waste and medical waste incineration units (http://www.cnie.org/nle/waste-16.html). Regulation of waste incineration is largely administered at the state level. Waste incinerators must follow the same air pollution control requirements as other emission sources (http://www.revisor.leg.state.mn.us/arule/7007/0200.html; http://www.pca.state.mn.us/air/permits/index.html).

Prevention – Incineration is considered by environmental groups to represent a destruction of materials that could potentially be reused and recycled. There are recommendations regarding how to minimize impacts from waste incineration facilities (http://www.sierraclub.org/policy/conservation/solidwaste.asp). True prevention consists of efforts to reduce waste production. There are many prevention efforts designed to reduce waste generation. Some of these are discussed under Unpermitted waste disposal and other sections that deal with generation of waste. The Coordinated Toxics Reduction Strategy refers to a collaborative effort by staff in the Office of Environmental Assistance and Minnesota Pollution Control Agency to gain meaningful cross-media reduction in toxic substances emphasizing preventative approaches (http://intranet.pca.state.mn.us/programs/ctrs/index.html#network). Although meetings of the Network have been discontinued for the time being, meetings will be resumed when current efforts in single- and multimedia monitoring, evaluation and modeling of PBTs have evolved to the point where the group is ready to consider developing and implementing multimedia pollution prevention strategies or other collaborative action items. The MOEA's website is a good starting point for more information on waste reduction efforts (http://www.moea.state.mn.us/reduce/index.cfm).

Education – Minnesota has many organizations involved in environmental education. They are not well coordinated and the focus is not necessarily on waste reduction (http://www.moea.state.mn.us/reduce/index.cfm). The MPCA does not have coordinated education programs.

List of Abbreviations

AST – Aboveground Storage Tank
AU – Animal Units
BACM – Best Available Control Measures
BMPs – Best Management Practices
BWSR – Board of Water and Soil Resources
CFC – Chlorofluorocarbon
CFR – Code of Federal Regulations
Ch. – Chapter
CRP – Conservation Reserve Program
CSO – Combined Sewer Overflow
CWP – Clean Water Partnership
DNR – Department of Natural Resources
EAW – Environmental Assessment Worksheet
EIS – Environmental Impact Statement
EPA – Environmental Protection Agency
EQIP – Environmental Quality Incentives Program
ERT – Emergency Response Team
FAA – Federal Aviation Administration
FANMAP - Farm Nutrient Management Assessment Program
FR – Federal Register
HAPs – Hazardous Air Pollutants
HHW – Household Hazardous Waste
HSWA - Hazardous and Solid Waste Amendments
IRRRB – Iron Range Resources and Rehabilitation Board
ISTS – Individual Sewage Treatment System
LUST – Leaking Underground Storage Tank
MDA – Minnesota Department of Agriculture
MSP – Minneapolis-St. Paul
MOEA – Minnesota Office of Environmental Assistance
MPCA – Minnesota Pollution Control Agency
NAAQS – National Ambient Air Quality Standards
NEMO – Nonpoint Education for Municipal Officials
NESHAP – National Emission Standards for Hazardous Air Pollutants
NPDES – National Pollutant Discharge Elimination System
NRCS – National Resource and Conservation Service
OHV – Off Highway Vehicle
OHWL – Ordinary High Water Level
PM – Particulate Matter
PBT – Persistent Bioaccumulative Toxic
POTW – Publicly Owned Treatment Works
R. - Rule
RCRA – Resource Conservation and Recovery Act
St. – Statute
SDS – State Disposal System
Subd. - Subdivision

TMDL – Total Maximum Daily Load
U of M – University of Minnesota
UMES – University of Minnesota Extension Service
US – United States
USDA – United States Department of Agriculture
UST – Underground Storage Tank
VIC – Voluntary Investigation and Cleanup
VPIC – Voluntary Petroleum Investigation and Cleanup
VOC – Volatile organic compound
VSQG – Very Small Quantity Generators

Appendix E: Socioeconomic Information

Contents

I. Introduction

A. Demographics, Socioeconomics, Economics, and Environmental Decision Making

The environment decisions of the Agency have always and inevitably been shaped and influenced by economic, social and demographic conditions and events, and by perceptions, assumptions and beliefs regarding the significance and relevance of such conditions and events. Correspondingly and characteristically, economic, social and demographic data and information has – with certain programmatic exceptions – only been brought into Agency decisions informally and implicitly: according to the case-by-case experiences and judgements of those Agency staff and stakeholders immediately involved in particular policies or programs.

To recognize these characteristic limitations of Agency decision making is not to suggest that over time Agency decisions have been incorrect or technically unsound. It is to argue however – in keeping with certain essential recognition of GOAL 21 – that by finding ways to more usefully and effectively bring demographic, socioeconomic and economic considerations into decision making, environmental policy decisions can potentially be: better focused and coordinated across media; more closely attuned to stakeholders issues and concerns; and better able to proactively respond to systemic societal change. As a part of this overall effort this section of the EIR is intended to be a first step.

B. The Challenge of Selection. One of the fundamental challenges of incorporating economic data and information into the Environmental Information Report (EIR) – and especially of trying to provide an overview and summary of such data and information – is that of selecting those facts to be presented. Across Minnesota there is a vast, almost limitless accumulation of recorded and unrecorded environmental, demographic, socioeconomic and economic facts and correspondingly literally thousands of specific and more general stories of economic – environmental interactions

To select and present in summary form certain, particular economic, social, demographic and environmental facts is to inevitably leave out the overwhelming majority of facts that could be profitably considered and explored. It is also – if not to actually suggest or present some number of stories regarding such facts – to select certain places where, based on the facts, stories of interactions ought to be considered explored and uncovered. In this first iteration of the EIR we have focused on the following major areas:

- *Demographics,* particularly the demographics of rural decline and urban expansion and the aging of Minnesota's population;
- *Income,* including the distribution of income within as well as between Minnesota's communities;
- *Economic Productivity and Materials Flows,* emphasizing the material basis of the economy as inflows, outflows and hidden flows; and
- *Transportation, Population Density and Energy Use*, particularly the role of transportation in structuring Minnesota's communities and their corresponding energy use.

In selecting these areas of attention we have necessarily and inevitably left out far more than we have included. It is the intent of this first iteration of the Demographics, Socioeconomics and Economics section of the EIR however, that what we have included serve as something like a *baseline* for the areas considered – subject of course to updating, expansion and correction. Subsequent iterations of the EIR will have the opportunity to explore other demographic, socioeconomic and economic questions, facts and stories.

C. Appendices and Supplemental Materials. Following the main body of the report there are several appendices that provide data tables used to generate the charts and graphs in the main body of the report along with supplemental data tables and graphics. Finally there is preliminary typology of five characteristic Minnesota socioeconomic/cultural groups; a discussion of conceptual issues faced by the overall EIR in bringing together the particular and the general; and a preliminary discussion of the demographics and socioeconomics of rural Minnesota relative to the ISTS program and programmatic alternatives.

II. Demographics

A. Demographics: Population Growth, Relocation and Decline

From 1900 to 1960 Minnesota's population close to doubled from 1.75 million to 3.41 million, growing at an average rate of approximately 15% per decade. By 1970 – the approximate beginning of the MPCA and its programs – the population of the state was 3.80 million. From 1970 to 2000 the State's population grew at an average rate of approximately 9% per decade (weighted by a 90s rate of 12.45%) to a total of 4.91 million. The projected 2020 population of Minnesota is 5.24 million. At least as noteworthy as this overall growth in population are two other trends:

- the geographical redistribution of Minnesota's population from rural to urban/suburban: and
- the overall aging of Minnesota's population.

In thirty year increments, from 1900 to 2020 the rural - urban (i.e., urban/suburban) balance of Minnesota's population changed and is expected to change as follows:

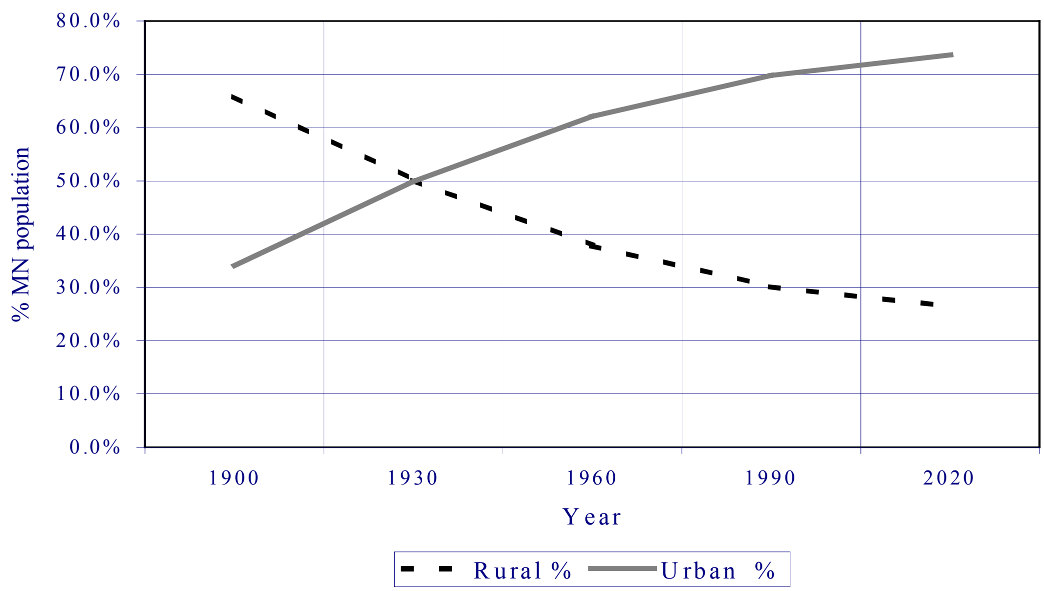

Figure D.1 The Urbanization of Minnesota's Population 1900-2020

The Demographics and Geography of Urban Expansion

Geographically the urban/suburban dominance of Minnesota's population has involved: the continuing rapid demographic and spatial expansion of the Twin Cities Metropolitan area; accompanied by the emergence as metropolitan centers of Rochester, Mankato, and St. Cloud, and by the development and expansion of population corridors extending from Rochester and Mankato north to the Twin Cities, and from the Twin Cities north to St. Cloud. In addition to St. Cloud and Rochester, those other regional centers designated as metropolitan areas by the US census: Duluth-Superior, Fargo-Moorhead, Grand Forks-East Grand Forks, have also continued to expand, if at a slower rate than the Twin Cities metropolitan area.

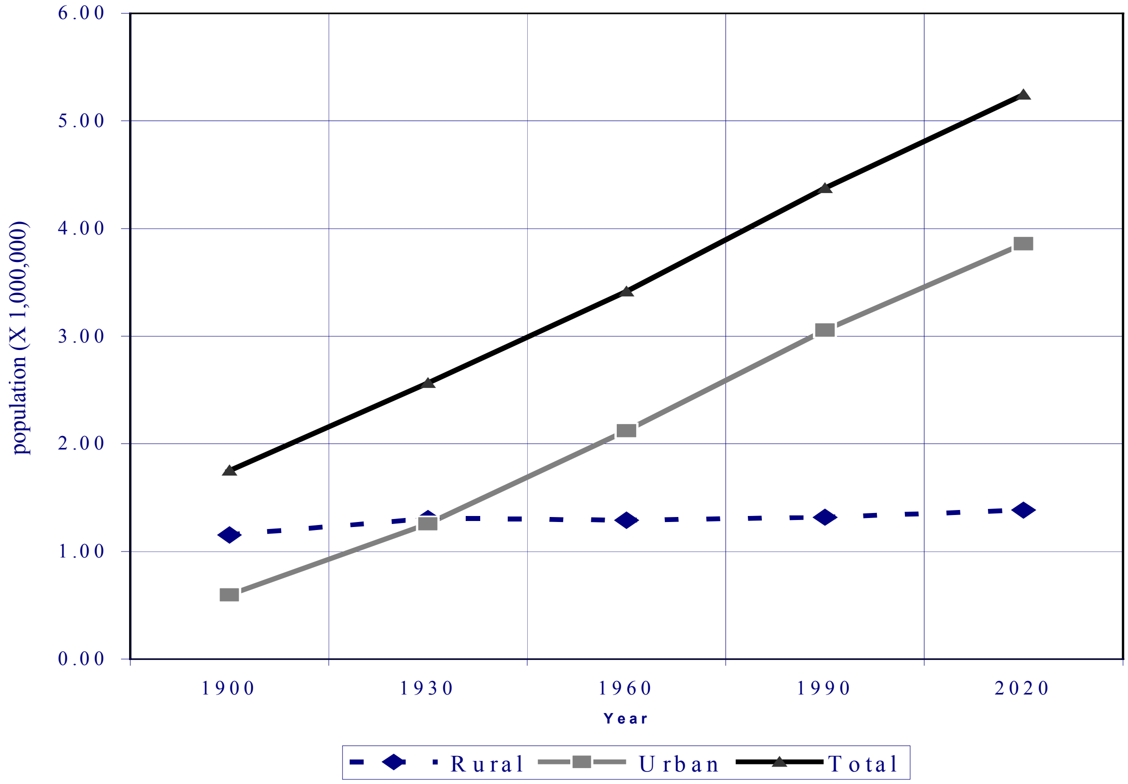

Figure D.2. The Rural/Urban Configuration of Population Expansion 1900-2020

<u>The Demographics of Rural Decline</u>
At a statewide level Minnesota's rural population has remained relatively constant from 1930 to 1990 and as projected to 2020. An exclusively statewide perspective however, masks significant even dramatic structural socioeconomic and cultural changes in the state's rural population. Consider that from 1980 to 2000 no less than forty of Minnesota's eighty-seven counties actually lost population, led by Traverse which declined at a rate of slightly more than 25%. In contrast, over the same time period Minnesota's two fastest growing counties – Sherburne and Scott of the Twin Cities metropolitan area – expanded at over 100%.

B. Demographics: The Aging of Minnesota's Population
Perhaps the most remarkable demographic change in Minnesota from 1900 through 2000 and as projected to 2025, is the dramatic re-distribution in the age profile of the State's population. The age profile of a population is the distribution of the overall population by age groupings. The population distributions in Figure D.3 represent the age distributions of the State's 1900, 1930, 1960, 2000 (i.e.,1998), and projected 2025 populations.

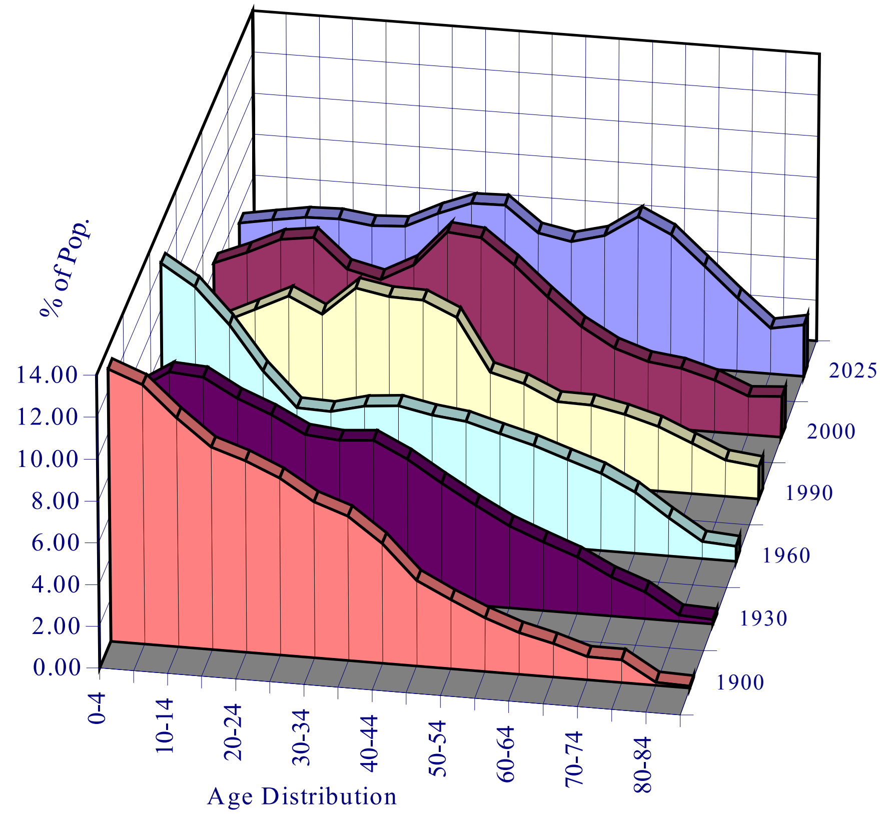

Figure D.3 The Age Distribution of Minnesota's Population

The shape of the age distribution for 1900, although somewhat exaggerated by the influx of young immigrants is generally analogous to the structure characteristic of pre-modern societies. In contrast, demographically the 2000 profile with its tiered configuration is characteristic if a *mature industrial society*. Finally the projected 2025 profile, where the lower age groupings are substantially reduced while the elderly population has become much more pronounced represents the aged population of a *post-industrial*. Overall the aging of Minnesota's population is generally recognized as one of the most significant demographic trends of the next several decades, but to fully appreciate the dramatic, even overwhelming effects of this change requires a structural consideration of changes in age distribution not only between but *within* Minnesota communities.

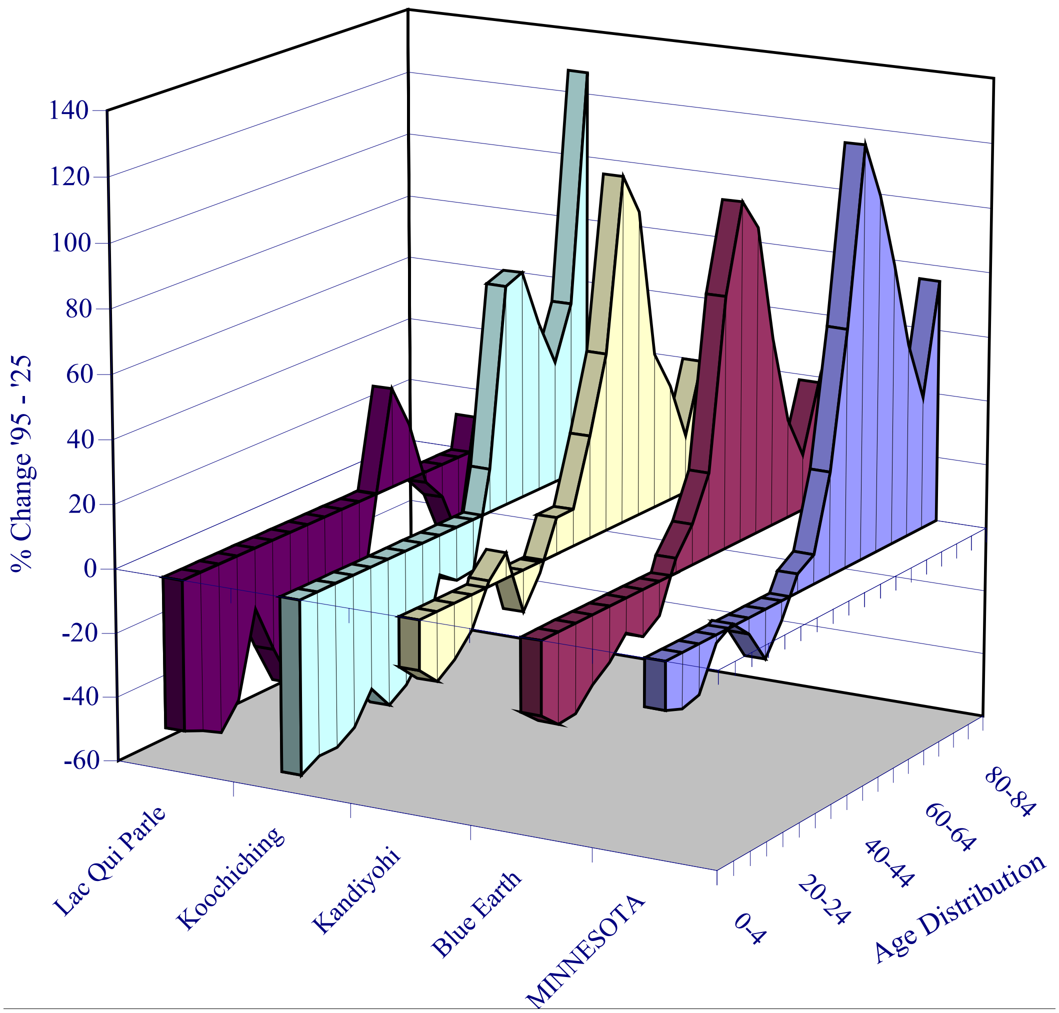

Figure D.4 Projected 1995-2025 Changes in Age Distribution of Four Rural Counties

Figure D.4 illustrates projected changes in age structure of five rural Minnesota counties for the period from 1995 to 2025. The corresponding projected changes in age structure of four urban/suburban Minnesota counties for the period from 1995 to 2025 is as follows:

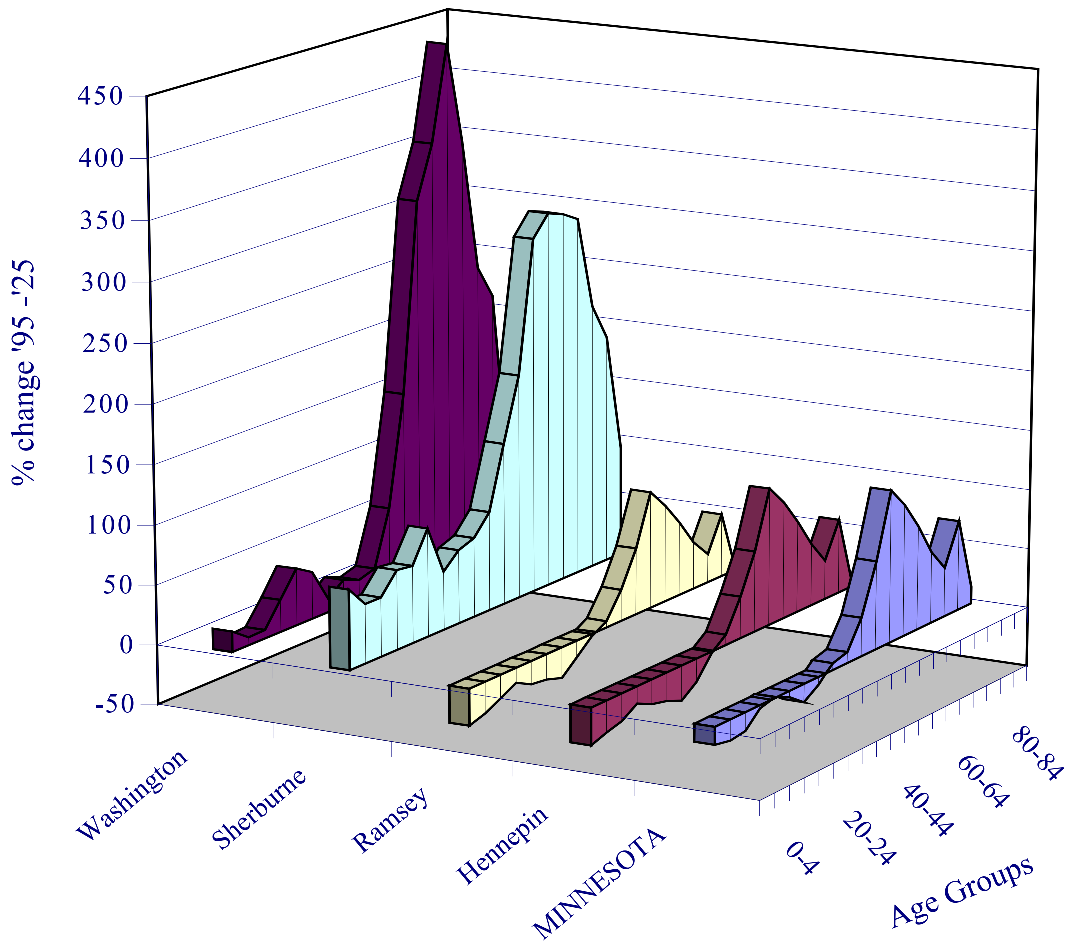

Figure D.5 Projected 1995-2025 Changes in Age Distribution of four Urban/Suburban Counties

The considerable difference in the positive scale of "% change '95 – '25" between Figures D.4 and D.5 (i.e., 140% to 450%) is driven primarily by Washington County and to a lesser extent Sherburne County. The dramatic increases in the elderly population is in part reflective of the small 1995 elderly population of these counties. Conversely, while the projected numbers of elderly in '95 and '25 are at least comparatively, not great the change in the character of these communities will nevertheless be pronounced.

Elderly Dependency and Rural Minnesota

For rural Minnesota, the *historically unprecedented* transformation to a population dominated demographically by the elderly has already been substantially accomplished.

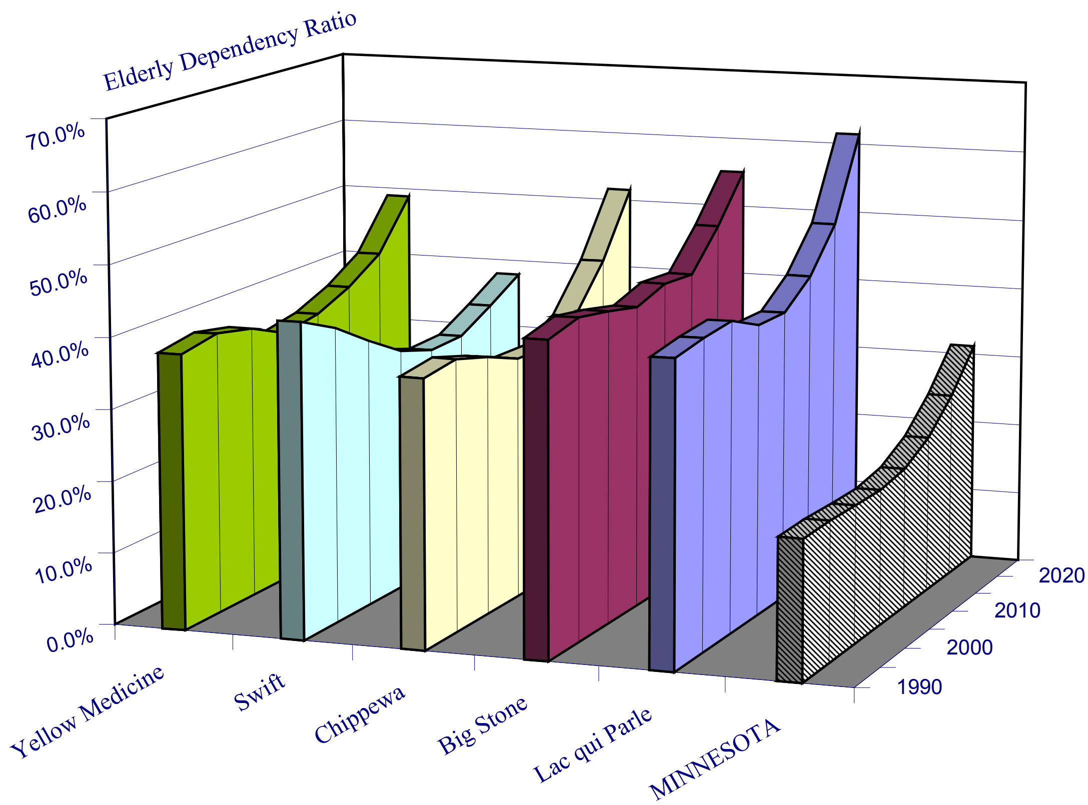

Figure D.6 Elderly Dependency Ratios of Upper MN River Counties: 1900-2025

As an example, consider the transformation of Lac Qui Parle County, as representative of the Upper Minnesota River Development District and of rural Minnesota generally. At the beginning of the 20th century the general age profile of Lac Qui Parle, as one of Minnesota's youngest communities, was as follows:

- 46.2% under 20;
- 49.9% from 20 to 64 inclusive;
- 3.8% 65 and older; and
- 6.4% elderly dependency ratio.

The *Elderly Dependency Ratio* is the number of individuals 65 and older as compared to the overall working age population (i.e., individuals from 15 to 64 years of age inclusive). It is in certain respects a measure of the ability of a community's government and community services to be self-supporting economically. That is, the lower the elderly dependency ratio the larger the working age population and corresponding economic activity available within the community to meet the needs of the elderly. With an elderly dependency ratio of 6.4% , Lac Qui Parle county of 1900 was a frontier community of recent immigrants

In contrast consider the elderly dependency ratio of Lac Qui Parle and the four other Upper Minnesota River counties[2] over the period from 1990 and as projected to 2025,

[2] These five counties are defined as the "Upper Minnesota River Economic Development District" by the Minnesota Department of Trade and Economic Development.

relative to the overall elderly dependency ration of Minnesota (Figure D.6). Note in particular that while the *change* in the elderly dependency ratio of the five counties over the period under consideration generally follows the 1990-2025 trend line throughout the State, the 1990 *starting point* of these Upper Minnesota River counties *already ranges from 38.3 to 43.8%* over twice that of the overall State (i.e., 19.3%).

<u>Elderly Dependency and Urban Minnesota</u>
Figure D.7 illustrates the 1990-2025 change in the elderly dependency ratio of four urban Minnesota counties and of the overall State. These counties exhibit greater variation in their 1990 elderly dependency ratios (9.6% to 18.4%) than the Upper Minnesota River counties, with the newly urbanizing suburban counties at close to one-half that of the state and the older, central city dominated counties approaching the overall state ratio. This variation however is clearly secondary to the striking contrast between these urban counties and Upper Minnesota River, where rural elderly dependency ratios are up to *four times* those of the identified urban counties.

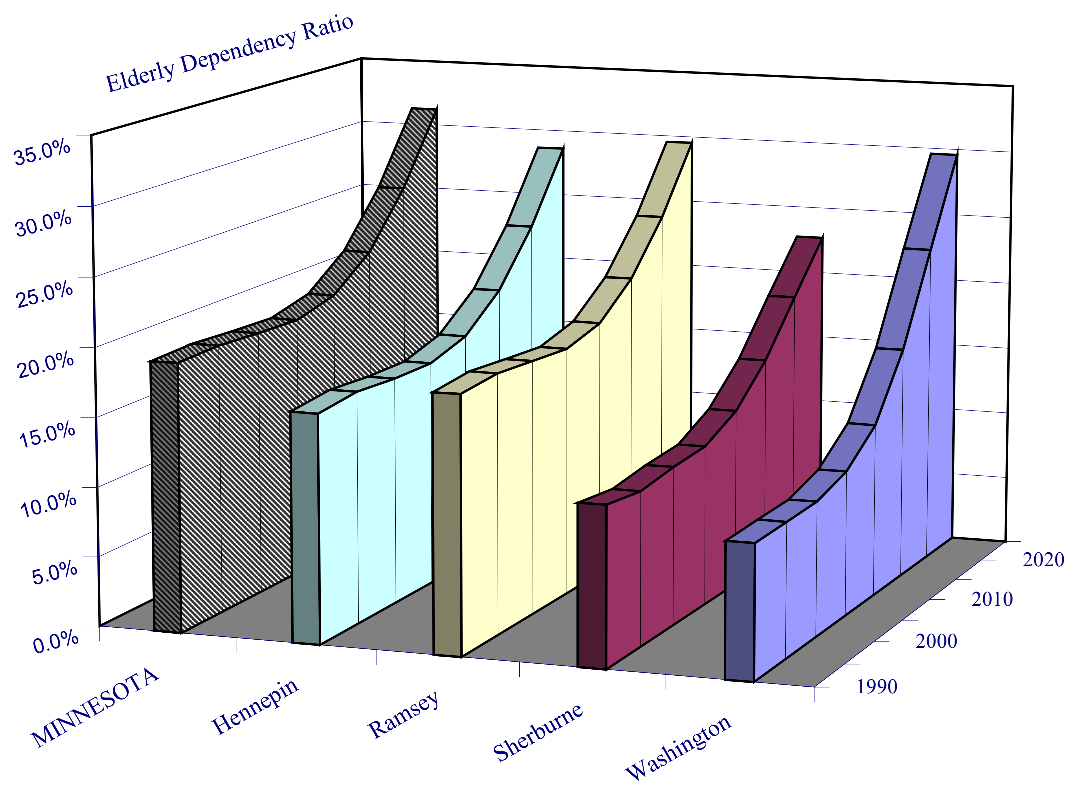

Figure D.7: Elderly Dependency Ratio for Minnesota and selected Minnesota counties.

III. Minnesota's Income, Income Distribution and Cost of Living

A. Income[3]

From 1970 to 2000 Minnesota's overall real[4] median household income (MHI) increased by 22.8% from $38,665 to 47,478., While characteristically at or above the national average, the trend of Minnesota's income from 1970 to 2000 paralleled the national economy, with income growth remaining relatively flat from the late seventies to the mid-eighties and then expanding continuously throughout the late eighties and nineties. Relative to per capita personal income Minnesota currently ranks among the top ten to fifteen states nationwide. Reflective of the structure of population and income nationally, Minnesota's economy and corresponding personal income is dominated by the state's metropolitan areas, as indicated below:

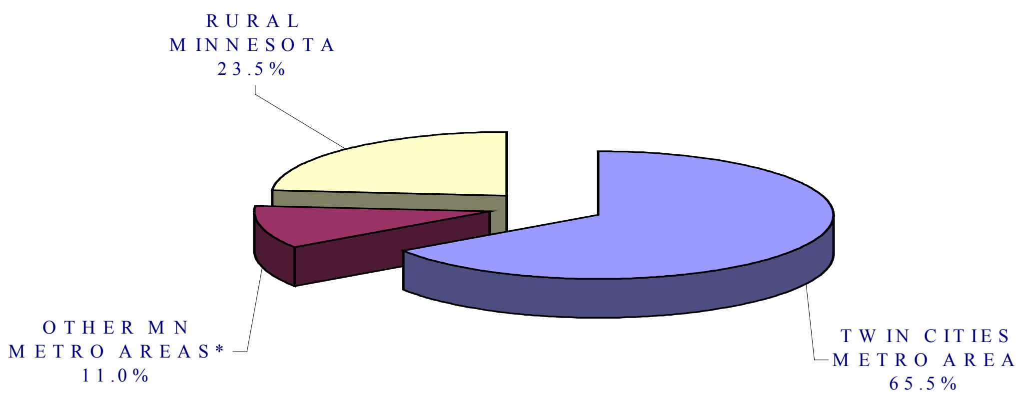

Figure D.8 Metropolitan – Rural Distribution of Household Income

* Duluth (Superior), Rochester, Moorhead (Fargo), St. Cloud, East Grand Forks (Grand Forks), Houston County (La Crosse)

B. Distribution of Income

While the metropolitan-rural geographical distribution of Minnesota's income is pronounced, uncovering the highly discontinuous and even dramatic character of the state's income distribution requires a structural consideration of *income levels* not only between but also *within* Minnesota communities. If we begin at a *generalized statewide* scale, the distribution of income according to *level of income* is, as illustrated in Figure D.9, *fairly continuous* with the exception of concentrations at the lowest and along a range of high incomes (i.e., from approximately $50,000 to $100,000).

[3] Because household income figures from the 2000 census are not scheduled to be available until the summer of 2002 the income information in this section is drawn primarily from 1990 census data. In those cases indicated the dollar amounts of such data have been converted to 2000 dollars.

[4] All dollar amounts are in 2000 dollars as adjusted by the Dept. of Commerce CPI.

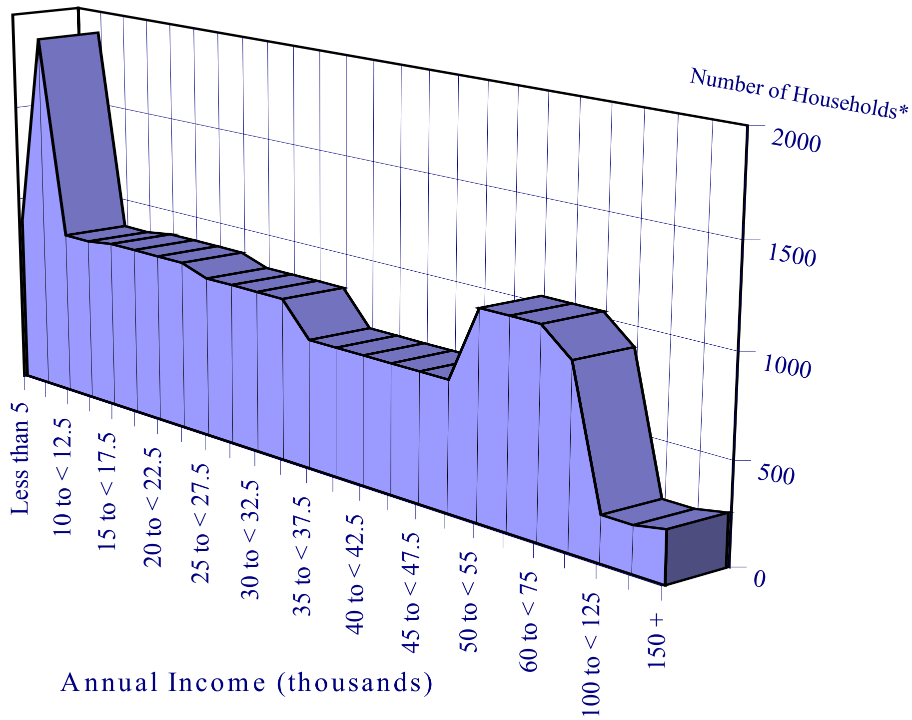

Figure D.9: Statewide distribution of household income by level of income
Number of households has been normalized to 20,000.[5]

As we turn from a *generalized statewide* distribution however to consider the characteristic income structures of a number of Minnesota communities we encounter a much different story:

[5] For the comparison of income distribution between very different size communities the number of households on Figures D.9 through D.12 has been normalized, that is adjusted as if all of the communities considered have a total of 20.000 households.

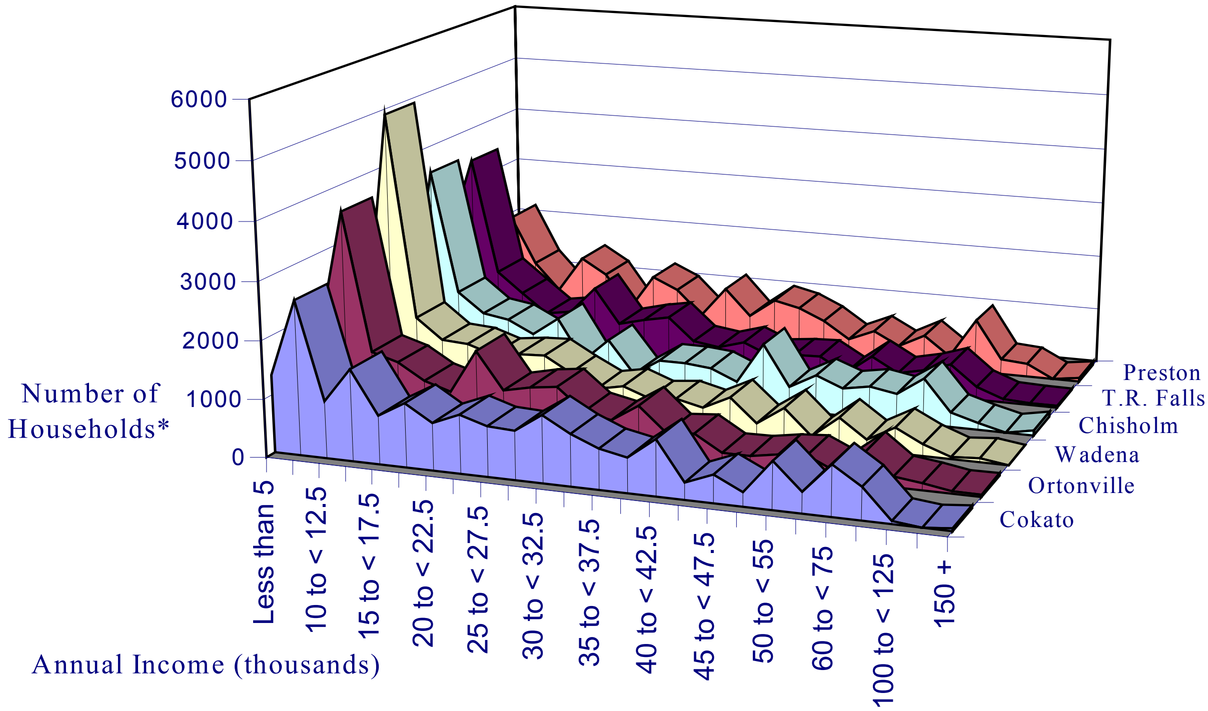

Figure D.10 Six Rural Cities: Distribution of household income by level of income Number of households has been normalized to 20,000.

These five cities are representative of the income structure of Minnesota's rural communities, and reveal the poverty levels characteristic of much of rural Minnesota. Of the five Cokato is an interesting example because given its location inside the western most boundary of Wright County it is technically categorized according to the US Census as a city of the Twin Cities metropolitan area. However the structure of its income is analogous to that of a rural community, and as such is something like a reversal or mirror opposite of the characteristic income structure of Twin Cities suburban communities as indicated below:

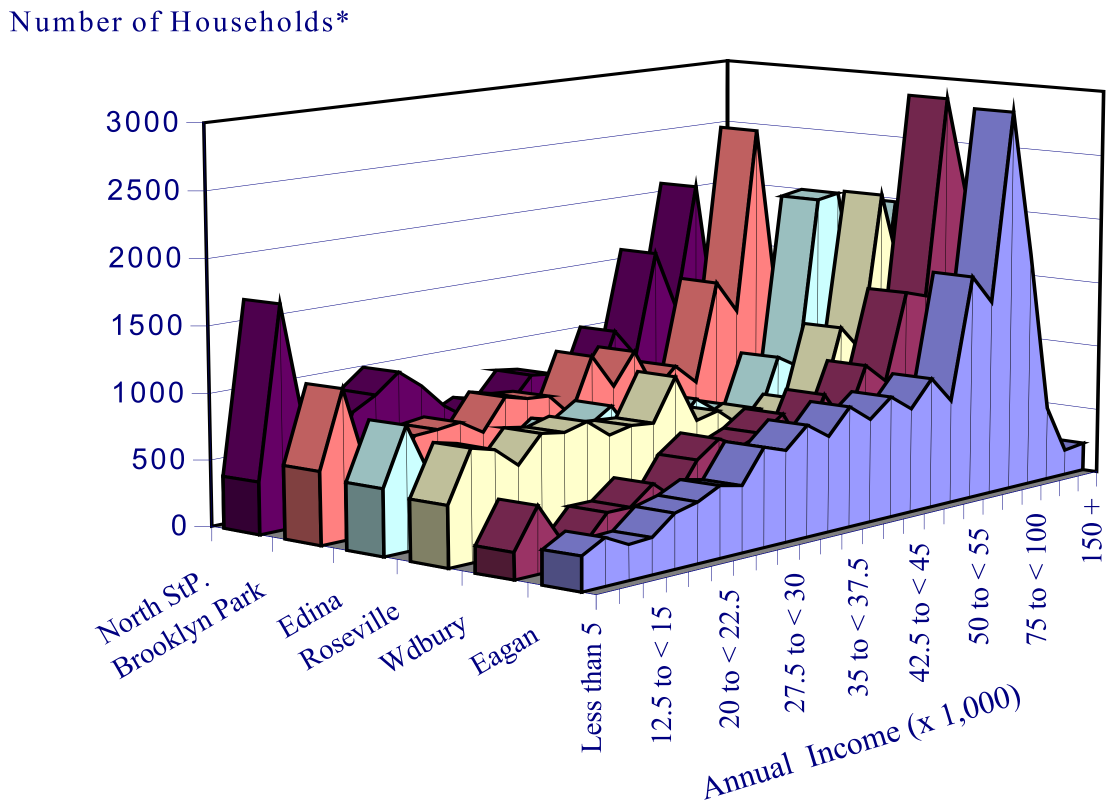

Figure D.11 Six Metropolitan Twin Cities Communities:Distribution of household income by level of income (Number of households has been normalized to 20,000).

In contrast to rural and suburban communities Minneapolis, St. Paul, and Duluth, as established central cities of metropolitan areas, share their own characteristic income structures as indicated below:

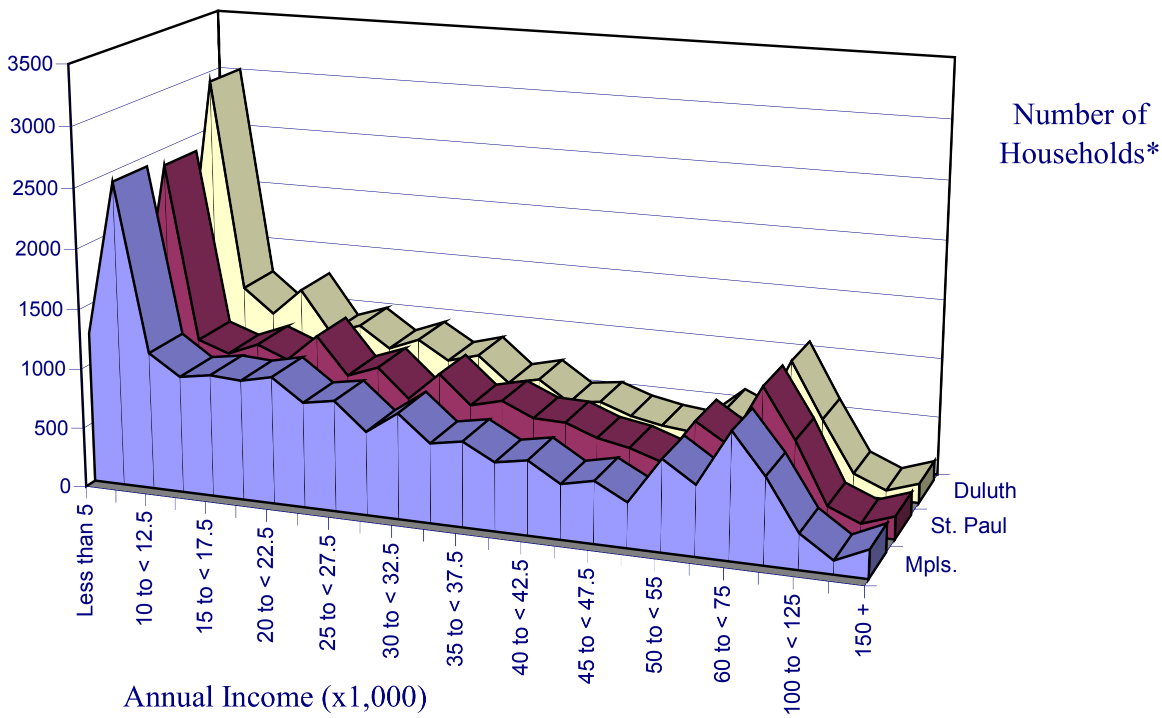

Figure D.12 Three Central Cities:Distribution of household income by level of income (Number of households has been normalized to 20,000).

B. Cost of Living

While the overall *disparity* of income between rural and particularly suburban Minnesota (i.e., Figure D.10 as compared to Figure D.11) would seem to be more pronounced than is generally assumed is the case; the corresponding and generally held assumption that a *lower cost of living* in rural areas substantially off-sets this disparity requires some consideration.

United States Bureau of Labor Statistics studies provide a picture of the *distribution of expenditures* in an average household budget in the Twin Cities Metropolitan Area, as illustrated in Figure D.13:

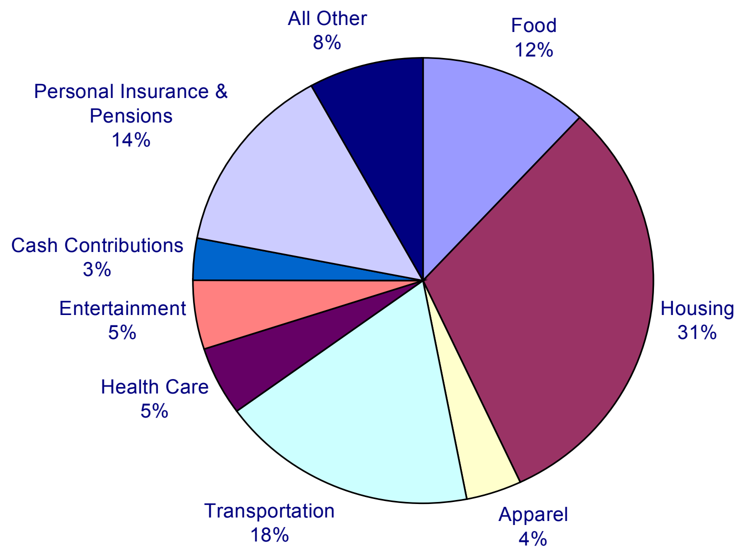

Figure D.13 Twin Cities Metropolitan Area:Distribution of Household Expenditures

Housing costs account for the largest part of the household budget. Housing costs cover more than house payments. They include the costs of: rents, property taxes, utilities, household appliances and furnishings, insurance, and maintenance. After housing costs come transportation and a mixed category called "health, recreation and other" costs. (Note: the transportation category includes an element of public transit costs.)[i]

Households outside of the Twin Cities metropolitan area have a different budget picture than Twin Cities metropolitan households. A Minnesota legislative auditor's report (1989) found that housing costs outside of the Twin Cities Metro Area averaged 40% lower than costs within the metropolitan area. This difference in housing costs is the primary factor in reducing the overall cost of living by 11% outside of – as compared to within – the Twin Cities metropolitan area. However regional differences in other areas of household costs tend to offset each other (e.g., Twin Cities metro area costs for physical goods and utilities are lower, costs of services are higher) such that apart from housing the prices of goods and services in rural Minnesota are not necessarily lower than in the Twin Cities metropolitan area. Accordingly the average difference of an 11% lower rural cost of living as driven by lower housing costs, does not make up for an average 29.3% difference in income, and as the remarkably skewed household income distributions in Figures D.10 and D.11 indicate, in this case averages are not particularly representative of the actual situations of households.

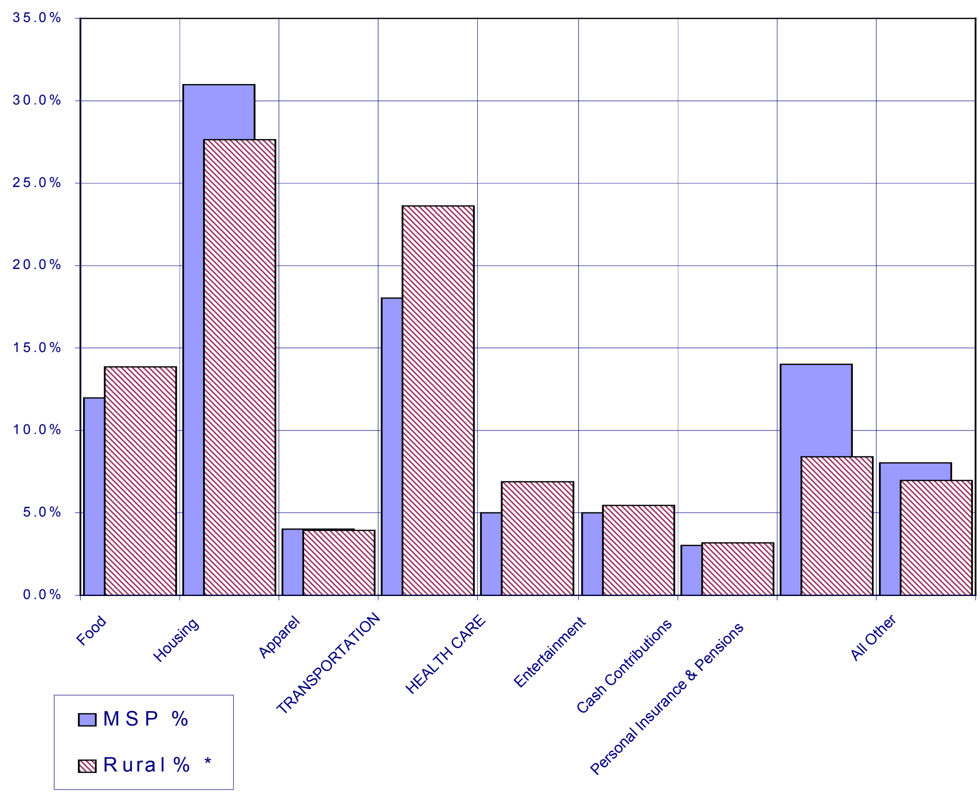

Figure D.14 Twin Cities Metropolitan Area and Rural Minnesota: Distribution of Household Expenditures

Finally, as indicated in Figure D.14, rural Minnesotan's expend a higher percentage of their overall household budgets on transportation and health care: costs that tend to be not only inflationary and even potentially volatile relative to household expenditures generally but where rural opportunities for economizing and substitution are limited by access and dispersion.

IV. Economic Productivity and Materials Flows

A. Economic Productivity

Minnesota's gross state product increased by 61.2% from 1986 to 1999 achieving a 1999 total of $167.11 trillion dollars (i.e., in constant 1997 dollars). As Figure D.15 indicates Minnesota's economic growth over the last two decades has generally exceeded that of the nation as a whole:

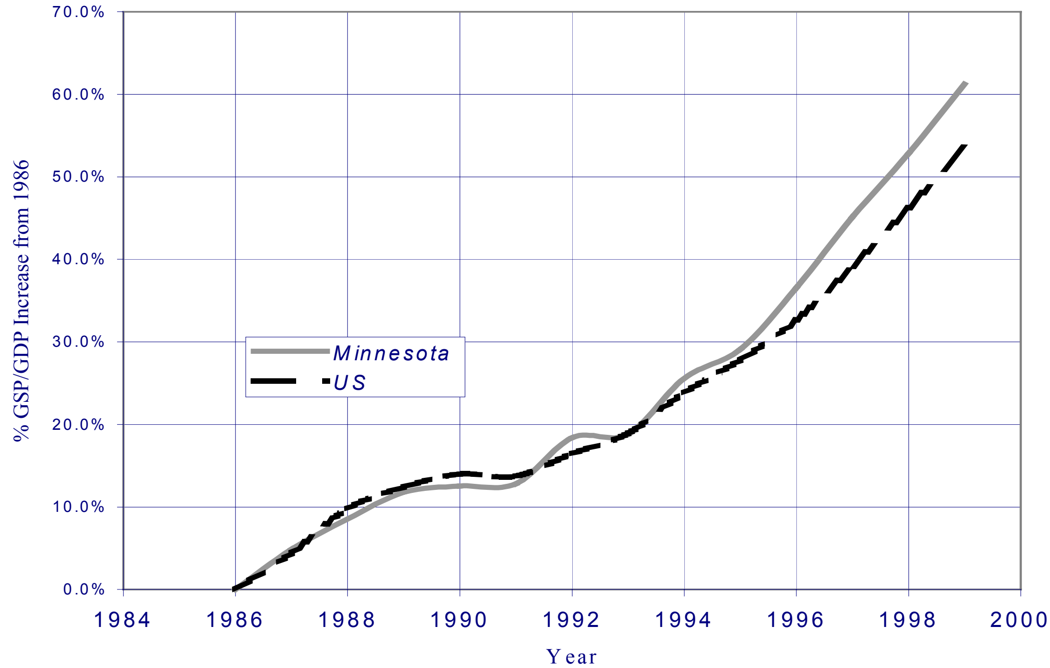

Figure D.15 Gross State Product as Compared to the US Gross Domestic Product
(in constant 1997 dollars)

As the source of Minnesota's income, perhaps the most significant and fortuitous characteristic of Minnesota's economy is its diversity. While certain regions of the state, for example the iron range, are dependent upon particular economic sectors, overall the diversity of Minnesota's economy closely matches that of the national economy. The makeup of Minnesota's economy by major industrial sector, represented below, varies by at most 1.5% per sector from the analogous distribution of the national economy

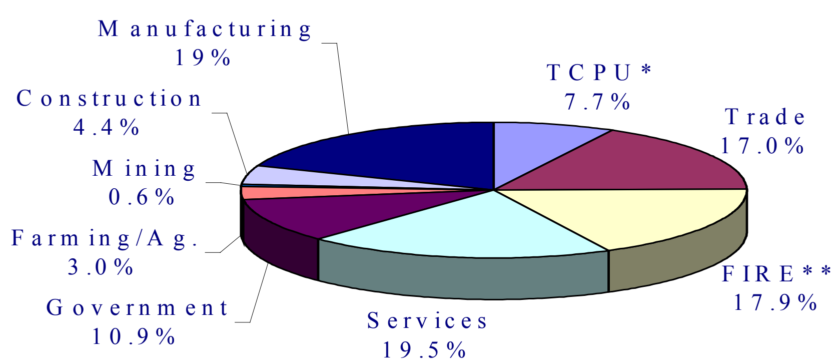

Figure D.16 Gross State Product by Industrial Sector
* TCPU – Transportation, Communications, Public Utilities; **FIRE – Finance, insurance, real estate (1996).

This diversity is in part the result of the established role of the Twin Cities as a regional center providing transportation, distribution, energy, communications, financial, legal, etc., services to a extensive geographical area, extending from western Wisconsin to Montana and from Iowa into Canada. Minnesota's diversity is also the result of the continuing strength of historically established industries and firms, as represented by, for example: Dayton-Hudson's, Supervalu, 3M, Northwest Airlines, General Mills, The St. Paul Companies, etc., and comparatively more recent expanding ventures in computing and in particular medical technologies and services. Parenthetically, while the diversity of Minnesota's economy closely matches the national economy, considered nationally the scale of the state's economy is relatively small, with the gross state product (GSP) comprising 1.86% of the overall U.S. gross domestic product (GDP).

B. Materials Flows Analysis[6]

Conventional economic accounts are not designed to identify or make explicit environmental modifications or uses of natural resources with potential environmental impact. For example, measures such as the GDP or GSP do not include the *movement, processing* and *disposal* of large quantities of materials that have no apparent or actual economic value and may have negative value. Concepts such as full-cost accounting attempt to deal with such shortcomings, but characteristically falter because of conceptual and data limitations resulting in an inability among natural resource and environmental economists to arrive at anything approaching consensus regarding the pricing of such *externalities* (i.e., *external* to market processes and metrics).[7]

Materials flow analysis provides an alternative or supplementary approach for addressing the movement, processing and disposal of materials that occurs as a result of economic activity. Materials flow analysis is based on a set of *physical* accounts that parallel such monetary accounts as the GDP and GSP. Relative to natural and environmental resource activities providing the necessary *materials inputs* for economic activity the summary measure of materials flow analysis is the Total Materials Requirement (TMR) of an industrial economy. Relative to *material outputs* to society and the environment, that is products and services as well as waste flows, the summary measure of materials flow analysis is Total Domestic Output (TDO).

Given the comparatively recent emergence and development of materials flow analysis data is at this point only available at the national level according to national accounts. Consequently, in order to provide a proximate description of materials flows relative to Minnesota's economy we are, for the purposes of our discussion, we are scaling national flow data so as to correspond to the State's proportionate scale of the national economy as GSP / GDP. While there are likely to be significant variations between the relative TMR and TDO of Minnesota's economy as compared to the national economy the fact

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[6] The majority of this section is based on the results of a collaborative multi-national effort which in the United States was lead and facilitated by the World Resource Institute (WRI). The two primary documents of that effort, published by WRI are: *Resource Flows: The Material Basis of Industrial Economies*. (1997) WRI. Washington D.C., and *The Weight of Nations: Material Outflows from Industrial Economies.* (2000) WRI, Washington D.C.

[7] For an introduction of the market based approach to the environment according to *externalities* see section: *3. Resource Management*, of *FIVE PARADIGMS RELATING THE ENVIRONMENT AND THE ECONOMY: A BACKGROUND PAPER*. April 1997. Water Quality Division; Minnesota Pollution Control Agency. Copies available from James R. Anderson.

that Minnesota's economy varies by at most 1.5% per sector from the analogous distribution of the national economy by major industrial sector suggests at least a reasonable level of congruency between the state and national economies relative to materials flows particularly for the Twin Cities metropolitan area. Keeping in mind that relative to certain flows such as iron ore mining state flows would be much higher, and for others such as coal mining, much lower.

For example, over 99% of US coal production is from domestic sources and at a 1994 TMR of 6,800 million metric tons (936 production + 5,864 hidden flows (including overburden removal)) while *coal represents no less than 31% of the TMR of the entire US economy* all of the coal used in Minnesota comes from out of state. Conversely, 80% of the iron ore mined in the United States comes from the Mesabi Range (1994) and accordingly Minnesota's environment is directly subject to an iron ore TMR which in 1994 consisted of 384 million metric tons (150.4 production + 233.6 hidden flows). Or consider, relative to domestic agriculture, Minnesota provides approximately 3.7% of total national production and accordingly is subject to a (1994) TMR of approximately 30.7 million metric tons (21.8 production + 8.9 hidden flows). Parenthetically, as of 1994, 55% of the nation's direct inputs of iron into production were provided by scrap, a percentage that has fluctuated without evidencing a trend over the period 1975-94, dropping to 45% during '81 – '82 and peaking at 62% in 1990.

C. Direct Inputs, Total Materials Requirements and Hidden Flows

The total materials required to provide those *inputs* necessary for economic production consists of two parts: 1) Flows of resources that as inputs are brought *directly* into the production of goods and services, and, 2) Flows of resources that are not production inputs but that come about through the processes of acquiring such inputs. The later are aptly described in materials flows analysis as *hidden flows*: hidden not because invisible – the slag and overburden from mining or the sediment loads in rivers from agricultural runoff are materially formidable – but because they are not accounted for according to conventional economic measures. Figure D.17 illustrates the annual Total Materials Requirements (TMR) of Minnesota's economy in million metric tons:

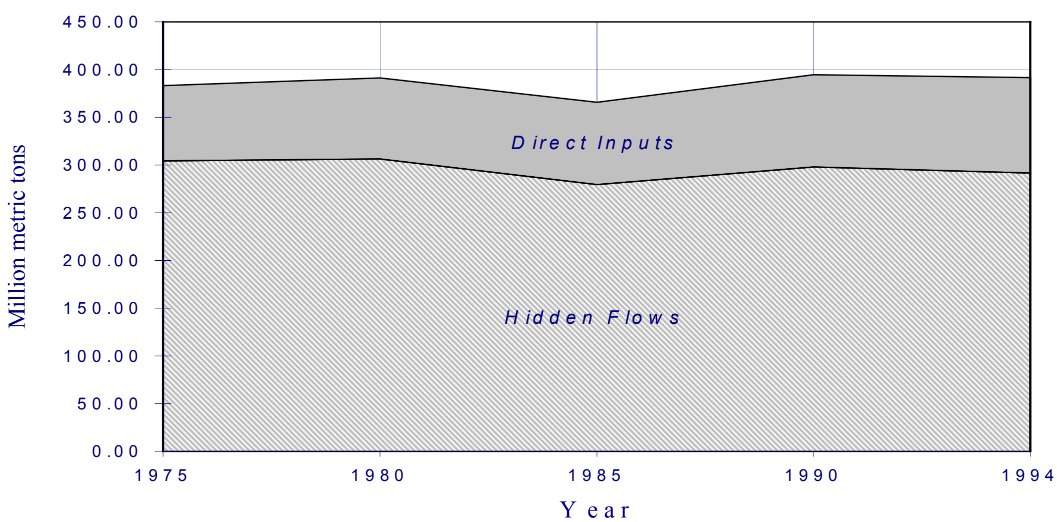


Figure D.17 Annual TMR of Minnesota's Economy

During the period from 1975 to 1994 the TMR of Minnesota's economy increased by a comparatively modest 2.2%, (i.e., 383.25 to 391.63 million metric tons) suggesting that the total materials requirement of *inputs* to the economy has changed little over the period 1975-94. The reduction indicated for 1985 is probably an expression of a general down turn in economic activity. Direct inputs (DI) increased as a percentage of TMR from 20.6% to 25.5%, representing a more efficient delivery of material inputs to the economy. Correspondingly from 1975-94 the hidden flows of Minnesota's economy declined by 4.1%.

D. Domestic Processed Output, Total Domestic Output and Hidden Flows

The total domestic *output* (TDO) from Minnesota's economy consists of Domestic Processed Output (DPO) and Hidden Flows. DPO consists of the quantity of materials of all of the goods and services *produced*, *consumed and disposed of* annually by Minnesota's economy. That part of domestic processed output that consists of infrastructure, structures, and durable goods (e.g., cars, washing machines, railroad cars, etc.) is earmarked by materials flows analysis as *net additions to stock*. Throughout the economy, *oxygen* is the *primary material addition* as inputs are processed and consumed and accordingly become DPO. For example, the various oxides that are released to the environment as a result of motor vehicle use, the burning of coal to produce electricity and other activities involving the combustion of fossil fuels proportionally increase the DPO over the DI (e.g., 22 metric tons per capita of CO_2 (1996)). Conversely recycled materials flows in the economy (e.g., metals, paper, glass) are *subtracted* from DPO. Finally, it is important to note relative to materials flow analysis that the Hidden Flows included in TMR and TDO are the same. According to systems terminology, for the purposes of physical accounting and the generally accounting principle of balancing accounts, hidden flows represent a simultaneous input and output. Correspondingly hidden flows (e.g., soil erosion from agricultural production, mining overburden) characteristically cannot be rigorously allocated exclusively to inputs or outputs.
Figure D.18 illustrates the annual Total Domestic Output (TDO) of Minnesota's economy in million metric tons:

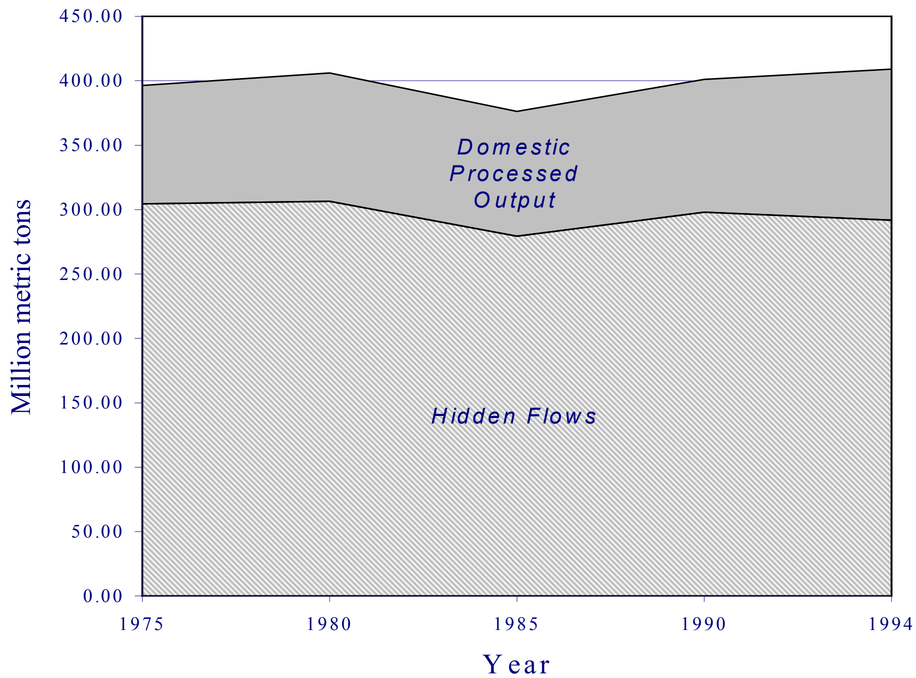


Figure D.18 Annual TDO of Minnesota's Economy

During the period from 1975 to 1994 the TDO of Minnesota's economy increased by 3.2%, (i.e., 396.39 to 409.06 million metric tons). As with TMR, the reduction indicated for 1985 is probably an expression of a general down turn in economic activity. During the same period DPO as a percentage of TDO increased by 5.5% from 23.2% to 28.7%, representing at least in part an increase in *recycling.* As with TMR there is a corresponding 1975-94 decline in hidden flows of 4.1%.

E. Materials Flow Indicators

Figure D.19 provides a series of materials flow indicators for Minnesota's economy. Please note that the units on the *y*-axis vary according to indicator as described in the legend.

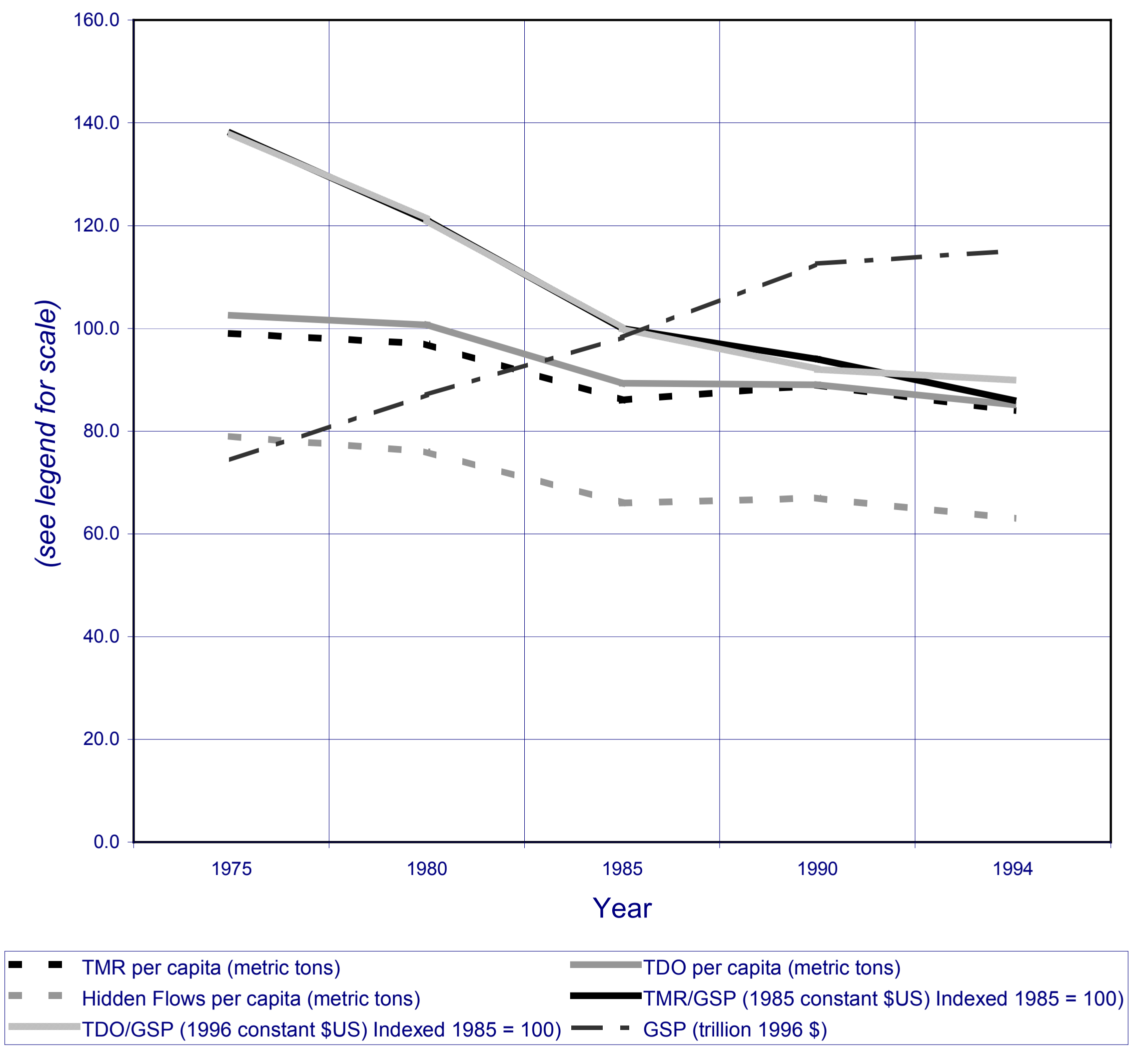


Figure D.19 Material Flow Indicators

- *Total Materials Requirement (TMR) per capita*: This parameter indicates in metric tons, what on average, is the annual per capita TMR necessary to achieve Minnesota's gross state product (GSP). The decline from 99 metric tons / person to 84 metric tons / person during the period from 1975-94 is a positive development relative to the environment. However relative to the State's total TMR, these per capital gains are at least in part offset by increases in population.
- *Hidden Flows per capita*. The 1975-94 decline in annual hidden flows per capita from 79 to 63 metric tons per person represents a substantial reduction of the hidden flows accompanying the processes whereby inputs are brought into economic production. This reduction is at least in part attributable to erosion control programs and set aside programs such as the federal Conservation Reserve Program (CRP) and the State's Reinvest in Minnesota (RIM).
- *Total Domestic Output (TDO) per Gross State Product (GSP) and Total Materials Requirement (TMR) per Gross State Product (GSP).* The trajectories of this parameters, which are virtually the same, represent some combination of: a)

increased recycling and greater efficiency in the extraction/acquisition and delivery of materials to production processes (e.g., DI as a % of TMR increased by 5% over 1975-94), b) the *de-materialization* of the economy (i.e., designing and manufacturing products that require lesser amounts of materials and substituting lighter materials), and, c) *services* as opposed to *goods* as representing an increasingly significant percentage of the GSP.

- *Total Domestic Output (TDO) per capita*: This parameter indicates in metric tons, what on average, is the annual per capita TDO of Minnesota's gross state product (GSP). The decline from 102.5 metric tons / person to 85.2 metric tons / person during the period from 1975-94 is a positive development relative to the environment. However as with the corresponding decline in per capita TMR, these per capital gains are at least in part offset by increases in population.

Rates of Materials Flow and Sustainability

Relative to the question of pressure upon the environment, natural resources and ecological systems, the comparatively modest increases in a comparative lack of change is something of a positive indicator. However it is essential to recognize, according to the general question of sustainability and related questions of the carrying capacities of ecological systems, that even a significantly declining annual TMR would not necessarily mean that the economy is sustainable relative to the environment. For *the annual TMR is essentially an annual rate of extraction* and the extractions themselves are in many cases partially if not entirely *cumulative*. If we are depleting natural capital, and continue to do so without addressing replacement a decline in the rate of depletion will only be palliative. For example, if the current economic TMR of lumber is such that we are over-harvesting by 15%, a 5% or even a 7% reduction of the TMR will postpone but not resolve the sustainability issue. In and of itself materials flow data and information does not provide information regarding the renewal and depletion – the ongoing budgets in which we are running a deficit or a surplus – of the various forms of natural capital. The acquisition of such natural capital information however, if used in conjunction with materials flow data offers the possibility of benchmarking environmental sustainability for specific materials and industrial sector activities.

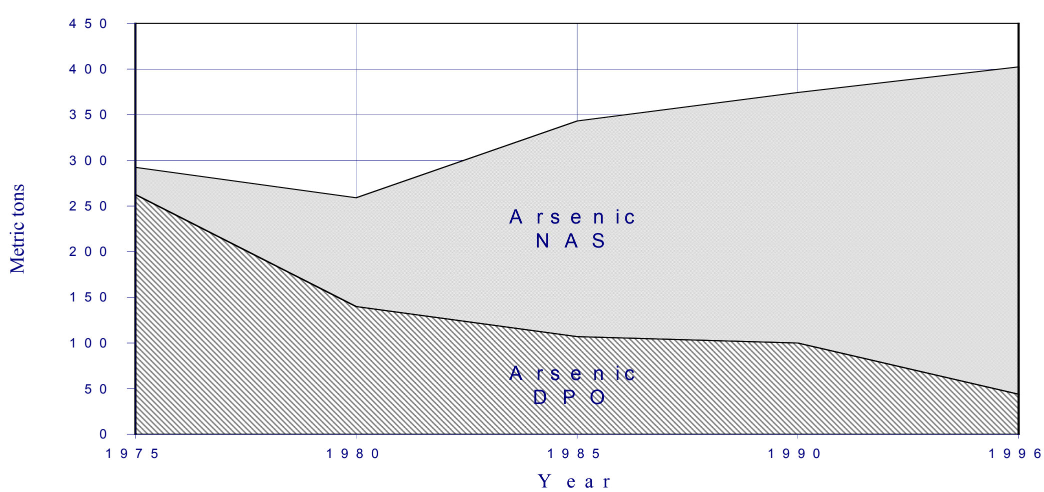


Figure D.20 Arsenic
NAS- Net Additions to Stock; DPO Domestic Product Output

F. Arsenic: A Materials Flow of Specific Environmental Concern
Clearly within the aggregation of materials flows that comprise the TDO of the economy all materials are not alike in their potential and actual effects on the environment. So for example, all else being equal, the domestic output to the environment of certain metals or organic compounds have are likely to have a decidedly more pronounced adverse effect on the environment and/or environmental health than substances such as sand or gravel. We will consider one such material: arsenic.

The output of arsenic to the environment depicted in Figure D.20 reveals that over the period 1975-96 the outflow of arsenic to Minnesota's environment (not including hidden flows) has increased by slightly more than 100 metric tons: from 292 to 402 metric tons. Relative to materials flow analysis arsenic is particularly interesting because over the period in question the type of product as well as the characteristic form of the output has shifted dramatically. In 1975, approximately 75%, or 219 tons of the 292 metric tons of arsenic in products released to Minnesota's environment was attributable to agricultural chemicals. By 1996 the arsenic released in agricultural chemicals was reduced to less than 20 metric tons. Relative to arsenic – and if consistent with 1975 one's focus continues to be on agricultural chemicals as close to 75% of the arsenic released to the environment – this is clearly a significant even dramatic environmental improvement. One might even be tempted to say that relative at least to products involved in the release of arsenic, the environmental problem of arsenic has been essential resolved. Conversely, if we move beyond agricultural chemicals and consider the *overall* materials release of arsenic to the environment we find the dramatic 38% in the release of arsenic (i.e., 292 to 402 metric tons) noted above. The new product that is the source of environmental release to the environment is of course treated lumber. Finally we would note that the delivery of arsenic has changed from the direct release and dispersal of arsenic as agricultural chemicals to arsenic as net additions to stock, where the following will become outputs to the environment in the course of there useful life and disposal.

V. Energy Use, Transportation, and Population Density

A. Energy Consumption in Historical Context
The environmental challenges facing 21st century Minnesota are the result of the state's dramatic transformation over the past one hundred and sixty years. A transformation characterized by extraordinary changes in population and even more extraordinary changes in the consumption of energy and transportation.

During the 1840s, on the verge of European expansion, the total population of Minnesota was approximately 21,000. Two-thirds of Minnesota's total population were Sioux, Chippewa, and other indigenous peoples, the remainder where Europeans. Energy sources were limited to foodstuffs from crops, hunting and gathering and firewood. Energy was expended through manual labor or by domesticated animals. The only noteworthy mechanical applications of energy were steamboat travel and shipping on the Mississippi and St. Croix Rivers, and sawmills on the St. Croix and at St. Anthony Falls on the Mississippi (1848). The total annual energy consumption of Minnesota's population was approximately 0.25 trillion BTU (British Thermal Unit) per year.

By the close of the 20th century the sources supplying over 90% of Minnesota's energy were petroleum (41.0%), natural gas (21.5 %), coal (20.9%) and nuclear electric power (8.8%). The total population of the state as recorded by the 2000 census was 4,919,479. The total annual energy consumed by Minnesota's population in 2000 was 1,733.47 trillion BTU. Between 1840 and 2000 the total annual level of energy consumed in Minnesota increased approximately *seven-thousand fold* (Figure D.21)

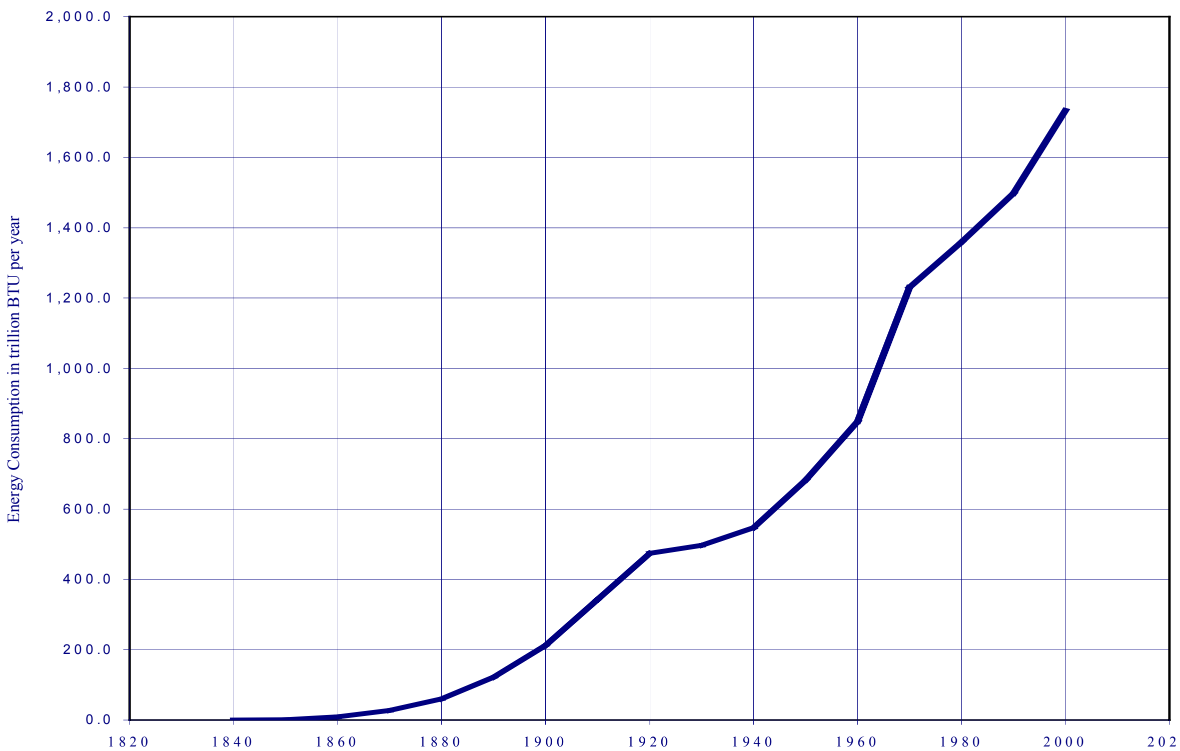


Figure D.21. Expansion of Overall Energy Consumption in Minnesota 1840-2000

When considered relative to the use of energy by *individuals* this extraordinary transformation represents a combination of a rapid expansion of population together with a twenty-five-fold increase in per capita energy use (Figure D.22).

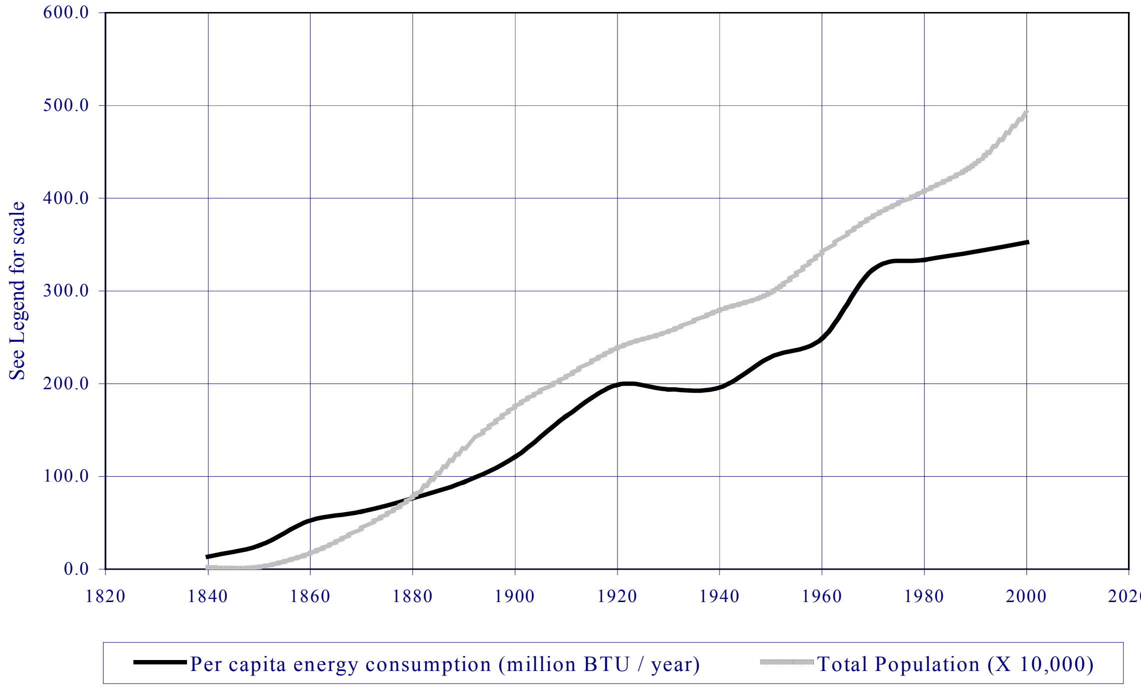


Figure D.22. Per capita energy consumption and Population in Minnesota 1840-2000

B. Energy and the Transformation of Society and Nature
In both its intended and unintended consequences, a change of this magnitude in the energy consumption patterns of a society over what is historical a comparatively short period of time is inevitably overwhelming even drastic in its impacts and its transformations of society the natural landscape and ecological systems:
The *intended* consequences of this transformation include:

- extracting, processing and manufacturing materials into finished products and consuming and disposing of materials (including reuse and recycling);
- extensive and intensive modifications of the land, of land use patterns and of the intensity of land use;
- the creation of infrastructure – the ongoing transformation of natural landscape into built and/or managed environment;
- the increasingly frequent movement of people, goods and materials in increased volumes and capacities and at increasing speeds;
- interior climate control;
- outdoor and indoor lighting;
- availability and use of outdoor and indoor appliances (e.g., lawn mowers, computers, washers, etc.); and
- energy intensive recreational activities.

In addition to the extensive and dramatic environmental effects of the *intended* uses of energy, the *unintended* results of energy production and consumption are also acute and extensive, and include:

- the release of high levels of energy directly to the environment due to inefficiency/entropy, resulting in the disruption and/or elimination of ecological activities and processes;
- the release to the environment of materials with high levels of embodied energy (e.g., fertilizers, pesticides; discarded industrial products, materials and chemicals, etc.);
- the release to the environment of the by-products of energy production and consumption (e.g., CO_2, SO_2, fly-ash, mercury, nuclear waste, etc.);
- routine as well as large scale releases of energy source materials (i.e., gasoline, natural gas, etc.) to the environment through handling and mishandling;
- the disruption and elimination of ecologies through the mining of materials (i.e., iron ore) and energy (i.e. coal);
- the disruption and elimination of landscapes and corresponding ecologies through intensive modifications of the land, of land use patterns and in the intensity of land use;
- the introduction of exotics as a result of the transportation of materials between regional, national and international ecological systems;
- noise pollution; and
- light pollution.

While energy is consumed and dissipated in all of these intended and unintended uses there are also clearly *cumulative effects and consequences* beyond the ongoing consumption of energy – particularly those involving changes in the land and in the built environment, and in the biological and physical accumulation of pollutants. Accordingly it is worth noting that the difference between 1840 and 2000 relative to energy consumption is not just a matter of overall *daily* and *annual* consumption – as vast as that difference may be – it is also the ongoing and cumulative effects of such dramatic differences in energy consumption. For example, over the fifty year time period *preceding* 1840 the cumulative total energy consumed in Minnesota was approximately 12.5 trillion BTUs, its accumulated effects were minimal, and the rate of energy consumption remained relatively constant. In contrast, during the *fifty years preceding 2000,* increasing annually at 3.1%, the total energy consumed was approximately 62,660 trillion BTUs.

C. The Transformation of Urban Industrial Society and Stages in Transportation and Transportation Infrastructure

The extraordinary expansion of energy consumption during the one hundred fifty years from 1850 to 2000 represents but one, albeit a major, indicator of innumerable, revolutionary transformations in the structure and fabric of Minnesota society and in the lives of individual Minnesotans. Remarkable transformations involving urbanization, industrialization, material wealth, communications, computerization, socioeconomic well being, diversity of life styles, etc.

While these extraordinary transformations can be useful examined and considered from any number of vantage points, for the purposes of our immediate discussion we will organize and examine the 1840-2000 transformation of Minnesota with reference to stages in the development of transportation and transportation infrastructure.

1840 – 1950 Steamboats, Ox Carts, Railways and Streetcars

European involvement in Minnesota originated during the 1700's with the fur trade, which continued to dominate the economy and export trade of the region into the first several decades of the 19th century. In the 1820s and 1830s steamboat travel connected the region to St. Louis and other established downstream destinations, and river towns began to develop on the Mississippi (Winona, Lake City, Red Wing, Hastings, St. Paul etc.) and on the St. Croix (Stillwater and Prescott, WI). The 1850 territorial census indicates the initial development of European settlement as concentrations in and surrounding these Mississippi and St. Croix river towns, particularly in St. Paul and Stillwater and surrounding Ramsey (i.e., 1850 pop. 2,227) and Washington (i.e., 1850 pop. 1,056) counties. The territorial census also indicates one other settlement of comparable size to St. Paul and Stillwater: the Pembina fur trading center on the Red River (1850 pop. 1,134) at what is now the boarder between Kittson County, Pembina, North Dakota and Canada. Pembina was an ethnically diverse community of European fur traders, native Americans and their descendants and the northern terminus of the Red River Ox Cart Trail. The trail, was initiated in the 1840s to connect the fur trade to the Mississippi followed the Red to its confluence with the Minnesota and the Minnesota to St. Paul and the steamboats. The ox cart trail, representing along with steamboat landings an early development of transportation infrastructure, peaked during the 1850s and then gave way to expanded steamboat traffic and the railroads.

In 1850 European settlement and economic activity in Minnesota was focused on the export of raw materials, principally furs and lumber rather than agricultural production. Sawmills were in operation on the St. Croix and the first sawmill at St. Anthony Falls opened in 1848. In contrast the total number of farms statewide as recorded by the 1850 census was 157, accounting for approximately 5,000 acres of improved and 24,000 acres of unimproved land. The development of steamboat service however – expanding up the Minnesota River during the 1850s – provided the initial infrastructure for immigration and as the tide of European settlement that surged across the Midwest reached Minnesota the dramatic extraordinary expansion of agriculture began. By 1860 there were more than *one hundred times* as many farms in Minnesota (i.e.,17,999) as in 1850 and the total of farmland had expanded from 18,000 to 2,711,968 acres. By the turn of the century the number of farms had again increased, this time by more than an order of magnitude to 154,659 spread over 26 million acres. The primary crop was wheat, and by 1900, with the extraordinary development of the milling industry centered at St. Anthony Falls, Minneapolis had become the largest flour-milling district in the world.

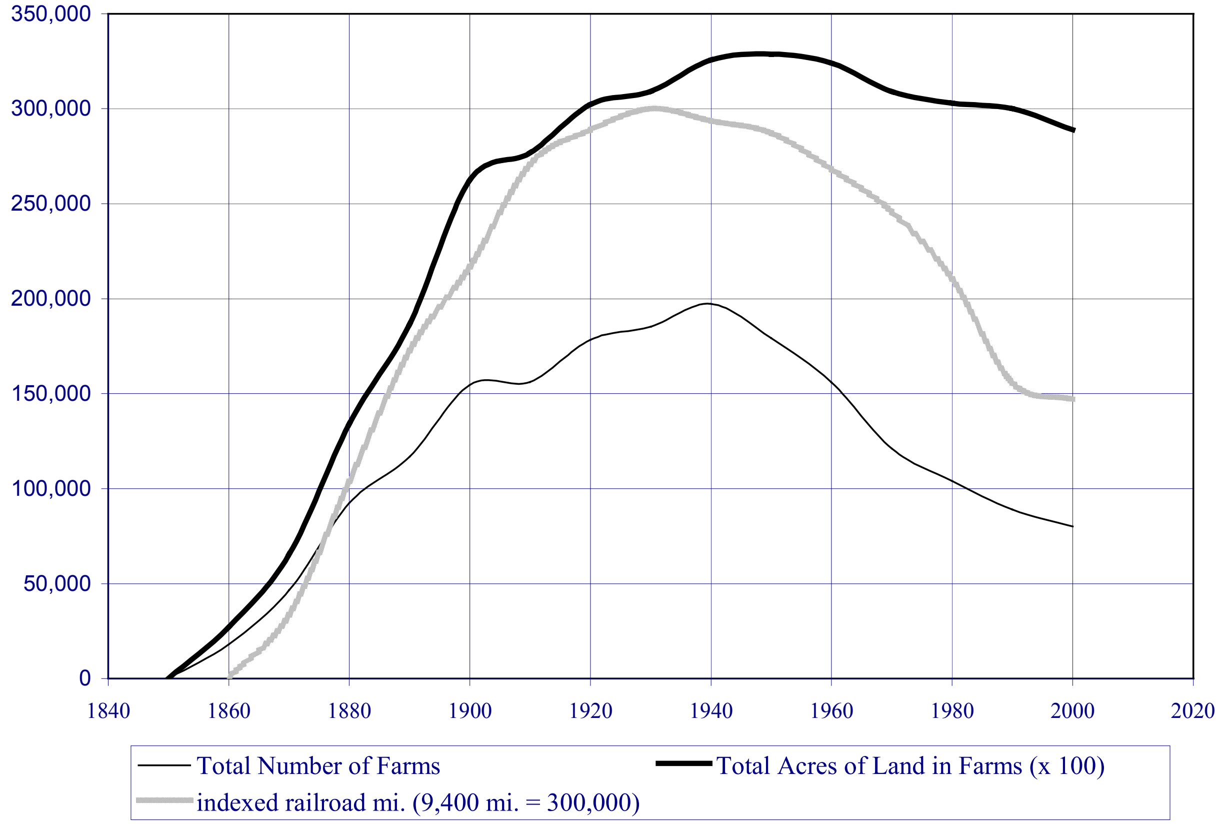


Figure D.23 The Expansion of Farms and Railroads 1840-2000

Corresponding to this rapid expansion of agriculture was the development of first statewide transportation system: the railroads. Beginning in 1962 with a railroad connection between St. Paul and Minneapolis, by the late 1920s track mileage had reached over nine thousand miles. Throughout the 19th and into the first decades of the 20th century, rural Minnesota reflected a bringing together of the railroads and the characteristic economic and transportation patterns of an agriculture of comparatively small scale family farms and limited in mechanization and the use of fossil fuel. The demographic, social, cultural and physical infrastructure characterizing rural Minnesota was a extensive patchwork of small towns accessible by wagon from the surrounding farms. These small town communities were in turn connected step-by-step in local and regional hierarchies to larger railroad communities and finally to the burgeoning Twin Cities.

Figure D.24 depicts the dramatic expansion of population of what is today the eleven county Twin Cities metropolitan area.

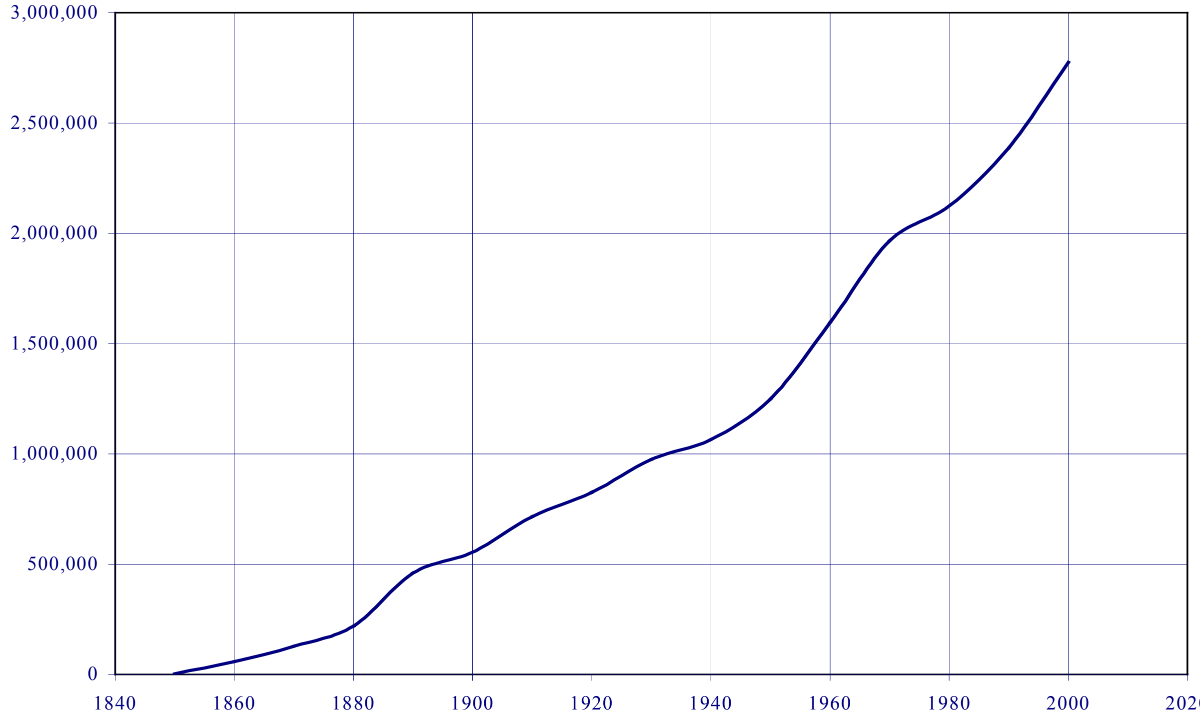


Figure D.24. The Expanding Population of the MSP 11 County Metropolitan Area

While this generalized information is useful for certain purposes it conceals the transformation of the urban and suburban Twin Cities according to population density and as stages in the development of transportation and transportation infrastructure. Figure D.25 depicts various aspects of the population density of the Twin Cities:

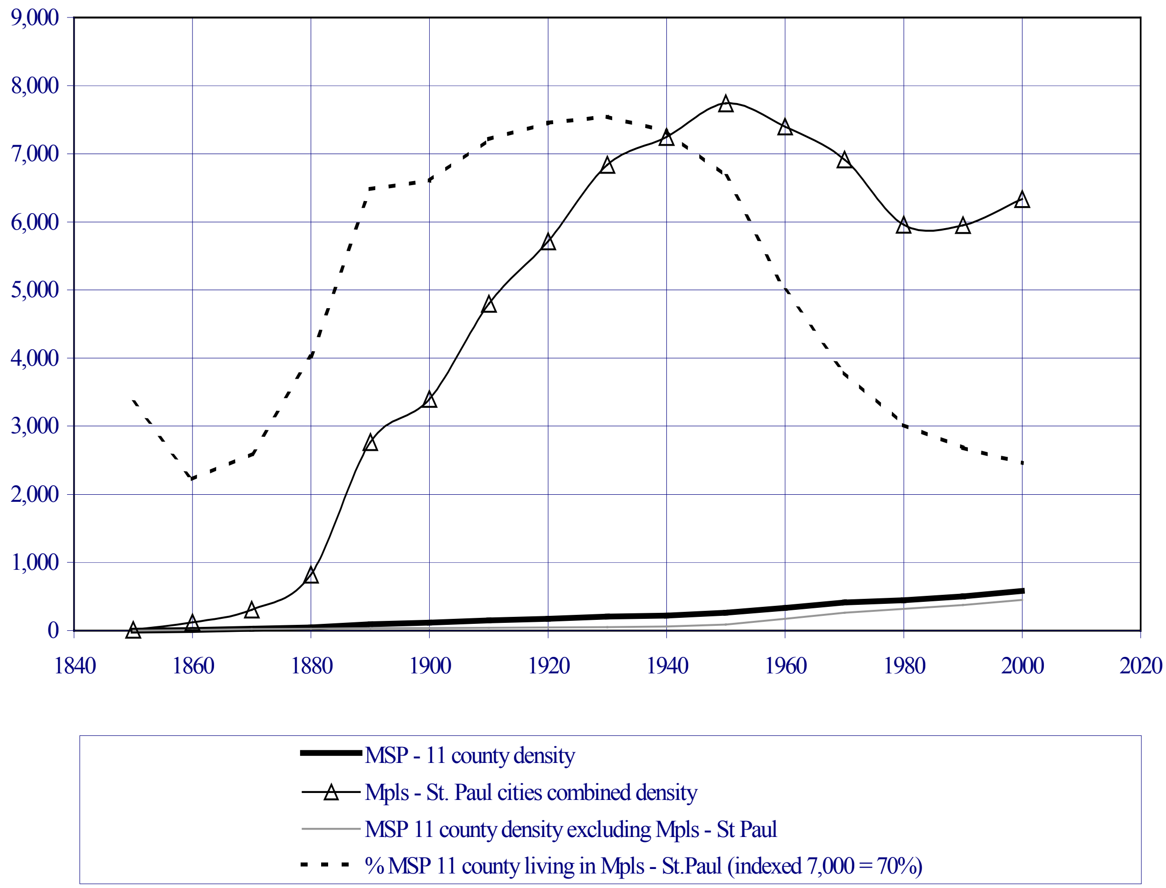


Figure D.25 Population Densities of the Twin Cities and of the MSP 11 County Metro Area

St. Paul and Minneapolis began as *walking* cities. The extension and density of walking cities is determined and bounded by the distance an individual can reasonably travel by foot from residence to employment to market, etc., extending no more than a mile or two from the center. The density of population and physical structures within a walking city is high, as pressures to expand *vertically* as well as *horizontally* are limited by human physiology and technology. Following a characteristic, nationwide pattern two developments in the second half of the 19th century transformed the *horizontal* and *vertical* limits of the walking city: the advent of urban street railroad transportation systems and the emergence and construction of steel frame buildings (i.e., skyscrapers) and elevators.

The first horse drawn street railroads where introduced in Minneapolis and St. Paul during the 1870s. By 1893 there was a combined two hundred ten miles of track in the Twin Cities and the system was almost completely electrified. By the late 1920s when the system reached its peak as far as mileage, there was a combination of four hundred thirteen (413) miles of track within the Twin Cities proper with additional lines running to Minnetonka (43 miles), Stillwater (33 miles) and fourteen miles of "local suburban" tracks in Columbia Heights, Robbinsdale, St. Louis Park and South St. Paul. With the expansion of the Twin Cities street railway system the walking city gave way to the "streetcar city." The horizontal Relative to land use the horizontal density of the streetcar city remained comparable to that of the walking city. However, the *vertical* density of the late 19th and 20th century city was also transformed by steel frame buildings (i.e., skyscrapers) and elevators. The first identified "skyscraper" was constructed in Chicago in 1885 to what – by today's standards – was a modest height of nine stories. In Minnesota the first phase of skyscraper development ended with the construction of the 32 story Foshay Tower in Minneapolis in 1929, the next phase would not begin until the 1970s. While the Foshay and the 1st National Bank Building in St. Paul (41 stories, (1931)) symbolized skyscraper development in the Twin Cities until the second phase of construction beginning with the IDS building in Minneapolis in 1971, the dramatic transformation of Twin Cities urban *vertical* space was accomplished primarily by more modest structures of less than ten stories – for example, the ____ story Pioneer Press Building (1989) and the six story Federal Courts Building (1902) in St. Paul.

Shaped by streetcar transportation and vertical expansion, the combined density of the cities of Minneapolis and St. Paul continued to increase throughout the first half of the 20th century to a 1950 peak of 7,742 pop./ sq. mile. (i.e., Mpls: 9,697 and St. Paul: 5,965). A density that, if one excludes such major metropolises as New York, Philadelphia and Chicago, is not dissimilar to other Midwestern and Eastern cities. During the second half of the 20th century however transportation, population density and energy use would be dramatically transformed by the automobile.

1950 –2000 Automobile Suburbs, the Decline of Rural Small Towns and Family Farms
With the introduction of the assembly line and mass production the automobile moved from being a curiosity to a reasonable form of transportation during the period from 1900 – 1930. By the end of the Twenties however only approximately one in ten households owned automobiles. All else being equal, the expansion of automobile use and ownership may very well have taken off during the 1930s and into the 1940s. Instead, the Depression and World War II severely stunted the growth in automobile production and availability. During the post WWII era however, three factors came together to initiate the transformations that have reshaped metropolitan as well as rural America during the second half of the 20th century:

- the conversion of the country's enormous war production capacity to consumer goods, especially automobiles, and to dramatic increases in the mechanization and the use of increasing levels of inputs (i.e., fertilizers, pesticides, fossil fuels) in agriculture;
- the GI Bill which made it possible for lower middle class and working class families to own homes, purchase automobiles and commute; and
- the Federal Highway Act of 1956 which committed the federal government to construction of the interstate highway system and encouraged and received corresponding commitments to highway development by the states and cities.

The following three figures depict the magnitude and the remarkable dynamics of Minnesota's automobile use throughout the 20th century.

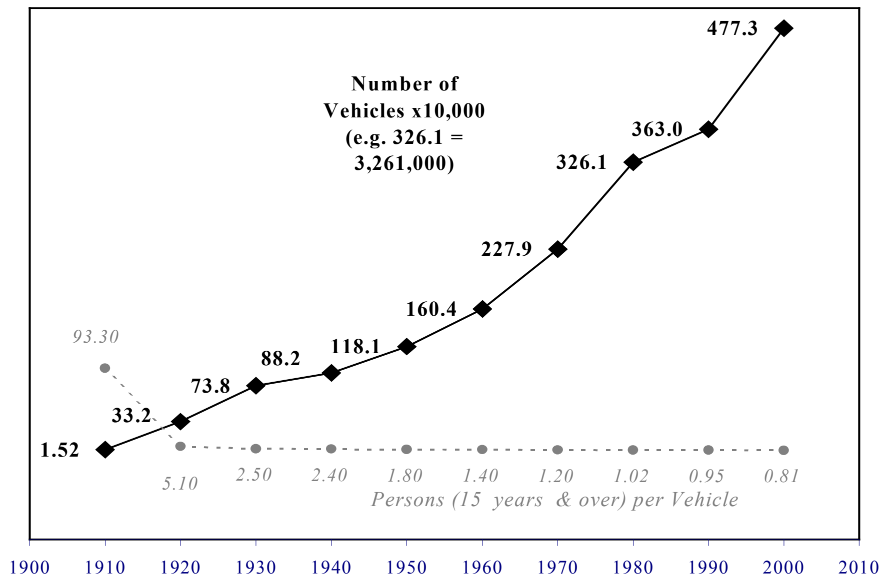


Figure D.26 Number of Vehicles and Vehicles Per Capita 1900-2000

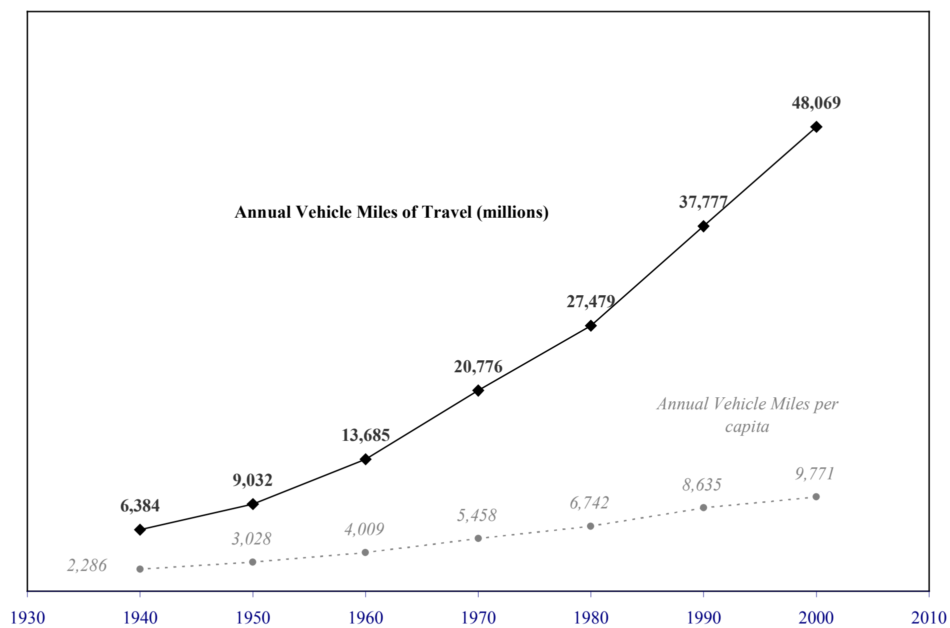


Figure D.27 Annual Vehicle Miles Traveled andPer Capita 1900-2000

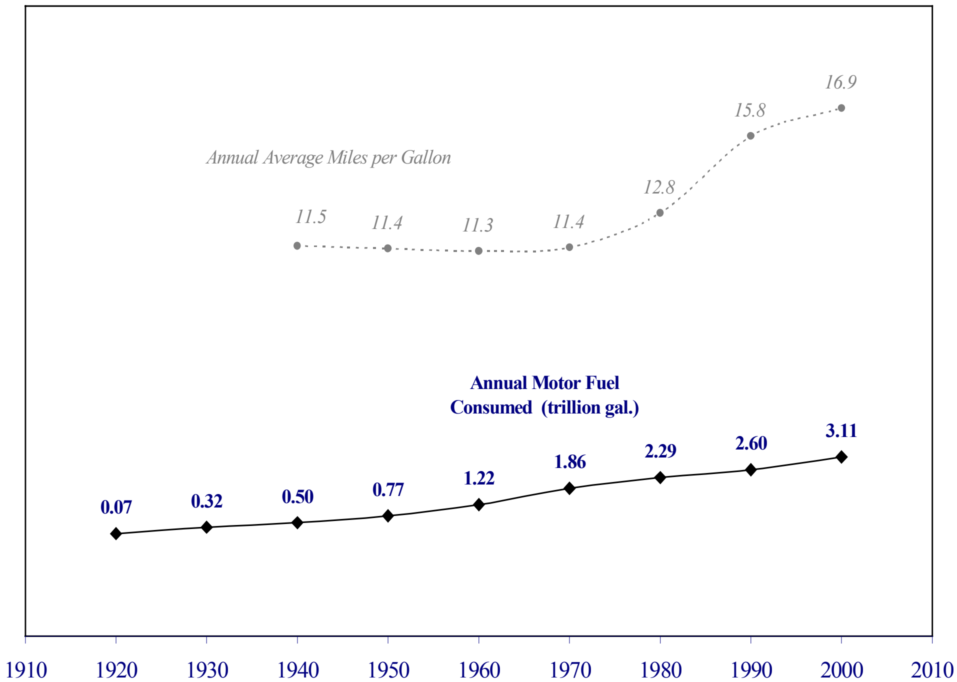


Figure D.28 Annual Motor Fuel Consumed and Vehicle MPG 1900-2000

Appendix F: Public/Stakeholder Information

This section provides information on Minnesotans' views and knowledge of environmental issues. As it is outside the scope of this report, this section will not address the public's views on specific *strategies* for addressing environmental problems.

I. Ranking the Issues

In the last five years we have completed the following projects that shed some light on the relative importance of various environmental issues to the public:

The Governor's Forums: Citizens Speak Out on the Environment. In 1999 the MPCA held seven meetings around the state with the public and one locally with stakeholders. One part of the meeting had the participants nominate issues requiring more attention, which they then rated on a low to high scale. Table 1 summarizes data across all of the public forums for issues that were nominated three or more times.

Table 1. 1999 Governor's Forums Issue Rankings

Rating	Issue
High	• Water quality issues
Medium-high	• Air quality • Chemicals in the environment • Ground water concerns • Feedlots
Medium	• Habitat destruction • Sprawl, development concerns • Solid and hazardous waste • Transportation
Medium-low	• Noise • Population growth • Genetically modified food/organisms

Statewide Citizen Survey (MPCA; 1999) and *Minnesota State Survey (U of M survey including MPCA questions; 1996).* Citizens were polled on a range of questions concerning environmental priorities and values. In both surveys a wide variety of responses resulted from an open-ended questions regarding the greatest environmental threats in Minnesota. Table 2 shows the top threats.

Table 2. Top environmental threats—MPCA and U of M surveys

MPCA Survey	U of M Survey
1. Agricultural runoff	1. Polluted lakes
2. Vehicle exhaust	2. General water pollution
3. Industrial chemical waste	3. Motor vehicle pollution
4. Manufacturing and refinery emissions	

Both the forums and surveys indicate the greatest concern was for *water quality issues. Air quality* and *chemicals in the environment* also scored high. Notable geographic differences include greater concern for *air quality in the Twin Cities Metro Area* and for *feedlots in southern Minnesota*.

Risk-Based Environmental Priorities Project (1996-97). Three groups were asked to rank the relative risk of 12 environmental issues. These groups were a Citizens Jury (a group of 20 citizens selected by the Jefferson Center), stakeholders representing sectors including industry, nonprofits, and local government and a group of MPCA staff. After listening to expert testimony the groups compared the *residual risk*, i.e., the risk remaining given our efforts to date, based on impacts to human health, the environment and quality of life. Table 3 summarizes the results.

Table 3. Final Rankings for Risk-Based Environmental Priorities Project.

Citizens Jury	Stakeholders	MPCA Staff
1. Industrial sources of air pollution	1. Nonpoint sources	1. Mobile sources of air pollution
2. Mobile sources of air pollution	2. Mobile sources of air pollution	2. Industrial sources of air pollution
3. Spills & environmental emergencies	3. Feedlots	3. Nonpoint sources
4. Hazardous waste	4. Area sources of air pollution	4. Area sources of air pollution
5. Superfund	5. Septic tanks	5. Feedlots
6. Area sources of air pollution	6. Industrial sources of air pollution	6. Wastewater treatment
7. Wastewater treatment	7. Superfund	7. Septic tanks
8. Nonpoint sources	8. Wastewater treatment	8. Solid waste
9. Feedlots	9. Spills & environmental emergencies	9. Superfund
10. Solid waste	10. Hazardous waste	10. Hazardous waste
11. Storage tanks	11. Solid waste	11. Spills & environmental emergencies
12. Septic tanks	12. Storage tanks	12. Storage tanks

Results for the Citizens Jury deviated somewhat from the results from both the Governor's Forums and the statewide surveys, particularly for water quality. After hearing the experts' perspective (and being tasked to think in terms of the whole state's needs) the members of the Citizens Jury tended to give higher scores to issues that…

- …involve pollutants that are transported to and affect large areas of the ecosystem and large segments of the population (especially with respect to health),
- …produce effects that are unknown and potentially catastrophic, and
- …do not have in place extensive and effective regulations to address the risks.

II. Public's views on specific issues

The following discussion provides specific analysis of several prominent issues.

Air quality:

- Minnesotans not overly concerned about future AQ. Sixty-three percent of respondents felt air quality will stay the same over the next 10 years, while 28% felt it will get worse (compares to the more pessimistic 35% and 44% figures for these outlook categories, respectively, for future water quality). The greatest concerns for air quality occurred in the Twin Cities Metropolitan Area. (Source: *MPCA Statewide Survey.)* Metro area citizens polled using keypad technology rated current air quality as "good," but were generally concerned for the future (i.e., 3.7 on a "not" (1) to "very concerned" (5) scale). (Source: *Citizen Input Forums: Air Pollution from Cars and Trucks (2000) Note: study was not statistically representative of population.)*

- Industry, cars and coal/oil pose equal threat. Manufacturing emissions, car exhaust and burning coal, oil and garbage all rated approximately 2 on a 3-point scale (1=not serious, 2=somewhat serious, 3= very serious threat to clean air). (Source: *MPCA Statewide Survey (1999))*
- Asthma a major concern. In a question seeking perceived connections of pollution to public health Americans expressed the greatest concern over childhood asthma (tied with sinus and allergy problems). (Source: *National public health survey (Pew Charitable Trust, 1999).*

Global climate change:

- Minnesotans: unconcerned or unaware? Though barely registering a blip at the 1999 Governor's Forums (rating medium-low at two meetings) and also scoring low in the MPCA's statewide survey this issue was reportedly a contributing factor in the Citizens Jury top ranking for industrial and mobile source air pollution. All this may point to the fact that most Minnesotans don't really understand the consequences of global climate change for our state, but once informed do care more. (But for all we know many Minnesotans might not actually mind if our state's climate was a little warmer…) (Source: *MPCA projects)*
- Status of knowledge on climate change. Fifty-two percent of Americans surveyed felt they are "somewhat informed" on this issue while 27% felt they were "slightly informed." Respondents did reasonably well correctly identifying the effects of global climate change, but were fuzzier on its causes (43% believing nuclear power is a cause). (Source: *National survey by University of New Mexico Institute for Public Policy Survey Research (1998).)*
- Benign energy sources? This survey found that just 33% of Americans know that most of our electricity (70%) comes from coal and other combustibles. A plurality (39%) thinks hydropower is our primary source of electricity. In total, 53% believe most of our energy comes from non-air-polluting sources (hydro, nuclear and solar power). (Source: *National Environmental Education & Training Foundation (NEETF)-Roper Survey (2000).)*
- Little faith in humanity currently. Focus groups convened by this group in five cities gravitated to two possible outcomes: Either scientists will find painless, technological solutions or an environmental catastrophe will force people to change destructive behaviors. (Source: *Public Agenda (1997-98).)*
- Government and business more responsible than public. 59% of Americans feel the US government, other countries' governments and business should do "a great deal" and "quite a bit" about global warming vs. 44% feeling average people should do these levels of action. (Source: *Ohio State University survey (1998))*

Water quality:

The following findings seem to point to the differences in the type of surface water at issue (lakes vs. major rivers), differences in who you ask (Minnesota lake users vs. wide range of Midwesterners), and/or perhaps the staying-power of all those media images of factory pipes spilling into rivers we've all seen again and again.

- Heavy use of lakes; various pollutant sources blamed. A large majority (77%) of Minnesotans said that they used lakes at least once ("use" includes both on-water activities and other activities near the shore) and 73% of those people fish. Statewide, the biggest perceived threats to lakes are lawn fertilizers and chemicals, followed by septic systems, and then equal concern over agricultural fertilizers and chemicals, exotic species invasions and exhaust/fuel leakage from watercraft. Significant geographic differences exist, however, with septic systems dominating outside the metro area. See table 4. (Source: *Sea Grant/DNR Survey (1999))*

Table 4. Public Rankings of Perceived Threats to Lake Water Quality by Region
(factors ranked on the percent of "great" plus "moderate" impact responses)

	Northwest		Northeast
1	Septic systems around lake	1	Septic systems around lake
2	Ag fertilizers and chemicals	2	Lawn fertilizers and chemicals
3	Exhaust/fuel leakage from watercraft	3	Exhaust/fuel leakage from watercraft
4	Lawn fertilizers and chemicals	4	Timber harvesting
5	Soil erosion from farms and fields	5	Urban, road, or parking lot runoff

	South		Central
1	Ag fertilizers and chemicals	1	Septic systems around lake
2	Lawn fertilizers and chemicals	2	Lawn fertilizers and chemicals
3	Septic systems around lake	3	Exhaust/fuel leakage from watercraft
4	Soil erosion from farms and fields	4	Aquatic plant (weed) removal
5	Livestock manure	5	Shoreline vegetation removal

	Metro
1	Lawn fertilizers and chemicals
2	Urban, road, or parking lot runoff
3	Exhaust/fuel leakage from watercraft
4	Exotic species invasions
5	Soil erosion from home sites

Source: Minnesota Lakes Survey, Sea Grant Minnesota and DNR (1999)

- <u>Point sources blamed for river pollution</u>. Respondents felt point sources rather than nonpoint sources are more to blame for pollution of this major river: 35% said industrial pollution; 19% said sewage; other sources (including farming and urban run-off) account for less than 10% each as the chief cause. (Source: *Mississippi River Survey by McKnight Foundation, 1995; a survey of MN, WI, IA and IL).)*

Malformed frogs:
Limited public opinion information (Governor's Forums, MPCA Statewide Survey) suggests relatively low concern for malformed frogs. However, it should be noted in both of these projects the issue of frogs was being compared to (or discussed at the same time as) relatively broad-scope environmental issues, e.g., water quality, agricultural run-off, chemicals in the environment, etc. It may very well be that people are reacting to this seemingly huge difference in scale and consider these malformities as just one piece or symptom of something larger. Certainly people feel strongly about the suspected possible causes of malformed frogs, e.g., water quality, agricultural run-off, chemicals in the environment, etc. (Also, a theme from stakeholders in the Biennial Budget Meetings (2000) was that frogs may be important, but the MPCA shouldn't take the lead on this national issue.)

Chemicals in the environment:
This is a catch-all category that's often expressed in terms like pesticides, toxins in the environment, hazardous wastes, and environmental cancers. It general ranks relatively high in people's list of concerns. One important manifestation of this general fear is revealed in the following survey regarding the lack of trust in our drinking water:

- Drinking water perceptions, use. Sixty-five percent of Americans either boil their tap water before drinking it, filter it, or use bottled water in the home. Respondents cite two to three reasons for this—69% cite taste, smell or color; for 49% it is stories about water pollution; and for 41% it is the convenience of bottled water. (Source: *National Environmental Education & Training Foundation (NEETF)-Roper Survey (1999).)*

Urban sprawl/development:
This is a very multi-faceted, complex, and often emotional issue for citizens, whose specific concerns are not easy to sort out. Some surveys do reveal some insights, however.

- Impacts of sprawl. This survey indicates that environmental impacts (vs. other types of impacts) are the most commonly identified and understood of sprawl's manifestations. This same poll, however, indicated that most Americans (64%) when hearing the term "suburban sprawl" generally think of it as describing "things both good and bad" vs. 21% who said "something bad" and 10% who said "something good." (Source: *National survey by Gallup (April 2000).)*
- Major transportation-related attitudes to overcome in Twin Cities? Results reveal that Minneapolis-St. Paul had the lowest percentage who said that their area was growing "too fast," that traffic congestion was "a very big problem," and that daily driving had a negative impact on quality of life. The data also indicates that Minneapolis-St. Paul residents are the least likely to make any lifestyle changes in order to solve the current traffic problem. However, Minneapolis-St. Paul had the highest percentage of residents who said that government was doing a "poor job" of managing overall growth and dealing with the various aspects of growth. (Source: *National Association of Home Builders: Surveys of citizens in Atlanta, Denver, San Diego, Washington D.C., and Minneapolis-St. Paul (1999))*

We can safely infer that development—at least lakeshore development—is viewed as a major threat outside the metro area by looking at previously discussed information. Specifically, surveyed citizens are most concerned about water quality (lakes, chiefly) and they perceive the biggest factors in lake pollution to be septic systems, lawn fertilizers and watercraft—all of which increase with lakeshore development.

III. Stakeholders' Views

Most of our work with stakeholders (regulated parties, government, environmental groups) has been more in the process- or strategy-related areas rather than what environmental work we should devote more or fewer resources on. In fact, we can probably generalize that the process-related side seems to be where they most want to spend their time with us. One example that illustrates this was at the stakeholder meeting of the 1999 Governor's Forums. In response to our asking, *What environmental issues need more attention?,* the top-rated issue was "simplified, coordinated reporting."

- For the *Risk-Based Environmental Priorities Project*, where there was a more disciplined focus on true environmental issues, stakeholders ranked issues very similarly to the MPCA staff (see table 3).

- At the Biennial Budget Stakeholder Input Meetings (2000) 120 stakeholders (primarily local government, business/industry and environmental groups) were presented a list of environmental threats and asked to choose the top three on which the MPCA should focus its attention. The resulting rankings are shown in table 5. There appears to be some parallels with the *Risk-Based Priorities Project* rankings, with the exception of wastewater treatment.

Table 5. Biennial Budget Meeting Rankings

1. Agricultural runoff
2. Wastewater treatment
3. Mobile sources of pollution
4. Urban Sprawl
5. Stormwater runoff
6. Industrial emissions/waste
7. Remediation of contaminated sites
8. Solid waste
9. Global warming
10. Malformed species

Appendix G: EIR Database Information

The Environmental Information Report (EIR) is organized by seven Impact categories (see Table 1). Since data in the EIR is provided for stressors and sources, it is difficult to use the EIR to identify specific information (such as all high contribution sources or stressors) or to compare data for stressors and sources. We created a database that allows us to query data by impact, stressor, source, or any combination of these. The database includes 14 tables and 16 basic queries. These tables and queries are described below. Example queries are included at the end of the discussion.

<u>Tables</u>

Tables consist of two types. Identifier tables assign codes or IDs to stressors, sources, pollutants, pollutant groups, PBT (persistent bioaccumulative toxin) classification, and impacts. The second group of tables contains most of the data and comments from the Environmental Information Report (EIR).

1. Identifiers – these tables assign unique identifiers to impacts, stressors, sources, source categories, pollutant groups, pbt, and individual pollutants. Table descriptions are described below. Tables are shown at the end of this section. Figure 1 illustrates how tables are linked. Three tables are not included in Figure 1 (Sources List, Source Categories, and Stakeholder Information).

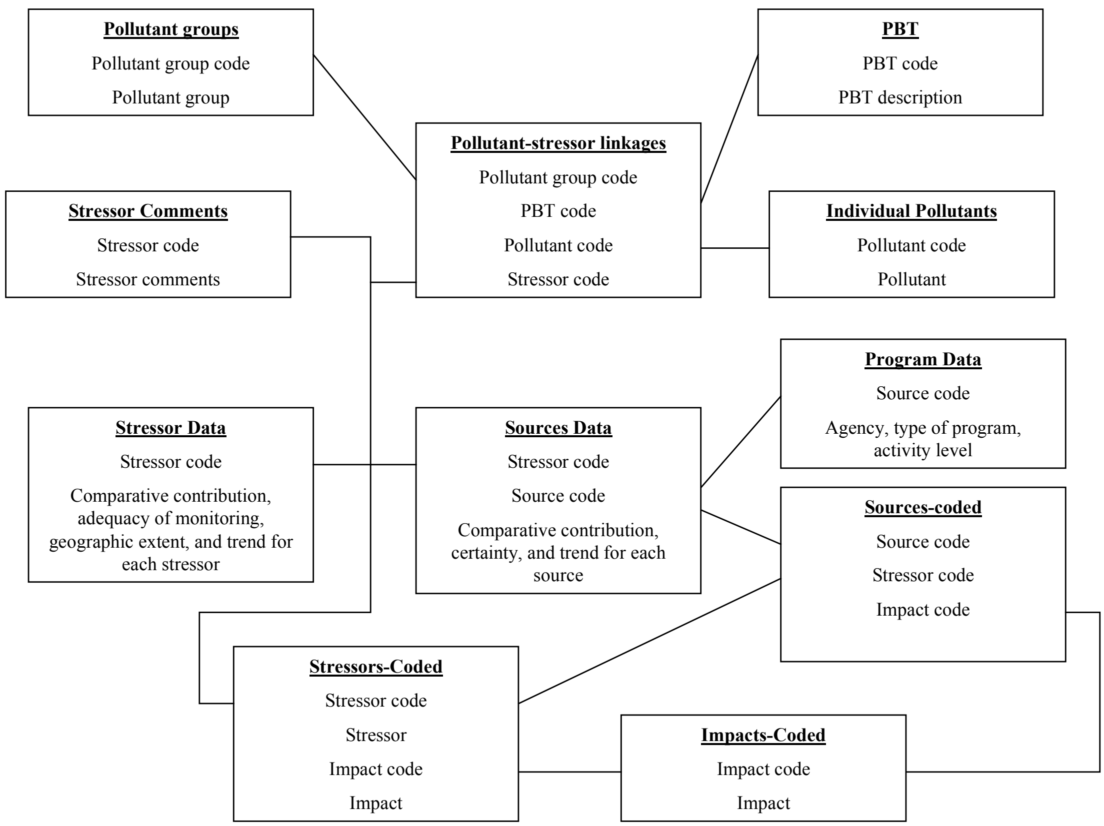
- *Impacts coded* assigns a numerical value to each of the 7 impact categories (Table 1);
- *Stressors-coded* assigns a numerical value to each of the 59 stressor-impact combinations (Table 2);
- *Sources list* assigns a numerical value to each of the 43 sources (Table 3);
- *Sources-coded* assigns a numerical value to each of the 324 impact-stressor-source combinations (Table 4);
- *Source categories* assigns a source category to each of the 43 sources. There are 6 source categories (see Table 5). Some sources may be assigned to more than one source category;
- *Pollutant groups* assigns a numerical value to each of the 18 pollutant groups (Table 6);
- *Individual pollutants* assigns a numerical value to each of the individual pollutants (Table 7)(there were 2780 individual pollutants when this document was completed); and
- *PBT* assigns a numerical value to each of the three PBT groups (Table 8).

2. Data – these tables contain data for stressors, sources, pollutant-stressor linkages, program data, and stressor comments. Table descriptions are described below. Tables are shown at the end of this section. Figure 1 illustrates how tables are linked.

- *Stressor data* contains data on comparative risk, degree of confidence, geographic location, trend, and adequacy of monitoring for the 59 stressor-impact combinations (Table 9);
- *Sources data* contains data on comparative contribution, degree of confidence, and trend for sources for the 324 impact-stressor-source combinations (Table 10);
- *Program data* contains data on program activity level for MPCA and external programs in the areas of cleanup, control, prevention, and education (8 entries for each source, for a total of 344 entries). The table also contains comments and web links (Table 11);

- *Pollutant-stressor linkages* assigns pollutants cited in the EIR matrices to corresponding stressors. There are 246 entries (Table 12). The table is linked to the table Individual Pollutants, which contains the names of the pollutants;
- *Stressor comments* provides comments for each stressor (Table 13). There are 286 entries. Comments are divided into Endpoint (what the health endpoint is), General, Pathway (how organisms are affected), Persistence (environmental persistence of the stressor), and Rationale (our rationale for assigning the stressor comparative contribution); and
- *Stakeholder information* contains data (1807 entries) on stakeholder results from other comparative risk projects in the United States (Table 14).

Figure 1: Description of information in tables and ways that tables are linked.



Queries

The tables *Sources Data*, *Program Data*, and *Stressor Data* each contain more than one field containing information from the EIR. To ensure that we could conduct multiple queries of the data across both sources and stressor, we established queries for each data field. Thus for stressors, the following queries exist:

- Stressor overall comparative contribution shows comparative contribution for the 59 stressor-impact combinations;
- Stressor shows confidence level for the 59 stressor-impact combinations;
- Stressor geographic extent shows geographic extent for the 59 stressor-impact combinations;

- Stressor adequacy of ambient monitoring shows adequacy of monitoring for the 59 stressor-impact combinations; and
- Stressor trend shows trends for the 59 stressor-impact combinations.

Each of these queries is linked by Stressor Code and Impact Code and utilizes three tables – Impacts Coded, Stressors Coded, and Stressor Data. For sources, we established the following queries:

- Source comparative contribution shows comparative contribution for the 324 impact-stressor-source combinations;
- Source confidence level shows confidence level for the 324 impact-stressor-source combinations; and
- Source trend shows trend for the 324 impact-stressor-source combinations.

Each of the queries is linked by Source Code, Stressor Code, and Impact Code and utilizes three tables: Stressors Coded, Sources Coded, and Sources Data.

For program activity information, we utilized queries for each combination of agency (MPCA or external) and activity type (cleanup, control, prevention, or education). This results in 8 queries, each of which contains information on activity level for a source.

- External cleanup activity shows activity level of non-MPCA agencies in the area of cleanup for each of the 43 sources;
- External control activity shows activity level of non-MPCA agencies in the area of control for each of the 43 sources;
- External prevention activity shows activity level of non-MPCA agencies in the area of prevention for each of the 43 sources;
- External education activity shows activity level of non-MPCA agencies in the area of education for each of the 43 sources;
- MPCA cleanup activity shows activity level of the MPCA in the area of cleanup for each of the 43 sources;
- MPCA control activity shows activity level of the MPCA in the area of control for each of the 43 sources;
- MPCA prevention activity shows activity level of the MPCA in the area of prevention for each of the 43 sources; and
- MPCA education activity shows activity level of the MPCA in the area of education for each of the 43 sources.

The program queries utilize two tables, Sources List and Program Data, which are linked by Source Code.

Additional queries can be run on any of the 14 tables or 16 basic queries. Thus, any of the information contained in the EIR matrices can be queried against other information in the matrices, including querying multiple fields.

Table 1: Impacts-coded table.

Impact code	Impact
1	Human health impacts-noncancer acute
2	Human health impacts-noncancer chronic
3	Human health impacts-cancer
4	Ecosystem impacts-aquatic organisms
5	Ecosystem impacts-terrestrial organisms
6	Quality of life-aesthetics
7	Quality of life-resource access

Table 2: Stressors-coded table.

Stressor code	Impact	Stressor	Impact code
1	Human health impacts-cancer	Particles in air	3
2	Human health impacts-cancer	Toxic volatile organic chemicals	3
3	Human health impacts-cancer	Toxic chemicals in food	3
4	Human health impacts-cancer	Excess UV radiation from	3
5	Human health impacts-cancer	Toxic chemicals in water	3
6	Human health impacts-cancer	Toxic chemicals in soil	3
7	Human health impacts-noncancer	Particles in air	2
8	Quality of Life-Aesthetics	Odorous chemicals from	6
9	Human health impacts-noncancer	Toxic chemicals in food	2
10	Human health impacts-noncancer	Toxic chemicals in water	2
11	Human health impacts-noncancer	Toxic chemicals in soil	2
12	Quality of Life-Aesthetics	Noise	6
13	Quality of Life-Aesthetics	Particles in air	6
14	Quality of Life-Aesthetics	Ground-level ozone	6
15	Quality of Life-Aesthetics	Phosphorus	6
16	Quality of Life-Aesthetics	Transported sediment	6
17	Human health impacts-noncancer	Pathogens in water	1
18	Human health impacts-noncancer	Toxic chemicals in water	1
19	Human health impacts-noncancer	Explosive/flammable materials -	1
20	Human health impacts-noncancer	Other criteria pollutants in air	1
21	Ecosystem impacts-aquatic organisms	Phosphorus	4
22	Ecosystem impacts-aquatic organisms	Nitrogen	4
23	Ecosystem impacts-aquatic organisms	Ammonia	4
24	Ecosystem impacts-aquatic organisms	Acid deposition	4
25	Ecosystem impacts-aquatic organisms	Temperature increase/climate	4
26	Ecosystem impacts-aquatic organisms	Excess UV radiation from	4
27	Ecosystem impacts-aquatic organisms	Dissolved solids	4
28	Ecosystem impacts-terrestrial	Temperature increase/climate	5
29	Ecosystem impacts-aquatic organisms	Toxic organic chemicals	4
30	Ecosystem impacts-aquatic organisms	Habitat modification	4
31	Ecosystem impacts-aquatic organisms	Transported sediment	4
32	Ecosystem impacts-aquatic organisms	Toxic metals	4
33	Ecosystem impacts-aquatic organisms	Oxygen-demanding pollutants	4

Stressor code	Impact	Stressor	Impact code
34	Ecosystem impacts-terrestrial	Toxic metals	5
35	Ecosystem impacts-terrestrial	Temperature increase/climate	5
36	Ecosystem impacts-terrestrial	Acid deposition	5
37	Ecosystem impacts-terrestrial	Habitat modification	5
38	Ecosystem impacts-terrestrial	Toxic organic chemicals	5
39	Ecosystem impacts-terrestrial	Excess UV radiation from	5
40	Quality of Life-Aesthetics	Oxygen-demanding pollutants	6
41	Human health impacts-noncancer	Ground-level ozone	1
42	Human health impacts-noncancer	Toxic volatile organic chemicals	1
43	Human health impacts-noncancer	Particles in air	1
44	Quality of Life-Aesthetics	Habitat modification	6
45	Human health impacts-noncancer	Toxic volatile organic chemicals	2
46	Human health impacts-noncancer	Excess UV radiation from	2
47	Human health impacts-noncancer	Other criteria pollutants in air	2
48	Human health impacts-noncancer	Ground-level ozone	2
49	Human health impacts-noncancer	Noise	2
50	Human health impacts-noncancer	Odorous chemicals from	2
51	Ecosystem impacts-terrestrial	Nitrogen	5
52	Ecosystem impacts-terrestrial	Ground-level ozone	5
55	Human health impacts-noncancer	Noise	1
56	Human health impacts-noncancer	Temperature increase/climate	1
57	Human health impacts-noncancer	Temperature increase/climate	1
58	Ecosystem impacts-aquatic organisms	Temperature increase/climate	4
59	Human health impacts-noncancer	Odorous chemicals from	1
60	Human health impacts-noncancer	Toxic chemicals in soil	1
61	Human health impacts-noncancer	Toxic chemicals - high level	1

Table 3: Sources list table.

Source ID	Source
1	Agricultural runoff
2	Agriculture
4	Area source combustion
7	Construction
8	Drainage and channelization
9	Dredging
10	Coal-fired power plants
11	Feedlots
12	Fertilizer use
13	Fire extinguishers
14	Fugitive dust
15	Industry
16	Land-applied manure

Source ID	Source
17	Land-applied municipal and industrial byproducts
18	Permitted waste disposal
19	Tanks
20	Mining
21	Municipal and industrial wastewater
22	Off-road equipment
23	On-road vehicles
25	Pesticide use
26	Power plants (thermal discharge)
27	Refrigerants
28	Residential fuel combustion
29	Septic systems
30	Spills
32	Streambank erosion
34	Unpermitted waste disposal
35	Urban development
36	Urban runoff
38	Waste incineration
40	Aircraft
42	Ethanol production
45	Petroleum storage and transfer
46	Pipelines
47	Recreational use (shooting ranges, fishing tackle)
48	Residences
49	Silvaculture
50	Solvent utilization
52	Treatment/settling ponds
53	Road salt
54	Lead Paint
55	Trains

Table 4: Sources-coded table.

Source code	Stressor code	Impact code	Source	Source ID
1	1	3	On-road vehicles	23
2	1	3	Off-road equipment	22
3	1	3	Area source combustion	4
4	1	3	Agriculture	2
5	1	3	Municipal and Industrial wastewater	21
6	1	3	Fugitive dust	14
7	1	3	Coal-fired power plants	10
8	1	3	Industry	15
9	2	3	On-road vehicles	23
10	2	3	Off-road equipment	22

Source code	Stressor code	Impact code	Source	Source ID
11	56	1	Coal-fired power plants	10
12	2	3	Residential fuel combustion	28
13	2	3	Industry	15
14	3	3	On-road vehicles	23
15	3	3	Off-road equipment	22
16	3	3	Residential fuel combustion	28
17	3	3	Mining	20
18	3	3	Pesticide use	25
19	3	3	Municipal and Industrial wastewater	21
20	56	1	On-road vehicles	23
21	3	3	Coal-fired power plants	10
22	3	3	Industry	15
23	3	3	Permitted waste disposal	18
24	56	1	Industry	15
25	4	3	Fire extinguishers	13
26	4	3	Refrigerants	27
27	4	3	Unpermitted waste disposal	34
28	4	3	Industry	15
29	5	3	Pesticide use	25
30	5	3	Land-applied municipal and industrial byproducts	17
31	56	1	Agriculture	11
32	5	3	Unpermitted waste disposal	34
33	5	3	Tanks	19
34	5	3	Municipal and industrial wastewater	21
35	5	3	Spills	30
36	6	3	Industry	15
37	6	3	Pesticide use	25
38	6	3	Land-applied municipal and industrial byproducts	17
39	6	3	Unpermitted waste disposal	34
40	6	3	Spills	30
41	40	6	Feedlots	11
42	40	6	Municipal and industrial wastewater	21
43	23	4	Feedlots	11
44	23	4	Septic systems	29
45	23	4	Municipal and industrial wastewater	21
46	33	4	Agricultural runoff	1
47	33	4	Feedlots	11
48	33	4	Septic systems	29
49	33	4	Municipal and industrial wastewater	21
50	33	4	Urban runoff	36
51	30	4	Drainage and channelization	8
52	30	4	Urban/suburban/lakeshore development	35
53	30	4	Dredging	9

Source code	Stressor code	Impact code	Source	Source ID
54	32	4	Industry	15
55	32	4	Urban runoff	36
56	32	4	Municipal and industrial wastewater	21
57	22	4	Agricultural runoff	1
58	22	4	Feedlots	11
59	22	4	Septic systems	29
60	22	4	Municipal and industrial wastewater	21
61	22	4	Urban runoff	36
62	21	4	Agricultural runoff	1
63	21	4	Feedlots	11
64	21	4	Septic systems	29
65	21	4	Municipal and industrial wastewater	21
66	21	4	Urban runoff	36
67	31	4	Agricultural runoff	1
68	31	4	Construction	7
69	31	4	Urban runoff	36
70	31	4	Municipal and industrial wastewater	21
71	24	4	Coal-fired power plants	10
72	24	4	On-road vehicles	23
73	29	4	Agricultural runoff	1
74	29	4	Urban runoff	36
75	29	4	Municipal and industrial wastewater	21
76	11	2	Lead paint	54
77	25	4	Urban runoff	36
78	25	4	Power plants (thermal discharge)	26
79	27	4	Urban runoff	36
80	56	1	Permitted waste disposal	18
81	25	4	Industry	15
82	25	4	Permitted waste disposal	18
83	31	4	Streambank erosion	32
84	24	4	Off-road equipment	22
85	20	1	Off-road equipment	22
86	20	1	On-road vehicles	23
87	46	2	Refrigerants	27
88	17	1	Feedlots	11
89	17	1	Septic systems	29
90	19	1	Tanks	19
91	19	1	On-road vehicles	23
92	25	4	Residential fuel combustion	28
93	59	1	Agriculture	2
94	50	2	Agriculture	2
95	60	1	Road salt	53
96	34	5	Industry	15

Source code	Stressor code	Impact code	Source	Source ID
97	55	1	Aircraft	40
98	49	2	Aircraft	40
99	48	2	Area source combustion	4
100	51	5	Coal-fired power plants	10
101	36	5	On-road vehicles	23
102	7	2	On-road vehicles	23
103	7	2	Off-road equipment	22
104	7	2	Area source combustion	4
105	7	2	Agriculture	2
106	7	2	Municipal and industrial wastewater	21
107	7	2	Fugitive dust	14
108	7	2	Coal-fired power plants	10
109	7	2	Industry	15
110	52	5	Area source combustion	4
111	32	4	Waste incineration	38
112	34	5	Waste incineration	38
113	8	6	Feedlots	11
114	10	2	Municipal and industrial wastewater	21
115	9	2	On-road vehicles	23
116	9	2	Off-road equipment	22
117	9	2	Residential fuel combustion	28
118	9	2	Mining	20
119	9	2	Pesticide use	25
120	9	2	Municipal and industrial wastewater	21
121	25	4	Coal-fired power plants	10
122	9	2	Coal-fired power plants	10
123	9	2	Industry	15
124	9	2	Permitted waste disposal	18
125	10	2	Pesticide use	25
126	10	2	Land-applied municipal and industrial byproducts	17
127	25	4	On-road vehicles	23
128	10	2	Unpermitted waste disposal	34
129	8	6	Treatment/settling ponds	52
130	10	2	Tanks	19
131	10	2	Septic systems	29
132	10	2	Spills	30
133	11	2	Industry	15
134	11	2	Pesticide use	25
135	11	2	Land-applied municipal and industrial byproducts	17
136	11	2	Unpermitted waste disposal	34
137	11	2	Spills	30
138	47	2	Coal-fired power plants	10
139	48	2	Coal-fired power plants	10

Source code	Stressor code	Impact code	Source	Source ID
140	34	5	Coal-fired power plants	10
141	52	5	Coal-fired power plants	10
142	59	1	Ethanol production	42
143	50	2	Ethanol production	42
144	18	1	Feedlots	11
145	59	1	Feedlots	11
146	50	2	Feedlots	11
147	51	5	Feedlots	11
148	51	5	Fertilizer use	12
149	19	1	Industry	15
150	20	1	Industry	15
151	41	1	Industry	15
152	55	1	Industry	15
153	61	1	Industry	15
154	45	2	Industry	15
155	47	2	Industry	15
156	48	2	Industry	15
157	49	2	Industry	15
158	38	5	Industry	15
159	39	5	Industry	15
160	51	5	Land-applied manure	16
161	52	5	Industry	15
162	18	1	Land-applied manure	16
163	8	6	Agriculture	2
164	60	1	Land-applied municipal and industrial byproducts	17
165	19	1	Pipelines	46
166	32	4	Mining	20
167	34	5	Mining	20
168	37	5	Mining	20
169	20	1	Residential fuel combustion	28
170	47	2	Residential fuel combustion	28
171	19	1	Trains	55
172	55	1	Off-road equipment	22
173	26	4	Unpermitted waste disposal	34
174	26	4	Fire extinguishers	13
175	26	4	Refrigerants	27
176	26	4	Industry	15
177	50	2	Treatment/settling ponds	52
178	60	1	Unpermitted waste disposal	34
179	34	5	Municipal and industrial wastewater	21
180	34	5	Recreational use (shooting ranges, fishing	47
181	34	5	Urban runoff	36
182	36	5	Coal-fired power plants	10

Source code	Stressor code	Impact code	Source	Source ID
183	25	4	Agriculture	2
186	18	1	Agriculture	19
187	37	5	Silvaculture	49
188	37	5	Agriculture	2
189	37	5	Urban/suburban/lakeshore development	35
190	61	1	Trains	55
191	18	1	Spills	30
192	18	1	Septic systems	29
193	45	2	Off-road equipment	22
194	18	1	Unpermitted waste disposal	34
195	18	1	Fertilizer use	12
196	47	2	Off-road equipment	22
197	18	1	Pesticide use	25
198	38	5	Land-applied municipal and industrial byproducts	17
199	38	5	Area source combustion	4
200	51	5	Area source combustion	4
201	48	2	Off-road equipment	22
202	49	2	Off-road equipment	22
203	39	5	Fire extinguishers	13
204	51	5	Off-road equipment	22
205	39	5	Refrigerants	27
206	39	5	Unpermitted waste disposal	34
207	52	5	Off-road equipment	22
208	55	1	On-road vehicles	23
209	61	1	On-road vehicles	23
210	45	2	On-road vehicles	23
211	47	2	On-road vehicles	23
212	48	2	On-road vehicles	23
213	49	2	On-road vehicles	23
214	51	5	On-road vehicles	23
215	52	5	On-road vehicles	23
216	60	1	Pesticide use	25
217	38	5	Pesticide use	25
218	41	1	Petroleum storage and transfer	45
219	48	2	Petroleum storage and transfer	45
220	36	5	Off-road equipment	22
221	27	4	Municipal and industrial wastewater	21
222	52	5	Petroleum storage and transfer	45
223	61	1	Pipelines	46
224	20	1	Coal-fired power plants	10
225	17	1	Land-applied municipal and industrial byproducts	17
226	17	1	Land-applied manure	16
227	41	1	On-road vehicles	23

Source code	Stressor code	Impact code	Source	Source ID
228	41	1	Off-road equipment	22
229	41	1	Area source combustion	4
230	41	1	Coal-fired power plants	10
231	42	1	On-road vehicles	23
232	42	1	Off-road equipment	22
234	42	1	Residential fuel combustion	28
235	42	1	Industry	15
236	43	1	On-road vehicles	23
237	43	1	Off-road equipment	22
238	43	1	Area source combustion	4
239	43	1	Agriculture	2
240	43	1	Municipal and industrial wastewater	21
241	43	1	Fugitive dust	14
242	43	1	Coal-fired power plants	10
243	43	1	Industry	15
244	9	2	Unpermitted waste disposal	34
245	8	6	Ethanol production	42
246	10	2	Fertilizer use	12
247	33	4	Spills	30
248	29	4	Spills	30
249	45	2	Residential fuel combustion	28
250	12	6	On-road vehicles	23
251	19	1	Residences	48
252	61	1	Residences	48
253	41	1	Solvent utilization	50
254	48	2	Solvent utilization	50
255	52	5	Solvent utilization	50
256	60	1	Lead paint	54
257	38	5	Spills	30
258	61	1	Tanks	19
259	59	1	Treatment/settling ponds	52
260	32	4	Coal-fired power plants	10
261	9	2	Waste incineration	38
262	17	1	Municipal and industrial wastewater	21
268	56	1	Residential fuel combustion	28
269	58	4	Power plants (thermal discharge)	26
270	58	4	Urban runoff	12
271	28	5	Coal-fired power plants	10
272	28	5	On-road vehicles	23
274	28	5	Industry	15
275	28	5	Permitted waste disposal	18
277	28	5	Residential fuel combustion	28
279	38	5	Municipal and industrial wastewater	21

Source code	Stressor code	Impact code	Source	Source ID
280	58	4	Coal-fired power plants	10
281	3	3	Waste incineration	38
282	3	3	Unpermitted waste disposal	34
283	38	5	Urban runoff	36
284	29	4	Area source combustion	4
285	29	4	Industry	15
286	12	6	Industry	15
287	12	6	Aircraft	40
288	12	6	Off-road equipment	22
289	13	6	Coal-fired power plants	10
290	13	6	On-road vehicles	23
291	13	6	Off-road equipment	22
292	13	6	Area source combustion	4
293	13	6	Agriculture	2
294	13	6	Municipal and industrial wastewater	21
295	13	6	Fugitive dust	14
296	13	6	Industry	15
297	14	6	On-road vehicles	23
298	14	6	Off-road equipment	22
299	14	6	Coal-fired power plants	10
300	14	6	Solvent utilization	50
301	14	6	Area source combustion	4
302	14	6	Industry	15
303	14	6	Petroleum storage and transfer	45
304	15	6	Agricultural runoff	1
305	15	6	Municipal and industrial wastewater	21
306	15	6	Feedlots	11
307	15	6	Urban runoff	36
308	15	6	Septic systems	29
309	16	6	Agricultural runoff	1
310	16	6	Construction	7
311	16	6	Streambank erosion	32
312	16	6	Urban runoff	36
313	16	6	Municipal and industrial wastewater	21
314	46	2	Fire extinguishers	13
315	46	2	Unpermitted waste disposal	34
316	46	2	Industry	15
317	57	1	Agriculture	2
318	57	1	Coal-fired power plants	10
319	57	1	On-road vehicles	23
320	57	1	Industry	15
321	57	1	Residential fuel combustion	28
322	57	1	Permitted waste disposal	18

Source code	Stressor code	Impact code	Source	Source ID
323	58	4	On-road vehicles	23
324	58	4	Industry	15
325	58	4	Permitted waste disposal	18
326	58	4	Residential fuel combustion	28
327	58	4	Agriculture	2
328	35	5	Residential fuel combustion	28
329	35	5	Coal-fired power plants	10
330	35	5	On-road vehicles	23
331	40	6	Spills	30
332	44	6	Urban/suburban/lakeshore development	0
333	44	6	Silvaculture	49
334	35	5	Industry	15
335	35	5	Permitted waste disposal	18
336	28	5	Agriculture	2
337	35	5	Agriculture	2
338	44	6	Agriculture	2
339	44	6	Mining	20

Table 5: Source Categories table.

Source ID	Source category
1	Agriculture
2	Agriculture
4	Business/Municipal/Industry
7	Development
8	Agriculture
9	Business/Municipal/Industry
10	Fossil fuels
11	Agriculture
12	Agriculture
12	Residential
13	Solid/Haz waste & products
14	Business/Municipal/Industry
15	Business/Municipal/Industry
16	Agriculture
17	Business/Municipal/Industry
18	Solid/Haz waste & products
18	Business/Municipal/Industry
19	Fossil fuels
20	Business/Municipal/Industry
21	Business/Municipal/Industry
22	Fossil fuels
23	Fossil fuels
25	Residential

Source ID	Source category
25	Agriculture
26	Business/Municipal/Industry
27	Solid/Haz waste & products
28	Residential
28	Fossil fuels
29	Residential
30	Business/Municipal/Industry
32	Agriculture
32	Development
34	Solid/Haz waste & products
35	Development
36	Development
38	Solid/Haz waste & products
40	Business/Municipal/Industry
42	Business/Municipal/Industry
45	Fossil fuels
46	Fossil fuels
47	Solid/Haz waste & products
48	Residential
49	Business/Municipal/Industry
50	Business/Municipal/Industry
52	Business/Municipal/Industry
53	Business/Municipal/Industry
54	Solid/Haz waste & products
54	Residential
55	Business/Municipal/Industry

Table 6: Pollutant Groups table.

Pollutant group code	Pollutant group name	Definition
1	Volatile Organic Compounds	Chemicals that vaporize readily; some volatiles are placed into other categories; these VOCs primarily have industrial sources
2	Polynuclear aromatic hydrocarbons	Includes all PAHs (carcinogenic and noncarcinogenic), including naphthalene
3	Metals and trace inorganics	Metals, trace elements, and metal- trace element-compounds, including metalloids
4	Nonmetals	Nonmetals and nonmetallic compounds, not including metalloids
5	Phenols	All phenols, regardless of volatility or association with metals and nonmetals
6	Phthalates	All phthalates, regardless of volatility or association with metals and nonmetals
7	Polyhalogenated biphenyls	Includes all conjugers of PCBs and PBBs

Pollutant group code	Pollutant group name	Definition
8	Dioxins and furans	Dioxins, furans, dibenzofurans, and all ether compounds
9	Radionuclide	
10	Amides and amines	
11	Ketones	
12	Particles	Air particulates. These include a range of chemicals that cannot be identified individually.
13	Pesticides	All pesticides, including herbicides, fungicides, insecticides, etc.
14	Organisms	Includes bacteria, viruses, and parasites
15	Octachlorostyrene	
16	Polychlorinated Benzenes	Benzene not classified as VOCs
17	Salts	Primarily chloride salts
18	Organic matter	

Table 7: Individual pollutants table. The following table illustrates only some of the data contained in the table *Individual Pollutants*, since there are 2780 entries in this table.

Pollutant	Pollutant code	Pollutant group code	CAS Number
1, 1-DIFLUOROETHANE	28	1	75-37-6
1,1,1,2-TETRACHLOROETHANE	42	1	630-20-6
1,1,1-TRICHLOROETHANE	47	1	71-55-6
1,1,2,2-TETRACHLOROETHANE	50	1	79-34-5
1,1,2,2-TETRAFLUOROETHYLENE	51	1	116-14-3
1,1,2-TRICHLOROETHANE	53	1	79-00-5
1,1-DICHLOROETHANE	58	1	75-34-3
1,1-DICHLOROETHYLENE	59	1	75-35-4
1,1-DIMETHYLETHANE	63	1	75-28-5
1,2,3-TRICHLOROPROPANE	84	1	96-18-4
1,2,4-TRICHLOROBENZENE	88	1	120-82-1
1,2,4-TRIMETHYLBENZENE	89	1	95-63-6
1,2-DIBROMOETHANE	100	1	106-93-4
1,2-DICHLOROBENZENE	103	1	95-50-1
1,2-DICHLOROETHANE	104	1	107-06-2
1,2-DICHLOROETHYLENE	105	1	540-59-0
1,2-DICHLOROPROPANE	106	1	78-87-5
1,3-BUTADIENE	132	1	106-99-0
1,3-DICHLOROBENZENE	136	1	541-73-1
1,3-DICHLOROPROPANE	137	1	142-28-9
1,3-DICHLOROPROPENE (MIXED ISOMERS)	138	1	542-75-6

Table 8: PBT codes table.

PBT code	PBT
1	A classified pbt
2	Not a classified pbt
3	Includes some classified PBTs

Table 9: Stressor data. Data for only 10 stressors is shown.

Stressor code	Overall comparative contribution	Confidence level	Trend	Geographic extent	Adequacy of ambient monitoring
1	High	somewhat speculative	no trend	urban areas	Adequate monitoring of hotspots
2	Medium	moderately confident	up and down	urban and localized areas	Reasonable
3	Medium	somewhat speculative	up and down	statewide	very limited
4	Medium	moderately confident	no trend	statewide	Reasonable
5	Low	moderately confident	up and down	urban and agricultural areas	Adequate monitoring of hotspots
6	Low	somewhat speculative	no trend	localized areas	very limited
7	High	moderately confident	no trend	urban areas	adequate monitoring of hotspots
8	Unknown	not applicable	up and down	localized areas	very limited
9	Medium	we're very unsure	up and down	statewide	very limited
10	Medium	somewhat speculative	up and down	urban and agricultural areas	adequate monitoring of hotspots

Table 10: Sources data. Data for only 10 sources is shown.

Source code	Comparative contribution	Confidence level	Trend
1	high	somewhat speculative	up and down
2	high	somewhat speculative	up and down
3	medium	somewhat speculative	up and down
4	medium	somewhat speculative	up and down
5	low	somewhat speculative	up and down
6	low	somewhat speculative	up and down
7	high	moderately confident	up and down
8	low	somewhat speculative	up and down
9	high	reasonable	up and down
10	medium	moderately confident	up and down

Table 11: Program data. Data for only two sources is shown.

Source ID	Activity Type	Activity Level	Agency	Comment	Web link
1	Education	Well-established	External		
1	Prevention	Well-established	External		
1	Control	Limited	External		
1	Cleanup	None exists	External		
1	Education	None exists	MPCA		
1	Prevention	Limited	MPCA		
1	Control	Limited	MPCA		
1	Cleanup	None exists	MPCA		
2	Control	Limited	External		
2	Prevention	Limited	External		
2	Cleanup	Limited	External		
2	Education	None exists	MPCA		
2	Control	Limited	MPCA		
2	Cleanup	Limited	MPCA		
2	Education	Well-established	External		
2	Prevention	Limited	MPCA		

Table 12: Pollutant-stressor linkages. Data for only two stressors is shown.

Stressor code	Pollutant code	Pollutant	Pbt code	Impact code
1	717	12	3	3
1	2757	3	3	3
1	2176	12	3	3
1	2175	12	2	3
1	2755	12	3	3
1	1237	12	3	3
1	2754	12	3	3
2	1438	1	2	3
2	132	1	2	3
2	559	1	2	3
2	765	1	2	3

Table 13: Stressor comments. Data for only two stressors is shown.

Stressor code	Comment	Comment type
1	Fossil fuel combustion emits particles and precursors.	General
1	Large portion of population exposed; cancer risk for ambient exposure levels not well understood.	Rationale
1	Toxicity may come from particles or attached chemicals; we have good data on the former, poor on the latter.	General
1	Lung cancer is the primary concern.	Endpoint

Stressor code	Comment	Comment type
1	Many listed sources do not emit particles. Instead, they emit compounds that form particles downwind of the emission point. These particles are known as particle precursors (e.g. agricultural practices and wastewater emit NH3, not particles).	General
1	There is limited PM2.5 data. Stressor trend is based on PM10 data. Primary health concern is with PM2.5 and nanoparticles.	General
1	Pathway is inhalation.	Pathway
1	It is unknown if cancer effects are primarily linked to mass of particulate or to number of particles. It is difficult to assess trends because while the mass of particles has remained steady or even decreased, the trend on number of particles is unknown.	General
2	Pathway is inhalation.	Pathway
2	Endpoint is cancer. Cancers vary with chemical (e.g. benzene causes leukemia). Cancer risks from exposures to multiple chemicals not well understood.	Endpoint
2	Pollutants and pollutant sources are ubiquitous; not all are listed.	General
2	Large portion of population exposed. A few chemicals are above health benchmarks. A few chemicals may be approaching health benchmarks.	Rationale
2	Effects might occur in microenvironments (e.g. gas stations).	General

Table 14: Stakeholder information. Only five entries are shown.

Name	Stressor	Stressor code	Reference	Group	Value	Rank
Area sources of air pollution	Particles in air	1	Minnesota	Citizen	2	medium
Area sources of air pollution	Particles in air	1	Minnesota	Stakeholders	1	high
Air pollution	Particles in air	1	Iowa	Staff	3	low
Wastewater	Particles in air	1	Minnesota	Staff	2	medium
Outdoor air quality	Particles in air	1	Iowa	Staff	2	medium

Example Queries

Example 1: What are stressor overall comparative contributions and trends for aquatic organisms.

Using Tables 1, 2 and 9 from the above discussion, we can link these three tables by Impact Code and Stressor Code. Using Table 2, we select Impact Code = 4 (Ecosystem Impacts - Aquatic Organisms). We select the fields Stressor, Overall comparative contribution, and Trend. Results are displayed in Table 15. Notice there are two entries for Temperature increase/climate. In the EIR, we included short-term and long-term effects of climate change. Thus, there are two entries for this stressor.

Table 15: Results of the query from Example 1.

Stressor	Overall comparative contribution	Trend
Acid deposition	low	no trend
Ammonia	low	Down
Dissolved solids	low	no trend
Excess UV radiation from	low	no trend
Habitat modification	high	up
Nitrogen	medium	up
Oxygen-demanding pollutants	medium	down
Phosphorus	high	no trend
Temperature increase/climate	high	up
Temperature increase/climate	low	up
Toxic metals	medium	no trend
Toxic organic chemicals	medium	no trend
Transported sediment	high	no trend

Example 2: Identify source contributions for the high contribution stressors for aquatic organisms. For this query, we utilize five tables: Impacts Coded, Stressors Coded, Stressor Data, Sources Coded, and Sources Data. These tables are linked through Impact Code, Stressor code, or Source Code (see Figure 1). Selected fields include Impact Code (= 4; field not shown), Stressor, Stressor overall comparative contribution (= "high"; field not shown), Source, and Comparative Contribution (from Sources Data table). Results are shown in Table 16.

Table 16: Results of the query from Example 2.

Stressor	Source	Comparative contribution
Habitat modification	Drainage and channelization	high
Habitat modification	Dredging	medium
Habitat modification	**Urban/suburban/lakeshore development**	high
Phosphorus	Agricultural runoff	high
Phosphorus	Feedlots	medium
Phosphorus	Municipal and industrial wastewater	medium
Phosphorus	Septic systems	low
Phosphorus	Urban runoff	medium
Temperature increase/climate	Agriculture	medium
Temperature increase/climate	Coal-fired power plants	high
Temperature increase/climate	Industry	medium
Temperature increase/climate	On-road vehicles	high
Temperature increase/climate	Permitted waste disposal	medium
Temperature increase/climate	Power plants (thermal discharge)	low
Temperature increase/climate	Residential fuel combustion	low
Temperature increase/climate	Urban runoff	medium
Transported sediment	Agricultural runoff	high
Transported sediment	Construction	high
Transported sediment	Municipal and industrial wastewater	low

Stressor	Source	Comparative contribution
Transported sediment	Streambank erosion	medium
Transported sediment	Urban runoff	medium

Example 3: For stressors with high overall comparative contribution, what are the trends in sources? We can use two basic queries, Stressor overall comparative contribution and Source trends, to get at this information. These queries are linked through Stressor Code. Selected fields include Impact, Stressor, Source, Overall comparative contribution (= "high"; field not shown), and Trend. Results are shown in Table 17.

Table 17: Results for query from Example 3.

Impact	Stressor	Source	Trend
Ecosystem impacts-aquatic	Habitat modification	Drainage and channelization	up
Ecosystem impacts-aquatic	Habitat modification	Dredging	no trend
Ecosystem impacts-aquatic	Habitat modification	Urban/suburban/lakeshore	up
Ecosystem impacts-aquatic	Phosphorus	Agricultural runoff	up
Ecosystem impacts-aquatic	Phosphorus	Feedlots	no trend
Ecosystem impacts-aquatic	Phosphorus	Municipal and industrial wastewater	no trend
Ecosystem impacts-aquatic	Phosphorus	Septic systems	no trend
Ecosystem impacts-aquatic	Phosphorus	Urban runoff	up
Ecosystem impacts-aquatic	Temperature	Agriculture	up
Ecosystem impacts-aquatic	Temperature	Coal-fired power plants	up
Ecosystem impacts-aquatic	Temperature	Industry	up
Ecosystem impacts-aquatic	Temperature	On-road vehicles	up
Ecosystem impacts-aquatic	Temperature	Permitted waste disposal	no trend
Ecosystem impacts-aquatic	Temperature	Power plants (thermal discharge)	no trend
Ecosystem impacts-aquatic	Temperature	Residential fuel combustion	no trend
Ecosystem impacts-aquatic	Temperature	Urban runoff	up
Ecosystem impacts-aquatic	Transported sediment	Agricultural runoff	no trend
Ecosystem impacts-aquatic	Transported sediment	Construction	no trend
Ecosystem impacts-aquatic	Transported sediment	Municipal and industrial wastewater	no trend
Ecosystem impacts-aquatic	Transported sediment	Streambank erosion	no trend
Ecosystem impacts-aquatic	Transported sediment	Urban runoff	no trend
Ecosystem impacts-terrestrial	Habitat modification	Agriculture	no trend
Ecosystem impacts-terrestrial	Habitat modification	Mining	down
Ecosystem impacts-terrestrial	Habitat modification	Silvaculture	no trend
Ecosystem impacts-terrestrial	Habitat modification	Urban/suburban/lakeshore	up
Ecosystem impacts-terrestrial	Temperature	Agriculture	up
Ecosystem impacts-terrestrial	Temperature	Coal-fired power plants	up
Ecosystem impacts-terrestrial	Temperature	Industry	up
Ecosystem impacts-terrestrial	Temperature	On-road vehicles	up
Ecosystem impacts-terrestrial	Temperature	Permitted waste disposal	no trend
Ecosystem impacts-terrestrial	Temperature	Residential fuel combustion	no trend
Human health impacts-cancer	Particles in air	Agriculture	unknown

Impact	Stressor	Source	Trend
Human health impacts-cancer	Particles in air	Area source combustion	unknown
Human health impacts-cancer	Particles in air	Coal-fired power plants	unknown
Human health impacts-cancer	Particles in air	Fugitive dust	unknown
Human health impacts-cancer	Particles in air	Industry	unknown
Human health impacts-cancer	Particles in air	Municipal and Industrial wastewater	unknown
Human health impacts-cancer	Particles in air	Off-road equipment	unknown
Human health impacts-cancer	Particles in air	On-road vehicles	unknown
Human health impacts-	Particles in air	Agriculture	unknown
Human health impacts-	Particles in air	Area source combustion	unknown
Human health impacts-	Particles in air	Coal-fired power plants	unknown
Human health impacts-	Particles in air	Fugitive dust	unknown
Human health impacts-	Particles in air	Industry	unknown
Human health impacts-	Particles in air	Municipal and industrial wastewater	unknown
Human health impacts-	Particles in air	Off-road equipment	unknown
Human health impacts-	Particles in air	On-road vehicles	unknown
Human health impacts-	Temperature	Agriculture	up
Human health impacts-	Temperature	Coal-fired power plants	up
Human health impacts-	Temperature	Industry	up
Human health impacts-	Temperature	On-road vehicles	up
Human health impacts-	Temperature	Permitted waste disposal	no trend
Human health impacts-	Temperature	Residential fuel combustion	no trend
Human health impacts-	Particles in air	Agriculture	unknown
Human health impacts-	Particles in air	Area source combustion	unknown
Human health impacts-	Particles in air	Coal-fired power plants	unknown
Human health impacts-	Particles in air	Fugitive dust	unknown
Human health impacts-	Particles in air	Industry	unknown
Human health impacts-	Particles in air	Municipal and industrial wastewater	unknown
Human health impacts-	Particles in air	Off-road equipment	unknown
Human health impacts-	Particles in air	On-road vehicles	unknown

Appendix H: Review of other Reports that Rank Environmental Stressors

Note to readers: **This appendix and others refer to reports and documents indicated as clickable internet links, which were live when the report was drafted. It is likely that some of these links are no longer live and current, as the MPCA cannot maintain those belonging to other organizations. If you are interested in a particular reference and cannot access it, please contact Michael Trojan at 651/297-5219.**

During the early stages of developing the Environmental Information Report (EIR), the EIR Team attempted to identify the best approach for assessing a wide variety of environmental issues. The Team discussed approaches that were used in other studies. These other studies provided examples of environmental information that could go into the EIR and different methods of assessing this information. The EIR Team never formally compiled this information. We did, however, produce some documents summarizing our literature review, as well as identify a large number of websites that provide information on environmental priority setting. This section provides a brief summary of some of the information we gathered during this early stage of the EIR. Included is a reference list.

Contents

REVIEW 1

This review summarizes results from four studies in which environmental issues were ranked. Issues are listed in order of perceived importance, from most important to least. For each study, there may have been multiple stakeholder groups.

Minnesota

Industrial source of air pollution
Mobile sources of air pollution
Spills & environmental emergencies
Hazardous waste
Superfund
Area sources of air pollution
Wastewater treatment
Nonpoint sources
Feedlots
Solid waste
Storage tanks
Septic tanks

Michigan

Absence of land use planning that considers resources and the integrity of ecosystems
Degradation of urban environments
Energy production and consumption: practices and consequences
Global climate change
Lack of environmental awareness
Stratospheric ozone depletion
Alteration of surface water and ground water hydrology, including the Great Lakes
Atmospheric transport and deposition of air toxics
Biodiversity/Habitat modification
Indoor pollutants
Nonpoint-source discharges to surface water and groundwater, including the Great Lakes
Trace metals in the ecosystem
Contaminated sites
Contaminated surface water sediments
Generation and disposal of hazardous waste
Generation and disposal of high-level radioactive waste
Generation and disposal of low-level radioactive waste
Generation and disposal of municipal and industrial solid waste
Photochemical smog
Point source discharges to surface water and groundwater, including the Great Lakes
Accidental releases and responses
Acid deposition
Criteria and related air pollutants
Electromagnetic field effects

Ohio

Abandoned industrial sites
Drinking water at the tap
Exposure from consumer unawareness
Inadequate infrastructure
Indoor air quality
Industrial/Commercial wastewater discharges
Mobile source emissions
Municipal waste disposal facilities
Ozone-depleting substances
Unregulated/Abandoned hazardous waste facilities
Filling/Diking/Draining of wetlands
Loss of species diversity
Loss of wildlife habitat
Population changes
Uncontrolled development
Combustion by-products
Mining activities
Nonpoint source/agricultural runoff

Pesticide spraying
Regulated hazardous waste facilities
Stationary air emissions (utilities, industrial and commercial)
Abandoned water wells
Natural food toxins
Oil and gas exploration
Pesticide residues on foods
Tire management
Underground storage tanks
Channelization of streams and rivers
Disposal capacity
Floods
Litter
Stormwater runoff from non-agricultural areas
Construction and demolition debris
Construction of dams
Fugitive dust
Harvesting natural resources
Illegal dumping
Municipal wastewater discharges
Overconsumption of natural resources
Recreation
Sludge disposal
Spills and accidental releases
Transportation of waste
Yard waste

Cleveland Area

Environmental and Related Economic Impacts of Outmigration from the Urban Core
Quality Of the Urban Environment
Public Committee Provisional Environmental Priorities
Quality Of Outdoor Air
Quality Of Surface Waters
Use Of Resources/ Energy
Global Climate Change
Hazardous Substances In Households And Schools Including Childhood
Lead Poisoning
Human Food Contamination
Quality Of Indoor Air
Quality Of Natural Areas
Stratospheric Ozone Loss
Acid Rain
Ecological Balance
Quality Of Ground Water
Radiation Exposure From Human Sources
Solid Waste Disposal

Human Health Technical Advisory Committee Rankings
Hazardous substances in households and schools, including lead poisoning
Outmigration from urban core
Quality of indoor air
Stratospheric ozone Loss
Food contamination
Quality of outdoor air
Quality of ground water
Quality of surface waters used for drinking or aquatic habitat
Radiation exposure from human sources
Solid waste disposal
Ecological balance
Quality of natural areas
Quality of urban environment
Acid rain
Global warming
Use of resources / Energy
Ecology Technical Advisory Committee Rankings
Ecological balance
Global warming
Outmigration from urban core
Quality of natural areas
Quality of surface waters used for drinking or aquatic habitat
Acid rain
Quality of ground water
Quality of outdoor air
Quality of urban environment
Stratospheric ozone Loss
Solid waste disposal
Food contamination
Hazardous substances in households and schools, including lead poisoning
Quality of indoor air
Radiation exposure from human sources
Use of resources / Energy
Hazardous substances in households and schools, including lead poisoning
Outmigration from urban core
Quality of urban environment
Quality of natural areas
Quality of outdoor air
Quality of indoor air
Quality of surface waters used for drinking or aquatic habitat
Use of resources / Energy
Solid waste disposal
Radiation exposure from human sources
Acid rain
Food contamination

Quality of ground water
Stratospheric ozone Loss
Ecological balance
Global warming

REVIEW 2

This review largely contains the same information as the above review, except that greater detail is provided for the results.

MINNESOTA

Citizens JuryTM Ranking Results

1. Industrial source of air pollution
2. Mobile sources of air pollution
3. Spills & environmental emergencies
4. Hazardous waste
5. Superfund
6. Area sources of air pollution
7. Wastewater treatment
8. Nonpoint sources
9. Feedlots
10. Solid waste
11. Storage tanks
12. Septic tanks

Stakeholders Ranking Results

1. Nonpoint sources
2. Mobile sources of air pollution
3. Feedlots
4. Area sources of air pollution
5. Septic tanks
6. Industrial source of air pollution
7. Superfund
8. Wastewater treatment
9. Spills & environmental emergencies
10. Hazardous waste
11. Solid waste
12. Storage tanks

Minnesota Pollution Control Agency Staff Ranking Results

1. Mobile sources of air pollution
2. Industrial source of air pollution
3. Nonpoint sources
4. Area sources of air pollution
5. Feedlots

6. Wastewater treatment
7. Septic tanks
8. Solid waste
9. Superfund
10. Hazardous waste

11. Spills & environmental emergencies
12. Storage tanks

Project Purpose:

The purpose of the 1996-97 Risk-Based Environmental Priorities Project effort was to help the agency
develop environmental priorities that reflect both the Minnesota Pollution Control Agency's best available
scientific information about environmental risks as well as the values of a diverse clientele.

Ranking Process:

In addition to ranking the 12 environmental issues on their own, the Minnesota Pollution Control Agency
also sought to involve the public through two parallel processes: a Citizens JuryTM and a Stakeholders
Workshop. Both of these groups constructed rankings of their own.

Participants in the Ranking Process: General Public, Governmental Agencies, Private Sector/Industry, Public Interest/Nonprofit Organizations, Scientific/Academic Community. Minnesota Pollution Control Agency constructed their own rankings, the General Public were represented in the Citizens JuryTM, and the other stakeholder groups were represented in the Stakeholders Workshop.

Reference

Schmiechen, Paul. Risk-Based Environmental Priorities Project: Final Report. Environmental Planning Unit, Minnesota Pollution Control Agency. September 1997.

MICHIGAN

Final Combined Committee Rankings

High-High

Absence of land use planning that considers resources and the integrity of ecosystems
Degradation of urban environments
Energy production and consumption: practices and consequences
Global climate change
Lack of environmental awareness
Stratospheric ozone depletion

High

Alteration of surface water and ground water hydrology, including the Great Lakes
Atmospheric transport and deposition of air toxics
Biodiversity/Habitat modification
Indoor pollutants
Nonpoint-source discharges to surface water and groundwater, including the Great Lakes
Trace metals in the ecosystem

Medium-High

Contaminated sites
Contaminated surface water sediments
Generation and disposal of hazardous waste
Generation and disposal of high-level radioactive waste
Generation and disposal of low-level radioactive waste
Generation and disposal of municipal and industrial solid waste
Photochemical smog
Point source discharges to surface water and groundwater, including the Great Lakes

Medium

Accidental releases and responses
Acid deposition
Criteria and related air pollutants
Electromagnetic field effects

Agency Committee Rankings

High

Absence of land use planning that considers resources and the integrity of ecosystems
Energy production and consumption: practices and consequences
Generation and disposal of high-level radioactive waste
Indoor pollutants
Stratospheric ozone depletion

High/Medium

Atmospheric transport and deposition of air toxics
Biodiversity/Habitat modification
Global climate change
Lack of environmental awareness
Nonpoint-source discharges to surface water and groundwater, including the Great Lakes

Medium

Alteration of surface water and ground water hydrology, including the Great Lakes
Degradation of urban environments
Generation and disposal of municipal and industrial solid waste
Photochemical smog
Point source discharges to surface water and groundwater, including the Great Lakes
Trace metals in the ecosystem

Medium/Low

Accidental releases and responses
Contaminated sites
Generation and disposal of hazardous and low-level radioactive waste

Low

Acid deposition
Contaminated surface water sediments
Criteria and related air pollutants
Electromagnetic field effects

Citizen Committee Rankings

High

Absence of land use planning that considers resources and the integrity of ecosystems
Alteration of surface water and ground water hydrology, including the Great Lakes
Degradation of urban environments
Energy production and consumption: practices and consequences
Global climate change
Lack of environmental awareness
Nonpoint-source discharges to surface water and groundwater, including the Great Lakes
Stratospheric ozone depletion

High/Medium

Biodiversity/Habitat modification

Medium

Atmospheric transport and deposition of air toxics
Contaminated sites
Contaminated surface water sediments
Generation and disposal of hazardous and low-level radioactive waste
Generation and disposal of high-level radioactive waste
Point source discharges to surface water and groundwater, including the Great Lakes
Trace metals in the ecosystem

Low

Accidental releases and responses
Acid deposition
Criteria and related air pollutants
Electromagnetic field effects
Generation and disposal of municipal and industrial solid waste
Indoor pollutants
Photochemical smog

Scientist Committee Rankings

High-High

Absence of land use planning that considers resources and the integrity of ecosystems
Energy production and consumption: practices and consequences
Global climate change
Indoor pollutants
Lack of environmental awareness

Stratospheric ozone depletion

Medium-High

Alteration of surface water and ground water hydrology, including the Great Lakes
Atmospheric transport and deposition of air toxics
Biodiversity/Habitat modification
Degradation of urban environments
Nonpoint-source discharges to surface water and groundwater, including the Great Lakes
Point source discharges to surface water and groundwater, including the Great Lakes
Trace metals in the ecosystem

Low-High

Contaminated sites
Contaminated surface water sediments
Criteria and related air pollutants
Generation and disposal of hazardous and low-level radioactive waste
Generation and disposal of municipal and industrial solid waste
Photochemical smog

Low-Low

Accidental releases and responses
Acid deposition
Electromagnetic field effects
Generation and disposal of high-level radioactive waste

Project Purpose

The goal of the project was to use input from citizens, scientists, and state agencies to identify and rank Michigan's environmental concerns.

Ranking Process

Three Working Committees (Agency, Citizen, and Scientist) separately ranked a consensus list of environmental issues, taking into consideration quality of life, human health, and ecological risks. After completion of this step, all of the committees met to discuss their respective rankings and develop the Final Combined Committee Rankings.

Participants in the Ranking Process: Governmental Agencies, Private Sector/Industry, Public Interest/Nonprofit Organizations, Scientific/Academic Community. All of the above stakeholder groups had representatives on a least one of the Working Committees. While the General Public were not explicitly involved, the Citizen Committee, primarily consisting of members of various state environmental commissions, was charged with representing their interests.

Reference

Michigan Relative Risk Analysis Project. Michigan's Environment and Relative Risk. Michigan Department of Natural Resources. July 1992.

CLEVELAND METRO AREA, OHIO

Public Committee Provisional Environmental Priorities

High

Environmental and Related Economic Impacts of Outmigration from the Urban Core
Quality Of Outdoor Air
Quality Of Surface Waters
Quality Of the Urban Environment
Use Of Resources/ Energy

Medium

Global Climate Change
Hazardous Substances In Households And Schools Including Childhood Lead Poisoning
Human Food Contamination
Quality Of Indoor Air
Quality Of Natural Areas
Stratospheric Ozone Loss

Low

Acid Rain
Ecological Balance
Quality Of Ground Water
Radiation Exposure From Human Sources
Solid Waste Disposal

Human Health Technical Advisory Committee Rankings

High/Medium

Hazardous substances in households and schools, including lead poisoning
Outmigration from urban core
Quality of indoor air
Stratospheric ozone Loss

Medium

Food contamination
Quality of outdoor air

Medium/Low

Quality of ground water
Quality of surface waters used for drinking or aquatic habitat
Radiation exposure from human sources
Solid waste disposal

Low

Ecological balance
Quality of natural areas
Quality of urban environment

Acid rain
Global warming
Use of resources / Energy

Ecology Technical Advisory Committee Rankings

High

Ecological balance
Global warming
Outmigration from urban core
Quality of natural areas
Quality of surface waters used for drinking or aquatic habitat

Medium

Acid rain
Quality of ground water
Quality of outdoor air
Quality of urban environment
Stratospheric ozone Loss

Low

Solid waste disposal
Food contamination
Hazardous substances in households and schools, including lead Poisoning
Quality of indoor air
Radiation exposure from human sources
Use of resources / Energy

Quality of Life Technical Advisory Committee Rankings

High

Hazardous substances in households and schools, including lead poisoning
Outmigration from urban core
Quality of urban environment

High/Medium

Quality of natural areas
Quality of outdoor air

Medium

Quality of indoor air
Quality of surface waters used for drinking or aquatic habitat
Use of resources / Energy

Medium/Low

Solid waste disposal

Low

Radiation exposure from human sources
Acid rain
Food contamination
Quality of ground water
Stratospheric ozone Loss

No Ranking Offered (various reasons)

Ecological balance
Global warming

Project Purpose

The goals were to provide a framework to better comprehend and prioritize regional environmental risks, to stimulate more informed public debate on environmental issues and solutions, to find common ground on the most urgent regional problems, and to produce some realistic action strategies that coordinate regional effort and possible develop new opportunities.

Ranking Process

Three Technical Advisory Committees (Human Health, Quality of Life and Ecology) separately ranked the
citizen-generated issues list. Largely based upon these results, the Public Committee constructed a set of Provisional Environmental Priorities, two of which they later designated as Definite Environmental Priorities.

Participants in the Ranking Process: General Public, Governmental Agencies, Private Sector/Industry, Public Interest/Nonprofit Organizations, Scientific/Academic Community. All of the above stakeholder groups had representatives on at least one of the Technical Advisory Committees or the Public Committee.

Reference

The Regional Environmental Priorities Project. Case Western Reserve University Center for the Environment. Published in: The Ohio Comparative Risk Project. Ohio State of the Environmental Report. Ohio Environmental Protection Agency. December 1995.

REVIEW 3

This review contains notes compiled for several studies of environmental priority setting.

Water Environment Federation
http://www.wef.org/GovtAffairs/Policy/wqep.jhtml

1. Environmental priority setting means setting priorities based upon the greatest opportunities to gain needed water quality improvements.
2. … activities for improving water quality must be based upon scientifically valid analyses of the relative environmental benefit of that activity compared to other programs required under

the Act. Resources must be focussed on those activities which will achieve the greatest benefit to the environment.

3. Priority setting should also consider cross-media application and pollution prevention.
4. Environmental priorities must be based upon state-of-the-art scientific information. Priorities should be periodically re-evaluated to incorporate new scientific and technical knowledge.
5. Wherever possible, efforts should be made to prioritize water quality improvement programs along logical geographic regions. Programs should be implemented in a manner which continues to guarantee state primacy in setting water quality standards, upon region-specific natural conditions.
6. Environmental priority setting and management proposals incorporate enforcement mechanisms appropriate to maximum water quality improvements. Maintaining and enhancing water quality and biological integrity must be the primary when setting environmental enforcement priorities.

State of Texas Environmental Priorities Project
http://twri.tamu.edu/twripubs/WtrResrc/v24n1/text-1.html

1. The effort worked this way. First, 27 potential issues were identified by a public advisory committee (PAC) comprised of 23 people. Then, three technical work groups consisting of ecological (13 members), human health (22 people), and socioeconomic experts (23 individuals) commented on these items. Afterwards, the PAC integrated the rankings from the workgroups into an overall list of priorities. An oversight committee examined these results and evaluated the extent to which these results can be used by state agencies when they develop new regulations or modifying existing ones.
2. A few clarifications need to be made regarding STEPP. First, the project focused only on "residual" risks, which are defined as those threats that can be reduced through management strategies. STEPP defines residual risks as those hazards which exist due to the absence of a program to protect ecosystems, human health or socioeconomic welfare; risks that remain after regulatory programs are implemented, and risks that result when regulatory programs fail.
3. Once each work group had identified and prioritized environmental threats, STEPP participants then developed a consensus ranking. This effort involved taking the results from

the individual groups and trying to find common grounds so that comparisons could be made between the groups' recommendations. To do this, the PAC considered such factors as whether the threats could be negated over time or were irreversible, the severity and adversity imposed by each risk, the number of people who could be exposed to the hazard, the robability or likelihood that threats will occur, and whether trends suggest that an issue is becoming more severe over time. Finally, the PAC voted on a series of "paired comparisons" to judge the severity of environmental threats. For example, PAC members may have been asked to choose whether the threat posed by flooding was more or less severe than risks presented by chemicals applied to landscapes.

Audubon International

http://www.audubonintl.org/environmentalpriorities.htm

1. Environmental Priority: Environmental Planning
    1.1. Goal: Ensure that public and private properties are properly managed to maximize environmental quality.
    1.2. To meet this goal, Audubon International teaches people to:
        1.2.1. Define their resources and constraints
        1.2.2. Define goals and objectives for participating in conservation projects
        1.2.3. Develop a plan of action for increasing conservation
        1.2.4. Seek out and include local resource people in planning and implementing projects
2. Environmental Priority: Wildlife Habitat Management and Improvement
    2.1. Goal: Ensure the healthy functioning of native, natural habitats and the wildlife that depend upon them for survival.
    2.2. To meet this goal, Audubon International teaches people to:
        2.2.1. Identify and learn about their local ecological region and native plant community
        2.2.2. Evaluate food, cover, and water sources for wildlife on their property
        2.2.3. Identify any endangered or threatened habitats or species and work to protect or enhance them
        2.2.4. Increase the quality and quantity of food, cover, and water sources available primarily through natural
        2.2.5. landscaping and native plant use

2.2.6. Supplement existing natural habitat resources with nest boxes and feeders as appropriate

2.2.7. Reduce or eliminate threats to wildlife and habitats as appropriate

2.2.8. Document increases in wildlife numbers, species and/or habitat acreage

3. Environmental Priority: Water Conservation and Water Quality Protection

3.1. Goal: Ensure clean, adequate fresh water supplies while protecting the habitat integrity and healthy functioning of water bodies such as rivers, streams, wetlands, lakes, and ponds.

3.2. To meet this goal, Audubon International teaches people to:

3.2.1. Identify their local watershed

3.2.2. Identify their water source

3.2.3. Identify water use and waste

3.2.4. Identify areas for improved conservation

3.2.5. Implement water conservation practices

3.2.6. Learn about the health of local water sources

3.2.7. Initiate water quality testing as needed

3.2.8. Implement best management practices

3.2.9. Implement integrated pest management practices

3.2.10. Document water reduction and water quality

4. Environmental Priority: Resource Conservation

4.1. Goal: Ensure that resources upon which people depend are sustained for current and future use. Decrease the impact of resource production, transportation, consumption and waste on the biological integrity of the natural systems from which they come.

4.2. To meet this goal, Audubon International teaches people to:

4.2.1. Evaluate resource consumption and waste generated

4.2.2. Reduce consumption of energy and resources through the use of appropriate technologies and efficient practices

4.2.3. Reduce, reuse, and recycle wastes

4.2.4. Document energy conserved and waste reduced

5. Environmental Priority: Community Outreach and Education

5.1. Goal: Ensure ongoing support for stewardship initiatives, strengthen local connections, and extend participation in environmental conservation activities.

5.2. To meet this goal, Audubon International teaches people to:

5.2.1. Contact local agencies and individuals who can help with planning and project implementation

5.2.2. Inform property stakeholders (i.e. employees, community members, neighbors, committee members, golfers, etc.) of participation in environmental activities and encourage their involvement and support

5.2.3. Involve people in conservation activities taking place on the property

National Science Board – Task Force on the Environment

http://www.iceis.mcnc.org/projects/dashmm/nsb_speech.html

The following are research priorities identified by the task force.

1. The need for cross disciplinary / interdisciplinary research to address environmental issues.
2. The importance of considering questions at the appropriate temporal and physical scale: emphasis was on long-term and large
3. scale research needs.
4. The need to include appropriate human components (i.e. economics and social sciences) in environmental research and
5. education activities.
6. The need for research to more effectively connect to decision making (policy, regulatory, and management).
7. The urgency of including educational elements in environmental programs and plans.
8. The need for better coordination among programs.
9. The need to improve predictive capabilities in a variety of environmental areas.
10. The importance of priority setting by individuals and organizations familiar with the research, education and assessment issues.

Additional comments:

11. … hydrologists, surface and sub-surface chemists, geologists, biologists, ecologists (to name a few), along with atmospheric scientists and chemists; should be funded in teams, …

12. … NSF's environmental research program -- in order to be successful -- will have to help foster perhaps the largest most ambitious data collection and archival enterprise undertaken to date. Much of this data, coming from many new sources, will need to be collected and archived in real-time. Thus, the requirements for, and the integration of efforts with coincident advances in high performance computing, information delivery and archival systems, metadata storage and access/retrieval systems, and advanced networks of very high bandwidth and minimal latency will be essential.
13. With the preceding five items as a framework, I believe the research community is poised to, and must be provided the funds to--sixth--take advantage of emerging environmental predictive capabilities on multiple space and time scales. …because stewardship of the environment, which is the ability of humans to proactively create sustainable development, depends upon our ability to predict--to an acceptable degree of accuracy—the consequences of anthropogenically emitted and deposited waste into the environment--we cannot ignore this outstanding NWP legacy in the next decade's environmental research agenda.

Environmental Defense

http://www.scorecard.org/comp-risk/

http://www.scorecard.org/comp-risk/cr_faqs.html#process

Use of comparative risk to set environmental priorities

1. Comparative risk projects involve a series of steps: participant and environmental issue selection, technical analysis, public input collection, risk ranking, priority ranking, environmental management planning, etc. The Project Description section of every Scorecard report identifies the process followed in a ranking project. Most projects begin with the formation of some sort of Steering or Public Advisory Committee and Technical Committees (often Human Health, Ecological, and Quality of Life). The next step is the selection of a list of issue areas or environmental problems to be ranked. The Technical Committees often write reports for each of the issues areas and develop risk-based rankings. These reports and rankings are then submitted to a central committee (usually Steering or Public Advisory) and this body creates an integrated ranking of environmental risks. Finally, these ranked risks may be turned into an environmental risk management agenda. While this is the common

process, there are nearly as many variations as there are projects (e.g., many projects do not integrate their technical rankings)

2. Multiple priority lists are to be expected given the complexity of any effort to set environmental priorities. To develop an integrated ranking, project participants need to reach consensus on a controversial series of value judgments: should human health risks be given the same weight as ecological risks? should rankings be based solely on risk magnitude or be balanced by considerations of cost and technical feasibility? should rankings reflect only technocratic assessments of risks or incorporate public risk perceptions? There are no easy answers to these questions, and may projects opted to leave them unaddressed by providing multiple rankings along different risk dimensions and refusing (or failing) to reach consensus on a single integrated priority list.

http://www.wced.org/publications/EightQuestions.htm

1. Why do we want to do a comparative risk project?
   - 1.1. Clear goals are important to the success of a comparative risk project. The goals should be revisited throughout the project to ensure the project is on track and if necessary, revised as the project progresses.
     - 1.1.1. Administrative Goals: Is there an administrative driver for the project such as impending budget cuts or need to set priorities for Performance Partnership agreements? Is there a political need to do a comparative risk project such as a new governor establishing a new direction?
     - 1.1.2. Programmatic Goals: Is the agency at a point in its evolution where it needs new ideas, new directions, or confirmation of the old?
     - 1.1.3. Organizational Goals: Does the agency need more credibility with its constituents such as the general public, the legislature, other agencies? Will increased contact and cooperation with other branches or agencies of government improve environmental management in the state?
     - 1.1.4. Process Goals: Does the agency need to build new or better relationships with the public, the legislature, other agencies?
     - 1.1.5. Behavioral Goals: Does the agency want to encourage a change in the public's behavior through increased involvement and education?

2. How will the comparative risk project be structured?
    2.1. The lead agency will usually support the key project staff consisting of at least one full-time project director. Many projects have small policy advisory boards to give guidance to the director. In addition, volunteers are recruited to serve on technical committees such as human health, ecological, and quality of life, and on public advisory committees. The exact structure of the project will depend upon the goals of the project.
3. What is the desired outcome?
    3.1. All comparative risk projects have produced a technical analysis and a ranking of environmental issues. Although the analysis and the ranking are interesting and educational products, they should not be the final outcome of a project. The CR technical results have been used to change environmental management in the state or local area through new legislation, inputs to the budget process, new planning structures; strategic planning; education; team building, and motivated individuals.
4. Who are the key audiences for our project?
    4.1. Reaching the public at large may be too time consuming and resource intensive to complete well. Project managers should identify subsets of the public such as groups interested in the topic; groups who will be angry if not asked to participate; groups that are affected or perceive that they are affected by environmental management changes; groups that have useful ideas; and groups that will assist with change. By targeting the program and messages to key audiences, the overall effectiveness of the project will increase.
5. What is our public participation plan?
    5.1. Defining the goals of the public participation plan should be the first step in the process. A part of defining goals is identifying key audiences and deciding how to interact with them. Communication should be consistent, even-handed, and interesting. An important component of a public participation plan is deciding how to get and what to do with input from the public. Will their views be integrated into the project? Will the efforts of the public be worthwhile for everyone? Assign implementation of the public participation plan to key agency staff to ensure completion.
6. What are the barriers to a successful comparative risk project? How can we plan for success?

6.1. Comparative risk projects usually have high visibility. Conflicts can arise in many parts of the projects from strong differences on technical issues, to controversies during election season, to attacks from the media. Although all future problems cannot be anticipated, seeing where conflicts are possible will benefit the project overall.

7. Do we have the resources to do an excellent project?

7.1. The funding from EPA is seed money and will not support a full scale project. Most state agencies contribute cash or in-kind contributions such as staff time and office space. The cost of the projects has ranged from $70,000 plus in-kind contributions for local projects to over $400,000 plus in-kind contributions. One state project estimated that nearly a million dollars in staff time was spend completing the technical analysis.

8. Are we on the right course toward success?

8.1. Evaluation of activities should occur throughout the project while a mid-course corrections are possible. The most simple tool is to ask participants if the project is doing well and what should be changed. Other approaches include using written evaluations; pretesting materials prior to broad distribution; checking in with original project goals; and documenting project successes and failures.

The following link provides access to the US EPA National Comparative Risk Project
http://www.scorecard.org/comp-risk/report.tcl?US=US

REVIEW 4

This section contains an MPCA memo discussing results of various stakeholder surveys.

DATE : October 27, 2000

TO : Design Advisory Group
Redesign Teams

FROM : Paul Hoff, Supervisor
Stakeholder Analysis Unit
Environmental Data, Information and Reporting Section
Environmental Outcomes Division

PHONE : 651/296-7799

SUBJECT : **Summary of Recent Stakeholder Research**

The attached document contains summaries of about two dozen recent stakeholder research projects that may be interesting and useful to the redesign teams. The summaries are organized broadly into two categories:

1) Research about the MPCA, its processes, and public environmental values generally, and
2) Program-specific stakeholder research

Staff in the Stakeholder Analysis Unit have attempted to capture the highlights of these studies, most of which were conducted within the last five years. One exception is the recent stakeholder input process for the coming biennial budget – the full report is included.

If you are interested in seeing the full versions of any of these reports, please let me know. Some will be more interesting than others, and there may be some you are aware of that we didn't include.

This is our initial attempt to capture the learning from pertinent research that is timely. As you look through it, please keep a couple things in mind. First, as you look at what is there, try to get a sense also for what is missing (the knowledge gaps), in the context of your team's areas of interest. And second, one lesson we've learned in the last two years is that no single study or technique is going to be the "Oracle" of wisdom for your work. It takes a mix of tools, target audiences and approaches to get a reasonable sense of what we think we know.

Any comments or feedback on these summaries are welcome. Thanks go to Pat Engelking, Carol Hubbard, Sherryl Livingston, Chris Zadak and Jan Eckart for their help with this!

PH:jae

Attachment

Index of Stakeholder Research Summaries

Research about MPCA in general, and citizen environmental values Page

Minnesota Pollution Control Agency

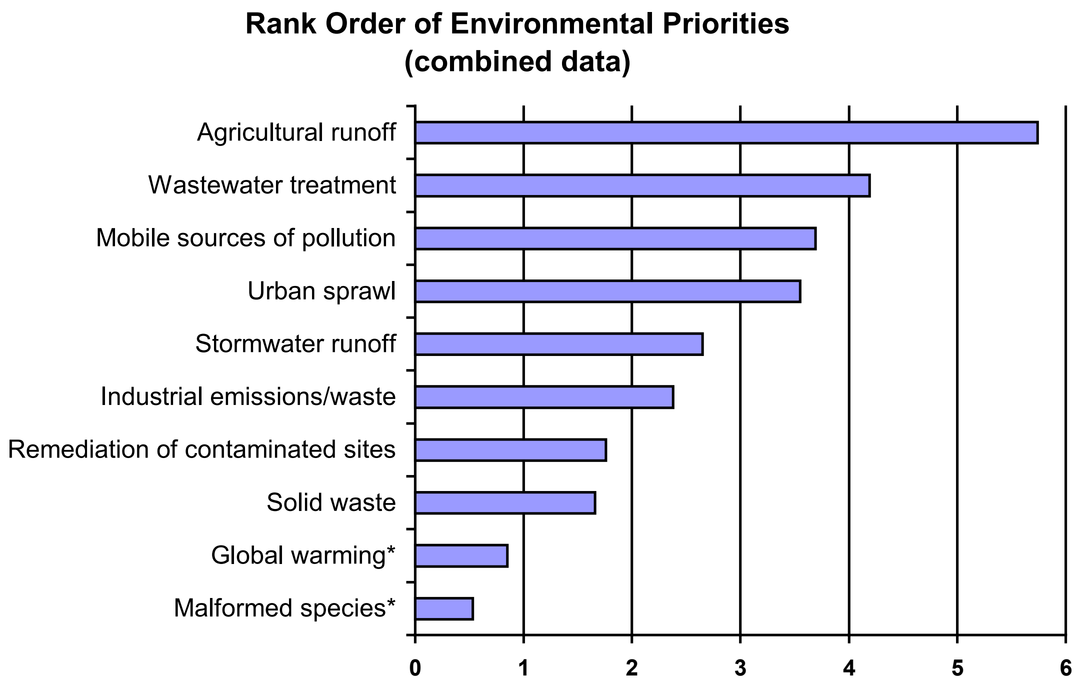
Stakeholder Input Meetings on the Biennial Budget Process: Results and Common Themes

August 2000

Background
This summer, as part of the biennial budget development process, the Minnesota Pollution Control Agency (MPCA) held a series of meetings throughout the state with interested stakeholders, including citizen, business, environmental, farming, and local government representatives. The purpose of the meetings was to share the MPCA's ideas and get others' ideas on the most important environmental problems and MPCA resource needs, and how to meet those needs. A total of 120 people attended the ten stakeholder input meetings held throughout Minnesota (see Figure 1). Geographically (using our district boundaries) we had the following attendance: South—34%; Metro—42% (which includes many of the environmental group and local government representatives); North—24%. In terms of sector the largest group was "local government" (32%) and the smallest was "citizen" (2%, which is just two people). The others were "business or industry" (29%), "environmental group" (21%), "elected official" (9%), and "all other government" (9%).

Environmental Priorities

Participants were asked "When you think of the threats to the environment, now and in the future, on which of the following issues should the MPCA focus their attention?" Ten issues were listed, and the participants were asked to choose their top three (in order). The computer software then boiled down the choices into an overall rank order. A summary of the results is shown in the following graph. Results by location and sector group can be seen in Attachment A.



* Many participants commented that while these are important issues, they are better addressed on a national level or by an entity other than the MPCA.

Notable locational differences included:

- The Metro group ranked mobile sources 1st and remediation of contaminated sites 2nd. The business community group ranked mobile sources higher then any other location.
- Somewhat similar rankings for these two issues occurred in Duluth.
- The Brainerd group ranked agricultural runoff the lowest (along with malformed species) and urban sprawl highest.

Following this question, participants were asked what issues that they feel are important were missing from the list of ten options. These ideas were listed on a flip chart, and can be found in Attachment B. The following issues were identified at multiple meetings:

- Feedlots (commentors wanted to be sure this issue was included in "agricultural runoff")
- Water quality (overall, and nonpoint source and surface water issues in particular)
- Construction (erosion, roads, subdivisions)
- Pollution prevention (including product stewardship)

Many participants commented that there was overlap and linkages between many of the 10 listed priorities.

Resource Needs

Following a brief presentation on the objectives of the meeting, background information on the MPCA's budget and a brief comment on each of the MPCA-identified resource needs, the meeting participants were next asked for their reaction to those needs. The question "considering the list of 10 priority needs, how important is ___________________?" was asked for each of the MPCA-identified resource needs, using a 1 to 5 scale with 1 being "low importance" and 5 being "high importance." The overall results, by average score, are summarized in the following table.

Resource need area (identified by the MPCA)	Avg. Score
Accessible Information for Decision-Making	3.8
Water Quality Program: permitting, compliance, phase II stormwater	3.8
Measuring Basin Health through Comprehensive Monitoring	3.8
MPCA Feedlot Program Staffing	3.7
Water Management Unification through Basin Management	3.7
Mobile Source Pollution Prevention	3.6
Feedlot Cost Share	3.5
Air Toxics	3.4
Implementation of Lake Superior Lakewide Mgmt Plan (LaMP)	2.8
Continued Research on Malformed Frogs	2.1

Locational differences were limited. However, the Metro group rated the air toxics and mobile source issues in the 3.7-3.8 range and rated the basin issues in the 3.3 range.

Sector differences were not terribly dramatic. Local governments and elected officials were less supportive than the other groups on air toxics and mobile sources. Those in state/federal government (i.e., the "all other government" category) were far more supportive of the Lake Superior LaMP than the other sectors (score=4.5).

Stakeholder-identified needs:

An extensive list of additional needs was generated during the meetings (see Attachment C). The following needs were mentioned at two or more meetings:

- Increased timeliness of permitting
    - "Sometimes it takes so long to get a feedlot permit that the landowner is no longer interested in the project."
    - "We need to move at the pace of business, not at the pace of MPCA resources." Business can't plan without knowing the permitting time frame—there is too much uncertainty.

    - “It is not just water permits that have a backlog – air quality Title V do as well”
- Translating and distributing information/better communication
    - “The MPCA needs to do a better job of communicating. It is refreshing to be here today—you need to do both education and regulatory actions. You need to do a better job of telling your story.”
    - “Communication needs to be a priority … hire ‘translators’ for the information.”
- Funding for citizen monitoring
    - “There is a vast pool of talented people that simply need the training and tools to conduct volunteer monitoring.”
- Full implementation of the phase I stormwater program prior to advancing phase II
    - “We haven’t even finished phase I and now we are moving on to phase II.”
- Keeping up to speed with developments in other states and on the federal level
    - “The MPCA should keep up with research (at other states and the federal level). Right now we have to educate MPCA staff so we can operate with the most current information.”
- Septic systems/unsewered communities.

Other notable comments/suggestions:
- Several participants commented that some of the resource needs are more regional in nature (either in reality or in perception) and some are more statewide.
- At several meetings, participants commented that the MPCA should stick to its “core” activities, like permitting and enforcement.
- “The MPCA should not be a research organization.”
- “The county commissioners here truly feel the need for the feedlot cost share.”
- “By working on issues, like malformed frogs and mobile sources, the MPCA is micro-managing a problem. MPCA should shift to higher-priority needs like stormwater, which then helps malformed frogs. Deal with bigger issues; don’t get lost in a swamp of research projects.”
- “Agencies don’t seem to consolidate information. For example, I have to go to seven different agencies to get groundwater data.”
- The legislature needs to give some serious support and funding for ambient monitoring of air and water.
- “At the legislature, agencies are at least implicitly competing with each other. Instead, they need to cooperate to design programs that will meet their multiple objectives.”
- The state should carefully decide when it is prudent for Minnesota to lead the way or adopt more stringent regulations then other states.

Options to Meet the Needs

Following the polling and discussion about MPCA resource needs, the participants were asked the following question about how to meet the needs: "What option do you prefer the MPCA pursue in providing resources for unmet needs?" and were given four options:

1. Drop a lower-priority activity or program
2. Shift some resources from lower-priority activities or programs to higher-priority needs
3. Request additional funding from current sources or establish a new funding source
4. Other

This question was intended mainly to prompt a discussion, but for the record 53% favored dropping or cutting back low-priority programs and 29% said to seek out more funding. The rest chose "other", often suggesting we use all the listed options. There were some interesting differences in the responses of various sectors:

- Participants who are elected officials and those representing business or industry favored shifting resources from low- to high-priority activities (50% of elected officials chose this option, as did 44% of business/industry representatives—and 41% of business/industry representatives favored dropping lower-priority activities). This option was also favored by local government, but to a lesser extent (34%).
- Representatives from environmental groups and all other government (i.e. state, federal, tribal) most often chose the option of requesting additional funding from current or new sources (55% for environmental group representatives and 43% for all other government). The two attendees in the "citizen" category also chose this option.

This question also spurred an involved discussion around each of the funding options, which is summarized on the following pages.

<u>1. Drop a lower-priority activity or program (21% overall):</u>

Common themes:

- The MPCA should drop frog research. While several groups qualified that the research is important, they said this is a national issue that the MPCA should not be the lead on.
- Several participants suggested there might be areas of overlap between agencies that could be eliminated, thereby freeing up resources. Examples included monitoring, research that could be done by colleges and universities, and other agencies that could take the lead on an issue rather than the MPCA (e.g. Dept. of Health could lead the air toxics effort).
- A few participants said they don't like the idea of dropping a program. One participant suggested that the MPCA put end dates on programs at the outset and communicate this information, so everyone knows when to move on.
- Other participants suggested that the reality is you have to drop something, because finding a new funding source will be very difficult.

Other notable comments/suggestions:

- There must be small programs that could be cut, or where you could gain seasonal savings.
- There seem to be a lot of planners – shift them to writing permits. Spend less time at the capital lobbying your perspective.
- Repeal the Listed Metals Program
- "I'd be more concerned about malformed people than malformed frogs."

2. Shift some resources from lower-priority activities or programs to higher-priority needs (32%):

Common themes:

- Participants commented that in reality it would be easier to phase-down a program or shift resources than to actually eliminate something.
- Funding flexibility: There were basically two opinions on this issue—that fees should only be used for the activity that they were collected for, and that funding flexibility is a good idea for the MPCA. Often both opinions were expressed at the same meeting. If anything, more participants expressed the former opinion, that fees should be used for the "dedicated" activity only.
  - "If people are paying a fee for something there is an expectation that the fee will go back to that issue." "Dedicated fees should stay where they were intended. If there is a new problem, look for new fees."
  - "It is a great idea to divert some of the fees. It would be an uphill fight but it is worth pursuing." "More flexibility would be great to the extent you can get it."

Other notable comments/suggestions:

- Avoid using the term "flexibility" when talking about the use of certain funding sources for other environmental issues. Work to educate people on the need for shifting resources within the MPCA and why this is a worthwhile strategy to employ.
- Funding flexibility breaks down internal constraints, but is not a major solution. The MPCA will still have to make choices.
- We need funding flexibility to shift to emerging issues.
- Pick what you can do well and focus on it. You need a flagship.
- If the MPCA can objectively assess a program, then shifting resources is OK. However, politics and the shifting sentiments of the Legislature heavily influence the MPCA. Empower the people so they will come to the MPCA's defense.
- Training might have some efficiency that can be gained.
- Perhaps some money could be shifted from remediation.

3. Request additional funding from current sources or establish a new funding source (29% overall):

Common themes:

- Several participants commented that the MPCA should pursue additional funds if there is a clear need, and educate the public and others about that need.
- Participants at several of the meetings were intrigued by/supportive of the impervious surface surcharge idea. One participant urged caution based on the experience of the City of Duluth with such a fee system.
  - "I like the idea of impervious fees. This could lead to incentives to do the right things."
- Many other ideas were brought forth for potential funding sources. They include:
  - Property tax accountability – tax properties that cause pollution at a higher rate than those that prevent pollution
  - Existing sources: LCMR, Conservation Re-Investment Act (if it passes), Coastal Zone Management, Minnesota Fund, leverage more federal funding
  - New fees: tennis-shoe tax to benefit the outdoors, a slight fee on watercraft to pay for surface water efforts, a fee on bottled water, a fertilizer tax
  - Make current fees reflect the true cost of doing business
  - Tax rebates should go to the environment

Other notable comments/suggestions:

- "I hope the MPCA is challenging the notion that the state surplus all be used for a tax cut…now is the time to invest in our natural resources"
- Recent polling shows incredible public support for spending the state surplus on water issues.
- "New funding won't happen unless there is public demand. The MPCA needs to do a better job of explaining the problem…the word at the MPCA is 'no problem, we're in good shape' environmentally."
- "Polluter pays" can go too far. There are general benefits to environmental protection and restoration, so some of the funding should be from the General Fund.
- If you are requesting additional funding from existing or new sources, make it clear what expectations won't be met if the funds aren't made available.
- Do your budget region-by-region and let the regions decide their priorities – a high priority here might not be a high priority elsewhere (and vice versa). At times it feels the needs of Greater MN get dropped or lost in the shuffle.
- Get rid of WIF, there are major problems with this idea. The public policy implications are huge. This is very disruptive and potentially could cause alienation between governments (the haves and the have-nots). It is a state responsibility. Look at re-targeting current local aids to solve this problem. Money should be set aside now.

<u>4. Other (18% overall):</u>

Common themes

- Participants at all the meetings agreed that a combination of all three funding options should be pursued to meet resource needs.
- Several specific ideas were suggested at the meetings, including the following:
  - Increase the efficiency of feedlot permit issuance—streamline engineering review, look at a one-step permit, etc.
  - Delegate more to the local level, especially in the nonpoint area and feedlots. Provide guidance, but don't actually carry out the program—look to the Wetland Conservation Act for an example.
  - Prevent overlap between city, county and state efforts.
  - Perhaps propose fee reform as a part of a larger water quality initiative (to meet both the expectations for reform and environmental needs)
  - Build more support with legislative and Governor's Office liaisons, as well as with the public.

Other notable comments/suggestions:

- The environmental landscape has changed. Maybe the MPCA's role is to facilitate action within the community. Look outside the box and think of other options for funding.
- The Governor needs to assign an overall coordinator of the environmental agencies.
- Perhaps the time has come to consolidate environmental fees. It is a headache and inefficient to get invoices trickling throughout the year.
- These meetings are good only if you follow through and bring this information up the chain.

Overall Observations/Common Themes:
The following four themes were heard repeatedly at the stakeholder meetings:

Core regulatory programs (esp. permitting) – The need for the MPCA to improve its core regulatory programs came up repeatedly during the meetings, especially in regards to permitting backlogs. In general, permittees focused on the need for better service from the MPCA, while non-permittees commented that the MPCA needs to ensure that it is handling its core responsibilities well.

Enhanced communication – Participants at all the meetings brought forward various needs for improved communication, including greater availability of raw data, the need for the MPCA to interpret and explain data, more education and technical assistance, and the desire for continuing opportunities for two-way communication with the MPCA.

Coordination among state agencies, and between MPCA and local government – Many participants expressed frustration over what they saw as a lack of coordination among state agencies, and between state agencies and local government. There was confusion about who does what, a perception that there is much overlap and duplication of effort, and concern about coordination and availability of data as well as oversight of state programs delegated to the local level.

Leadership on statewide issues – Several participants at various meetings commented that they look to the MPCA for leadership on statewide issues (including information on how to prioritize environmental issues), but do not necessarily support the MPCA taking the lead on nationwide issues.

MPCA Name Change

In addition to discussing the biennial budget process and environmental priorities, the MPCA used the opportunity of these stakeholder meetings to get input on a potential MPCA name change. This input is part of a broader effort to investigate the possibility of a name change. The results of this investigation, including the input from these stakeholder meetings and additional citizen and stakeholder research, will be summarized in a report to the Legislature, which the MPCA anticipates completing in November 2000. If you would like a copy of that report, please contact Assistant Commissioner Kristen Applegate at 651/296-7354 or kristen.applegate@pca.state.mn.us to be added to the mailing list.

MPCA Northeast Region Phone Survey, 1997

1. Survey Tool: Telephone survey with 600 persons randomly selected from four geographic regions: The WLSSD service area, the Iron Range, International Falls and the Lake Superior North Shore. Survey was conducted between June 30 – July 11, 1997.
2. Principal Findings: The survey primarily indicates that, although respondents have very strong ideas about the environment, they do not have a clear idea of MPCA's lines of authority. As a group, they recognize that government has a role to play in the planning of environmentally sensitive projects and in the enforcement of rules. However, they seem unaware of MPCA's activities in these matters. They are generally in favor of coming down hard on violators. The respondents do not want to cut taxes at the expense of the environment. Water quality is their primary concern.

Minnesota State Survey Results
MPCA Questions 1991-2000

1. Questions the MPCA has asked every year:

A. "Do you have an idea what the Minnesota Pollution Control Agency does?"

Year	Yes %	No %	Maybe
1991	64	32	5
1994	57	36	7
1995	52	40	7
1996	51	39	10
1997	56	34	10
1998	64	31	5
1999	**63**	**32**	**6**

B. "Overall, how do you think the Minnesota Pollution Control Agency does at protecting the environment....excellent, good, fair or poor?"

Years	Excellent	Good	Fair	Poor
1991	4	48	42	5
1994	4	44	44	8
1995	5	52	36	6
1996	5	50	39	6
1997	5	44	43	8
1998	8	55	32	6
1999	**8**	**48**	**38**	**6**

2. Minnesota Survey Quality of Life Question – 1995, 1997 and 1998 (The MPCA did not pay for this question):

"In your opinion, what do you think is the single most important problem facing people in Minnesota today?"

	1998 %	1997%	1995%
Economy	19	16	16
Taxes	18	13	12
Social Issues	14	15	15
Crime	11	17	24
Education	10	7	4
Family	8	7	5
Health care	7	5	12
Environment	4	6	3
Other	4	5	3
Government	3	6	5
Transportation	1	2	0
Housing	1	0	0
Food	0	0	0
War	0	0	0
Energy	0	-	-

3. 1991 Question:

" How well do you think the Minnesota Pollution Control Agency does at {read list} .... excellent, good, fair or poor?"

	Excellent	Good	Fair	Poor
Protecting air quality	4%	53%	35%	8%
Protecting water quality	5%	42%	38%	15%
Resolving solid waste issues	8%	41%	44%	12%
Regulating hazardous wastes	5%	41%	41%	14%

4. 1992 Questions

A. (Both 1992 and 1996 results) "What do you think is the single most important environmental problem facing Minnesota in the next five years?"

Environmental problem	1992 Percent %	1996 Percent %
Polluted lakes	12.9	12.5
Landfills	9.5	1.6
More recycling	9.2	3.1
Motor vehicle pollution	8.2	8.8
General air pollution	6.9	5.4
General water pollution	6.6	10.1
Acid Rain	4.6	
General solid waste	4.6	
General Pollution	4.3	5.8
Groundwater pollution	3.8	1.8
General hazardous waste	2.5	
Population control	.1	5.6
Agriculture runoff	.9	3.3

B. (1992) Please tell me if you strongly agree, agree, disagree or strongly disagree with the following statement:

"Protecting the environment usually has a negative effect on the economy"

	Percent %
Strongly agree	8
Agree	30
Disagree	45
Strongly disagree	17

Review 5

Notes from an EPA priority document are included in this section.

EPA Document

1. The document summarizes findings of a group charged with identifying research priorities for the EPA for the next 20 years (foresight analysis).
2. Three methods were utilized for foresight analysis.
   - 2.1. Scanning : gathering information about trends and events that may be relevent to the future. Helps to think beyond individual disciplines.
   - 2.2. Delphi : an iterative process of gathering and analyzing expert opinions. Helps to involve stakeholders.
   - 2.3. Scenario development : synthesizing hard data and speculative judgements in a set of stories showing how different assumptions or events might lead to different futures. Starts conversations between analysts and decisionmakers.
3. Some things to consider in foresight analysis:
   - 3.1. Economics;
   - 3.2. Social changes;
   - 3.3. Technological changes (for example, telecommuting, our ability to monitor).

    3.4. Human health
4. Research findings relevent to the EPA task:
    4.1. The largest challenges will be changing/overcoming institutional and social barriers. It is difficult to sway people to invest in the unknown. People and institutions tend to deal with what is known and immediate.
    4.2. Foresight analysis can be used to restructure the Agency, particularly with respect to improving the Agency's mobility.
    4.3. Foresight analysis must have application within the next few years, otherwise it will be abandoned.
5. Opening statement in Chapter 1: "For a decade and a half, the U.S. Environmental Protection Agency has tried-and generally failed-to turn its attention away from the crises of the day and, instead, anticipate the environmental problems and management opportunities of the future."
6. In 1995 it was recommended to the agency that they build an early-warning system to identify potential future environmental problems.
7. Presenting scenarios to managers may be more effective than a technical document.
8. There have been conflicts within the EPA's ORD regarding its mission/responsibilities. It has had to collect information that would support the regulatory programs, primarily in development of new rules. Other tasks included advancing the science and application of risk assessment and risk management and addressing emerging environmental issues.
9. A major obstacle is having knowledge of research being conducted by others, including others within the Agency.
10. It was recommended to institutionalize a scientific planning process and make sure the process was multimedia.

Notes

1. We first need a system for identifying environmental priorities.
2. Technical staff would play a small role in identifying environmental priorities. We also need information on the following:
    2.1. Demographics
    2.2. Lifestyles
    2.3. Technology changes
    2.4. Regulations
    2.5. Economics
    2.6. Public opinion
3. How do we include this other information.
4. Some roles of technical staff might be
    4.1. Identifying trends
    4.2. Identifying new chemicals
    4.3. Modeling (scenario development)
    4.4. Effectiveness monitoring
5. The process of priorities setting will take time. Some of the parts include:
    5.1. Establishing the mechanism
    5.2. Assigning tasks
    5.3. Gathering information
    5.4. Analyzing information
    5.5. Developing scenarios
    5.6. Refining the process
    5.7. Adjusting the process over time
6. Identifying priorities and emerging issues should focus on social aspects and how these might relate to environmental quality.

7. The Agency should establish a lateral team that employs judgement methods of foresight analysis. The goal of this team is to identify emerging issues through personal contacts with experts, literature reviews, etc. The lateral team would be across Divisions and probably should include people outside the Agency on issues such as social, economic, etc.
8. Who is determining the direction for the Data Integration Unit.
9. The Quarterly Report continues to summarize information related to the number of sites where some sort of activity (permit, enforcement, etc.) took place.

1992 Questions – cont.

C. (1992) "How likely is it that you would believe information from {insert name} about a controversial environmental issue affecting your community ... very likely, somewhat likely, somewhat unlikely, or very unlikely?"

Organization	Very likely	Somewhat likely	Somewhat unlikely	Very likely
State environmental agency staff	20	55	18	7
Environmental groups	24	52	16	8
Industry representatives	5	36	34	25

5. 1994 Question:

"How likely is it that you would believe information from {insert name} about a controversial environmental issue affecting your community ... very likely, somewhat likely, somewhat unlikely, or very unlikely?"

Organization	Very likely	Somewhat likely	Somewhat unlikely	Very likely
Agency staff	17	58	16	8
Environmental groups	16	52	20	11
Industry representatives	5	39	36	20
The media	11	48	28	13
Elected officials	3	36	36	23

6. 1995 Question:

A. <u>"How likely is it that you would believe information from {insert name} about a controversial environmental issue affecting your community ... very likely, somewhat likely, somewhat unlikely, or very unlikely?"</u>

Organization	Very likely	Somewhat likely	Somewhat unlikely	Very likely
Agency staff	17	60	16	7
Environmental groups	18	51	22	9
Industry representatives	4	37	37	21
The media	7	52	24	17
Elected officials	4	40	34	24

B. (1995) "Have you ever contacted the Minnesota Pollution Control Agency for information, attended one of their public meetings or workshops, visited their booth at the State Fair, or had any other contact with them?"

	Yes	No
Contacted for information	13%	87%
Attended meetings/workshops	8%	92%
Visited booth at State Fair	18%	82%
Had other contact	8%	92%
Through work or work related	4%	96%

C. (1995) Follow-up question, "If yes to above question, How would you rate the service that you received from the Minnesota Pollution Control Agency ... excellent, good, fair or poor?"

Service	Percentage
Excellent	10
Good	54
Fair	26
Poor	10

7. 1996 Questions:

A. "What do you think is the single most important environmental problem facing Minnesota in the next five years?"

Environmental problem	Percent %
Polluted lakes	12.5
General water pollution	10.1
Motor vehicle pollution	8.8
General Pollution	5.8
Population control	5.6
General air pollution	5.4
Agriculture runoff	3.3
Preserve forests	3.3
More recycling	3.1
General solid waste	3.0
Drinking water safety	2.9
Loss of wetlands	2.8
Industry discharge	2.3
BWCA protection	2.3
Groundwater pollution	1.8
Landfills	1.6

B. Follow-up question (1996)

"What is it about this problem or issue that makes it so important to you?"

Why environmental problem is important	Percent
To protect human health	30.9
To protect future generations	12.0
To protect the resources	8.4
To protect recreation opportunities	7.8
To protect plants and animals	6.4
To protect quality of life	6.3
It is important	5.6
To protect natural beauty	5.0

C. (1996) "Do you think that scientists and citizens generally agree or disagree about which environmental problems are the most important?"

Agree	Disagree
45%	55%

D. (If disagree) "When they disagree, should the state focus more of its attention on the environmental problems that citizens say are most important, or on the problems that scientists say are most important, or don't you have an opinion on this?"

Focus	**Percent**
Citizen concerns	36
Scientist concerns	23
No opinion	29
Other	2
Both	10

E. (1996) "How helpful would information about (read list) be to you ... very helpful, somewhat helpful, not very helpful or not at all?"

	Very helpful	**Somewhat helpful**	**Not very helpful**	**Not at all helpful**
The amount of pollution that is now in the air, water, and soil	46	41	10	4
The effect of pollution on the health of animals and plants	46	41	11	2
The effect of pollution on human health	59	34	5	2

8. 1997 Questions:

A. "Minnesota state agencies plan to increase use of the Internet to answer citizens' environmental and natural resource questions and information needs. To do that effectively, they would like to know what kind of information or data citizens want. What are the most important information or data you would like to have about Minnesota's environmental and natural resources?

	Grouped responses (%)	**First response (%)**	**Second response (%)**
Water Quality	16.5	19.8	15.6
Other	8.4	8.1	7.2
Recreation areas	7.9	9.5	6.8
Air pollution	7.0	4.7	9.7
Protect resources	6.9	6.7	8.6
Wildlife	4.7	3.2	6.8
Don't use internet	4.3	8.1	
Forests	3.5	2.3	5.0
Recycling	3.3	4.0	3.0
Environmental cleanup	2.9	4.0	1.9
Natural resources	2.7	3.6	1.5
Agriculture	2.6	1.5	4.2
Business polluters	2.2	2.9	1.4
Voluntary opportunities	2.2	1.2	2.3
Policy decisions	2.2	2.4	2.9

B. (1997) "Would this information help you in your work, at school, in your civic or volunteer activities, in planning a vacation trip, or in some other way?"

	Yes (%)	No (%)
Work	28	72
School	19	81
Civic or volunteer activity	32	68
Planning a vacation trip	50	50
Other	18	82
Info would not help (volunteered)	7	93
Info in general would help (volunteered)	8	92

C. (1997) "Do you have access to information on the Internet at work, at home, or somewhere else?"

	Percentage
Yes, at work	19
Yes, at home	18
Yes, both	16
Yes, other	3
No Internet access	36
Yes, at library	2
Yes, at friends	4
Yes, at school	3

D. (1997) {If respondent was not in the area five years ago, go to next question}

"Compared to ten years ago, is the quality of Minnesota's air in your area better today, about the same or worse?"

	Percentage
Better	12
About the same	63
Worse	21
Not in the area 10 years ago (volunteered)	4

E. (1997) “Compared to ten years ago, is the water quality for fishing and swimming in the lakes and rivers in your area better today, about the same, or worse?”

	Percentage
Better	14
About the same	29
Worse	57
Not in the area 10 years ago (volunteered)	4

F. “Compared to ten years ago, is the soil in your area less contaminated today, about the same or more contaminated?”

	Percentage
Less contaminated	11
About the same	58
More contaminated	31

Met Council Customer Research Project

- **General Public**
- **City Officials and Staff**
- **Industrial Users**
- **Other Government Agencies**

- **General Public**

1. Survey Tool: 1997 Twin Cities Area Survey
   A total of 803 telephone surveys of adults, age 18 and over, who reside in the seven County Twin Cities metropolitan area, were completed for the 1997 Twin Cities Area Survey. Data collection was conducted from November 1997 to February 1998 by the Minnesota Center for Survey Research at the University of Minnesota.
2. Purpose: To get the customers' point of view in assessing Met Council's customer service responsiveness.
3. Results:
   - Quality of Life and Water:
     a) Regarding the environment, respondents indicated the most important activity for regional government to be increased environmental protection, followed closely by public education.
     b) Respondents were more satisfied with the quality of their drinking water than with the water quality of area lakes and rivers.
   - Water Quality Improvements:
     c) Protection of lakes and rivers and reduction of agricultural runoff were named most often as the most important way to improve water quality.
     d) Respondents indicated strong support for use of a "set aside" from residential sewer bills to fund activities to improve water quality and the addition of a water pollution charge to the cost of lawn fertilizers
   - Public Information and Communications
     e) Respondents rely heavily on the media (newspapers, TV, radio) and prefer it for information about water quality and the environment, although they believe the media does not change their attitude about water quality.

- **City Officials and Staff**

1. Survey Tool: A total of 206 interviews were conducted with mayors, city managers directors of finance, public works and development staff.
2. Purpose:
   - Determine water resource priorities and regional needs
   - Assess reactions to revenue issues
3. Results:
   - Water Resources Issues
     a) Non-point sources of pollution frequently were identified as significant sources of metro area pollution and improvement efforts are warranted.
     b) Groundwater quality and aquifer management are seen as priorities which may benefit from a regional approach.
     c) Few believe their community has a long term water supply problem.
   - Revenues, Budgeting and Rates
     d) Use of service availability charge, industrial waste charges and sewer user fees for broader purposes has limited support among respondents
     e) Cities are receptive to user-based fee concept.

- **Industrial Users**

1. Survey Tool: A sample of 497 customers were drawn and a total of 290 interviews were conducted.
2. Purpose: To conduct more in-depth analysis with one of their major customer groups.
3. Results:
   - Water Resource Issues
     a) Groundwater quality, swimmable lakes and aquifer management are seen as priorities which may benefit from a regional planning approach.
     b) Non-point sources of pollution frequently were identified as significant sources of metro area pollution and opportunities to address this issue appear viable.
     c) Continued industrial waste management, coordinated with other water, air and land use programs, is needed for overall environmental protection.
   - Respondent Water Quality Effects
     d) A wide range of pollution prevention in the last two years was reported. Most frequently mentioned were changes to reduce volume or to pretreat wastes.
     e) ISO certification prompted few respondents to change waste treatment processes
     f) Consistent enforcement and standards development were the most important regulatory concerns.

- **Other Government Agencies**

1. Survey Tool: In-depth, face to face interviews were conducted with 10 Local, State and National Agencies t provide a broad sampling of the various government perspectives. Twenty-five interviews were conducted between July 2 through August 18,1998.
2. Purpose: To conduct more in-depth analysis with one of their major customer groups.
3. Results:
   - Common Interest Areas
     a) Sustainable development is an emerging issue area for several agencies
     b) Restructuring and organizational development along a geographic, cross-functional basis is an emerging trend
   - Success Factors For Joint Efforts
     c) Several potential areas for cooperation and coordination were identified; priority areas to pursue include areas of overlap related to data gathering, public education and planning.
     d) Outcome-based reporting and use of a coordinated, systems approach provide a basis for effective, cooperative efforts.

2000: Citizen Environmental Values Research (re urban sprawl)

This was a literature review and analysis conducted by David Wall of the Dept. of Geography of St. Cloud State University. The idea was to focus on Minnesota-related information, but include national data where relevant. The basic contents were:

PROBLEM IDENTIFICATION

- What Minnesotans Think About Sprawl: Minneapolis-Saint Paul, the Metropolitan Regional Perspective
- What Minnesotans Think About Sprawl: The Perspective from Individual Cities and Counties

BEHAVIORS, ATTITUDES AND VALUES

- What attributes of neighborhood, community, housing amenities do Minnesotans value?: Results from Fifteen Metropolitan Communities
- Transportation habits and choices
- Who is using what mode of transportation and for what reasons?
- Trade-offs in transportation behavior
- How do people's beliefs compare with actual behavior?
- Beliefs and Behavior: Americans and the Environment
- Beliefs and Behavior: Minnesotans and the Environment
- How do Minnesotans Compare with Other Regions?

SOURCE AND NATURE OF OPPOSITION
(note: This project was too lengthy to summarize – if you're interested in any of the above-mentioned subject areas in the report, contact Chris Zadak 297-8613.)

1999: Report on the *Governor's Forums: Citizens Speak Out on the Environment*

This was a series of forums conducted around the state in May 1999. We polled over 400 Minnesotans on what they see as the top environmental priorities and asked specific questions about the performance of the agency.

Key ideas from Forums and Potential Follow-Up Questions

Brainerd – **priority issues:** ***Lakes & rivers, septic systems, wetland destruction***

- Development: A major threat
- Perception that septic systems are largely to blame for declines in WQ
- PCA's role: Strong calls for education and enforcement
- *"We like regulation for other people to follow."*
- **Potential follow-up questions:** How should the Agency address the perception that septic systems are a big problem for water quality, when our watershed studies indicate that septic systems generally are a small component of the total watershed load--significantly less than other sources like agricultural land, etc.? Septic systems are, however, a key component of the stewardship/ personal responsibility element of watershed management. How then do we use this information to improve our programs? Do we increase our efforts and priority related to septic systems, educate people about the true environmental impact to change their perception, or ……….?

Detroit Lakes – **priority issues:** ***Well water quality, lake quality, erosion control***

- WQ stressors: P fertilizers, septic systems
- Call for more education, information
- Pesticides, industrial-scale farming among the other concerns
- *"I'm more willing to point out what someone else should do."*
- **Potential follow-up questions:** Many of the participants at this forum did not know the MPCA had a Detroit Lakes Office. Their opinion of the MPCA's work came from coverage in the Mpls./St. Paul papers, most notably the *Star Tribune* and the Koch story. Clearly the metro media is the most significant factor of the public's view of the Agency's work across the state. How can we use this information to improve our communication strategy?

Duluth – **priority issues:** ***WQ, toxins, lack of a conservation ethic***

- Main stressors: Over-development and pervasiveness of toxins
- Lack of responsibility by manufacturers; distrust of gov't (conspiracy theory...)
- Need for more rigorous regulation/oversight by state
- **Potential follow-up questions:** It was clear at this forum that the participants did not trust government or business. Knowing this for this area, should it impact how we do communication and carry out regulatory activities? How can we approach issues regarding trust, and address communication concerns?

Arden Hills – **priority issues:** ***WQ, industrial air emissions, HW & SW***

- Vehicles and the environment: different standards for SUVs; emissions testing should be kept, but modified; would pay $1 more per gal of gas if it would improve the environment.
- Varied discussion: HW drop-off sites; urban sprawl--problem or not?; tax "bads" not "goods"; overall environmental decline in TC in last 5 yrs.
- **Potential follow-up questions:** At these meetings we saw people willing to support ideas that you would not expect or even believe, such as the willingness to pay $1 more per gallon of gas. When we find provocative ideas should the Agency follow up and with additional and broader research to determine if there is public support for these kinds of initiatives?

Minneapolis – **priority issues:** ***AQ, WQ, vehicle emissions***

- Strong support for improved public transportation
- More environmental education
- Tax environmentally-damaging activities
- *"When I came here transit was not high on my list, but it is now much higher because I realize it's connected to so many things--WQ, AQ, etc."*
- **Potential follow-up questions**: There was a clear desire for more environmental education. What role and level of involvement should the Agency have in delivering this?

Marshall – **priority issues:** ***Rivers and drinking water, industrial bioloading, declining rural quality of life***

- Agriculture dominated, but no finger-pointing
- Willing to pay more tax to help farmers protect environment
- More environmental education
- **Potential follow-up questions:** "Declining rural quality of life" was one of the top three environmental issues named at this forum. How can this information help us understand and communicate the Agency's role in rural MN? How could we use this knowledge to help leverage our environmental efforts?

Rochester – **priority issues: M*unicipal "legal" river dumping, fertilizers and pesticides, feedlots***

- Strong belief by farmers that they're unfairly being targeted for WQ problems (a "double standard")
- Farm size makes a big difference
- Break-through moment: *"Both urban and rural share responsibility; we need to work together."*
- **Potential follow-up questions:** 1. There was a strong perception that the "real" environmental problem is the dumping of sewage into the river by municipalities. People in attendance were convinced the metropolitan wastewater treatment plants are still dumping raw sewage. Obviously the success story hasn't reached much of Minnesota. 2. The MPCA is also feared by farmers, who tell stories of MPCA staff showing up at "somebody's farm" and acting like a tyrant. These rural legends are shared and passed on, though nobody in attendance had direct experience with a situation like this. As LL said "Until we deal with their fear, we won't make any headway".

Stakeholders and Partners – **priority issues: *Statewide land planning/urban sprawl, pesticides, feedlots***

- Ag issues dominated ("farming: a sacred cow")
- Pesticides (+other toxins): too many/too compl. to ever know potential effects
- Strong call for "simplified, coordinated reporting"
- PCA needs to improve most in: *setting/upholding regulations, promoting innovation and conducting research/monitoring*.
- **Potential follow-up questions:** The stakeholders and partners attending this forum were more interested in the "how" instead of the "what." What might this mean given the Agency's focus on outcomes rather than process? This may not be surprising knowing our own preoccupation with process, but this may prove to be barrier to the Agency moving to an outcomes focus if our key partners are also process focused and aren't ready to make the change. How does knowing the stakeholders/partners viewpoints help us?

1997-1999: The National Environmental Education & Training Foundation

A review of this website: **http://www.neetf.org/reportcard/index.htm** reveals a range of findings on public knowledge, misperceptions, level of support for environmental protection, etc. Here are some highlights from surveys from '97-'99:

- Only 23% of Americans are able to identify run-off as the leading cause of water pollution. (Twice that number believe factories are the main source.)
- Only 33% of Americans know that burning fossil fuels is America's primary method for generating electricity, or what impact this has on air quality. (Nearly half believe dams produce most of our electricity).
- Americans have been very consistent over the past six years in their belief that the environment and economy can go hand in hand, and four to one reject polarized positions on the environment.
- Increased knowledge of the environment helps people notice more compromises and lessen their overall support for certain types of environmental regulation as the *only* solution to environmental problems.
- Environmental knowledge makes people less inclined to think we might face an environmental catastrophe in the next ten years.
- Individuals who know the major source of water pollution are more likely to take action to prevent it.
- Childless adults who know that cars are the major source of air pollution in the U.S., and who have alternative transportation available, are more likely to use the alternative.
- Fully 95% of adult Americans and 96% of parents support children being taught environmental education in the schools.

Statewide Phone Survey, April 1999

This survey was conducted by C.J. Olson Market Research, Inc. for the MPCA in April of 1999. The consultant divided the state into three nearly equal areas (Metro, north and south) and surveyed 814 Minnesotans by telephone. The research was done to gather the views and values of the state's citizens as they relate to the environment. Also to determine Minnesotans' awareness of the causes of pollution, discover what environmental information the public wants and how they want to receive that information. We intended to use the results to establish priorities, plan educational outreach and develop communications.

Summary

Awareness of the Causes of Pollution

Awareness of the causes of pollution was measured by the perceived seriousness of various threats to the Minnesota environment. Overall, the top three environmental threats rated most serious were agricultural runoff, vehicle exhaust and industrial chemical waste.

When different parts of the environment were looked at specifically, awareness of the causes of pollution became apparent.

- Minnesota residents perceived the most serious threats to lakes and streams to be urban storm water runoff, agricultural runoff, leaking septic systems and discharges from waste water treatment plants.
- The most serious threats to air quality were perceived to be emissions from factories and refineries, vehicle exhaust and the burning of coal, oil and garbage to produce electricity.
- Industrial chemical waste was perceived to be the most serious threat to clean soil and groundwater.

Environmental Values

This study revealed the Minnesota public believes the most important reason for protecting the environment is to keep it clean for future generations.

Current water quality was considered to be between fair and good and, overall, it was expected to stay about the same in the next ten years. However, the breakdown of the actual responses was as follows: 42% said "get worse;" 34% said "stay the same;" and 20% said "get better." Current air quality was considered to be good. It was expected to stay about the same in the future.

Overall, mercury in fish was the environmental problem about which the public was most concerned. Minnesota residents indicated they were somewhat concerned about the parts of the environment they never see or visit, like a rare plant or a remote river.

When asked how well the Minnesota government was protecting the environment, respondents gave a mean rating that was between not doing enough and doing the right amount.

Environmental Information Wanted and Preferred Sources

Survey participants were asked if they would be interested in learning more about sources of pollution in Minnesota, how to help prevent and reduce pollution and/or health risks from known pollution in Minnesota. For each of the topics, over half of the survey participants indicated they were interested in learning more about the subject.
The preferred sources of information were brochures/newsletter/fact sheets, newspapers, and TV or radio.

Voices and Views: Listening Posts Across Minnesota, MN Planning April 2000

Minnesota Planning organized "listening posts" in ten development regions in the state between December 1999 and April 2000 to determine what rural Minnesota saw essential to their future. These public- participation opportunities were hosted by Regional Development Commissions and cosponsored by the United States Department of Agriculture-Rural Development. A total of 630 citizens, of which 16 were state senators or representatives, attended the listening posts.

Summary

The overwhelming impression gained from the listening posts was that Minnesotans are proud of their regions, value their quality of life, and want safe, welcoming, economically-viable communities. Many of the attendees shared the following views:

- Most rural areas are experiencing a decline in population and that population is aging.
- There is a need to create viable economies that encourage more young people to move out of the Twin Cities to rural Minnesota.
- Job creation is a major concern. Higher-functioning and better-paying jobs are needed to retain young people.
- Rural Minnesota needs greater access to higher education with training being responsive to the evolving job market.
- Welcoming minorities to rural communities would help the region thrive economically.
- Rural communities want to work with the state to encourage businesses, especially high-tech businesses and financial institutions, to relocate to rural areas. Large businesses can be encouraged to expand into rural Minnesota by awarding them tax breaks or economic assistance.
- The state should move some state government jobs to rural Minnesota.
- Local businesses must be helped to grow and the development of niche markets in rural areas is important.
- Rural communities should not import what can be produced locally.
- Regional planning should take a holistic approach.
- An inter-district dialogue should be encouraged.
- Agriculture is still at the heart of the rural economy but must be made viable. We need fewer corporate farms, more family-run farms of 200 to 400 acres and a free market for agriculture.
- New uses for agricultural products must be sought.
- Government has turned its back on production agriculture.
- Tourism is a viable option in many areas.
- Good telecommunications access is essential for economic development. A side benefit to this is reduced road congestion.
- Good transportation is also essential to economic development. Clearly, road transportation is considered the priority for moving both people and products.
- Health care is a concern in many rural areas.
- Affordable housing is an economic issue.
- Quality education systems will stimulate economic growth.
- Communities must respect the environment. In all regions, citizens were conscious of the richness of their natural resources and the importance of protecting them and maintaining clean air and water. They agreed economic development should not come at the expense of land use and infrastructure planning.
- Water and sewer (infrastructure) issues must be dealt with.
- Education about the environment is essential, both in the schools and in communities.
- Effective land use requires planning. Sprawl is a concern and zoning was favored in most places. Planning should be regional and the state should act as a catalyst, providing guidelines, projections and funding, with greater cooperation between state agencies and citizens.
- In Fergus Falls, many citizens believe that over-regulation is a problem, exacerbated by a belief that the Pollution Control Agency does not understand how farmers operate. Some regulations do not make sense, and as a result, some dairy farmers are pulling out of the region, they said.
- Grant allocation should be fairer. There should be more flexibility and grants with performance goals, not restrictive guidelines. It was suggested that Regional Development Commissions be given a larger role. There is also a concern regarding fund matching—many rural communities lack the resources to match funds. This sets up a situation in which rich areas get more and poor areas get less.
- Partnership between all levels of government is essential. Statewide planning is necessary but the state needs to maximize local participation. State government could decentralize more.

1992 Executives' Opinions of Environmental Issues (Fredrickson and Byron Law Firm)

The population for this survey is executives from the largest manufacturing companies in Minnesota. A total of 78 telephone interviews were conducted with the 100 largest companies and 22 with the next 50 largest. The purpose of this survey was to better understand how Minnesota executives deal with the challenges of balancing environmental concerns and business interests as well as managing compliance. A variety of questions were asked about environmental compliance including the most valuable source of compliance information, what motivated companies to comply and the effect of environmental compliance on competitiveness. Among the findings:

- Executives said that their company's most valuable sources of information for understanding environmental regulations are internal environmental staff, such as quality assurance managers. Second most valuable source was trade associations and their publications.
- When asked about satisfaction with their company's involvement in regulatory compliance, executives are most satisfied with their company's compliance with regulations and their efforts to minimize corporate liability on environmental issues. They are least satisfied with their company's preparedness for future environmental regulations.
- Nearly 50 percent of executives surveyed believed that Minnesota's environmental regulations have had a negative effect on their company's ability to compete nationally. Fifty percent of the executives believe Minnesota's environmental regulations put them at a competitive disadvantage internationally. One-third felt that Minnesota's environmental regulations had no effect on their ability to compete nationally or internationally.
- Competitors' actions regarding compliance are not a major motivator affecting companies' approach to compliance.
- 65 percent of executives surveyed said the possibility of fines has a minor or no effect on their approach to compliance.
- Factors that motivated compliance included damage to their company's public image and revocation of permits and licenses.
- When asked who they call first when their company needs outside assistance related to environmental compliance, executives most often mentioned environmental engineers (41 %) and attorneys (21 %). Government and regulatory agencies were at the bottom of the list of resources to call (2 %).

1994 Customer Views on 1994 Strategic Planning (PCA with help from U of M, focus groups of end user and partner customers)

MPCA staff conducted eight focus group interview with 74 participants around the state between June 21 and June 28, 1994. The purpose of the focus groups was to gain information about how Minnesotans view the environment and the MPCA's protection efforts to support the Strategic Planning process underway at the time. Participants included both Minnesota residents and MPCA customers. Key findings included:

- Nearly all focus groups gave water the highest importance of environmental factors that people value.
- Education was mentioned in all groups as very important.
- Environmental protection must be balanced with economic growth.
- Participants wanted the MPCA to provide additional leadership in prioritizing environmental problems.
- Participants wanted MPCA to have more of a customer service orientation, to be more responsive and more accessible on a local level.
- Participants expressed frustration about the apparent lack of communication and coordination between the agencies responsible for environmental programs and also between MPCA divisions. Participants wanted consistent standards and regulations.

1995 Customer-Centered Strategy Plan (Himle Horner interviews of agency customers)

To assist the MPCA in developing a long-term customer-focused strategic plan, Himle Horner interviewed MPCA customers and staff to identify MPCA core products and the potential gaps between delivery and customer expectations. Himle Horner conducted telephone interviews with 16 MPCA customers from a variety of organizations and locations throughout the state between November 10 and November 15, 1995. The objective was to find out their perceptions on the level of customer service while using MPCA products. The interviews were selected from a list of names proposed by the MPCA. Himle Horner selected the interview candidates, which included both large and small companies who had had recent dealings with the MPCA.

Findings:

- MPCA is responsive to customers, but on its terms. The MPCA staff only works within its regulatory boundary, rarely allowing for creative solutions.
- Customers are often frustrated with the lack of integration among departments.
- The entry point to the MPCA often is confusing and/or inaccessible. Customers feel they get bounced around several times before being put in touch with the right person.
- Representatives of small businesses express much greater frustration with the MCPA than larger company contacts. There is a perceived lack of empathy among MPCA staff toward the issues facing the small business owner. Regulations seem designed as a "one-size-fits-all" solution, making it difficult to comply.
- MPCA staff transition is a problem for some customers. When MPCA staff turnover occurs, while the customer is in the middle of a process, customers are often asked to start the process over.
- Customers in outstate Minnesota prefer to work with their regional office. Regional MPCA representatives are members of their own communities and are perceived to understand their needs better.
- MPCA's training programs and seminars are perceived as positive. Nearly all the customers view the MPCA's statewide training and seminar programs to be of significant benefit to them.
- Professional relationships are good. Staff members are seen to be very knowledgeable and committed to the protection of the environment.

- MPCA's relations with customers have improved dramatically in recent years. Although there is still quite a bit more work to be done, customers feel that real progress toward better customer service has been achieved in recent years.

1995 MPCA Customer Expectations (Prism, Inc., phone interviews of MPCA customers)

Building on preliminary research conducted by Himle Horner, Inc., PRISM, Inc. conducted a series of 30-minute interviews with 41 MPCA customers between December 8-15, 1995. The purpose of the interviews was to probe customer expectations and satisfaction regarding a pre-defined set of products currently provided through the MPCA.

Findings: What Customers Like About the MPCA

- They place a great deal of value on the MPCA's willingness to solicit customer input.
- They agree that environmental rules and controls are needed.
- They feel that they have positive relationships with MPCA staff.

Findings: What Customers Would Like to Change about the MPCA

- Improvements in the way the MPCA implements "Environmental Rules," "Guidance Documents and Technical Assistance," "Environmental Permits," and "Enforcement."
  - Specifically, customers had a desire for processes that are easier to understand, less expensive to implement, and more effective. MPCA customers are more concerned about taking actions that result in real environmental improvements than in compliance with policies that do not appear to have a direct effect on the environment. Customers also cited several instances where they suffered real dollar losses as a result of delays associated with the permitting process.
- Longer-term, more collaborative relationships with MPCA representatives.
- Greater flexibility to create broad environmental plans.
- Better access to the MPCA in greater Minnesota.

1996 Customer Interviews on MPCA Products and Services

The MPCA contracted with the Management Analysis Division of the Department of Administration to conduct interviews of 35 of the MPCA's external customers about specific MPCA products and services. The customers include representatives from local units of government, consultants, environmental groups and state legislators. Of the 35 interviewed, 11 were staff from local units of government, 18 staff from for-profit or nonprofit organizations and six were state legislators from both the House of Representatives and Senate, all but one sitting on the environmental and natural resources committee. Except for legislators, interviewees were asked to comment specifically on particular MPCA products and services. The legislators were asked more general questions about the MPCA's mission and delivery of products and services. This research is similar to that conducted by PRISM, Inc., and Himle Horner, Inc, with different customers. Note that this is a very small sample size and probably should be used to generalize with great caution.

Findings:

- Customers interviewed felt the MPCA's products and services should accomplish the following:
  - Environmental protection
  - Compliance by regulated entities through meeting rules and regulation; or
  - Provision of guidelines and guidance on implementing environmental laws.

- Questions were asked about five of the MPCA's products and services (guidance documents and technical assistance, rules, compliance activities, environmental review and permits). Three of the above five (guidance documents and technical assistance, compliance activities, and environmental review) are believed by these customers to be achieving the correct objectives.

- A number of interviewees said they did not believe that rules and permits are meeting their objectives.

- Most customers stated that their relationship with MPCA staff is good and multiple examples existed to show how MPCA products and services are useful. Examples included:
  - Opportunities are provided for public comment.

- The products and services perform an educational function.
- MPCA has the ability to institute penalties and get entities to respond.
- MPCA is a resource to turn to when problems or questions arise.
- Rules provide a level playing field within industries and draw attention to particular hazards.

- **Multiple examples exist to explain how products and services are not meeting objectives.**
  - Standards are out-of-date or don't address major problems.
  - A lack of consistency is seen among inspectors.
  - Not enough time is allowed to make thorough inspections.
  - Staff are rigid, and interpret rules literally, not considering the specifics of a given situation.
  - Rule language is hard to understand.
  - Standards for protecting the environment and sanctions for violations are not high enough.
  - Pro-industry bias is shown.

- Multiple suggestions for improvement exist
  - Speed up processes and actions.
  - Be consistent across processes, among staff and among regulated entities.
  - Balance the MPCA's stance to prevent some customers from seeing the MCPA as pro-business at the cost of the environment and others from believing that the MPCA protects the environment at too great a cost to business.
  - Work more effectively with regulated parties by:
    - providing one permit to cover all media,
    - achieving balance between enforcement and helping businesses comply,
    - give more attention and individualized work to a specific project or industry,
    - provide shorter permit renewal periods and
    - allow more flexibility of means to companies that agree to perform at higher standards.
    - Be creative in protecting the environment by taxing pollution and focusing on prevention, being more risk-based and targeting the more significant pollution sources, focusing on specific goals for preventing pollution or cleaning the environment and making permits more outcome-based or results-oriented.
    - Improve MPCA's interaction with the general public by making the rules language and rulemaking process easier to understand.

Mercury Contamination Reduction Advisory Council
Summary of Post-Process Participant Interviews
and Recommendations

July 1999

This piece is included in the synopsis not because of the mercury issue but rather because the process evaluation itself turned out to be very instructive the the art and practice of using stakeholder advisory or decision making groups, which may be of interest to the redesign teams.

To learn from the experiences of the Mercury Contamination Reduction Advisory Council, the MPCA interviewed about 30 Council participants at the conclusion of the Council's work. The interviews focused on opinions about the overall process, the role of the MPCA in the process, and the role of the Council itself. Lessons learned from the interviews will be incorporated into future efforts of this type.

Part I of the report summarizes the major themes heard from participant interviews, and some notable quotes related to each theme to further illustrate the concepts and range of opinion. Part II describes recommendations for future processes, based on the interviews. In addition, a copy of the interview questionnaire with a compilation of the raw data (responses of interviewees) is included as an attachment to this report.

For the redesign teams, here are a couple excerpts from the report that may be interesting. The entire report is 13 pages, and is well worth reading if you haven't done so.

Based upon Outcomes' staff interviews of participants in the Mercury Reduction Advisory Council and other research, we have developed recommendations on the use of group decision-making processes by the MPCA and recommendations for planning and implementation of these processes. The recommendations should be considered a beginning step in our understanding of the variety of external input tools. As our knowledge and understanding increases, the recommendations may change or expand in detail.

It should also be noted that the recommendations discussed below apply to a type of process in which a group works together to make consensus decisions about an issue, sometimes called "collaborative decision making" or "group decision making." Although the MPCA called the mercury effort an "advisory council" and may have formed the group to provide advice, it evolved over time into a decision-making body. Thus, the recommendations developed here are appropriate to group decision-making processes, rather than to an advice-giving processes.

The recommendations are categorized into three phases: deciding whether to use group decision-making; designing the process; and implementing the process. We've included the recommendations for deciding whether to use group decision-making in this stakeholder research synopsis.

DECIDING WHETHER TO USE (OR NOT USE) A GROUP DECISION-MAKING PROCESS.

Group decision-making is one tool for developing solutions to environmental problems. It is not the only tool and should not be used in every circumstance. In fact, group decision-making can be considered a reactive tool and should be used sparingly. Use of this type of process is warranted in situations where:

- there is a compelling problem. Compelling problems are those that have an environmental impact, socio-economic consequences, and a range of understanding and viewpoints on the issue;
- parties are committed to finding a solutions;
- the problem affects a broad array of people;

- the problem has no obvious scientific or regulatory solution;
- participants are willing to devote the time needed; and
- the MPCA is willing to invest significant resources.

If all of the above conditions are not met, group decision making should not be the tool of choice. Two examples of problems which seemed to be well suited to this process were the landfill problems addressed by the Select Committee on Recycling and the Environment (SCORE) and the flooding problems in northwestern Minnesota, addressed by the Red River Mediation Project.

For a copy of the full report, contact Paul Hoff or Liz Gelbmann, who was the primary author.

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Note: This stakeholder research piece is included as an example related to the broader activity of basin planning.

Red River Basin Planning Process

Follow-up Evaluation, 1999

To learn from the experiences of the Red River Basin Planning process, the MPCA interviewed 20 participants at the completion of the basin plan. The interviews focused on opinions about the overall process, the people involved in the process, and the basin plan itself. Lessons learned from the interviews will be considered and incorporated into future basin planning efforts in Minnesota.

This report summarizes the major themes heard from participant interviews, and some notable quotes related to each theme to further illustrate the concepts and range of opinion. In addition, a copy of the interview questionnaire is included as an attachment to this report.

Three themes came through again and again during the interviews. These overall themes were:

- There are <u>many</u> planning processes going on at the state, basin and local level, and these processes need to be coordinated (examples: Red River Basin Plan, MN Water Plan 2000, local water planning).
- The agency better follow through on the Red River planning effort and come up with some money to fund projects…either agency funds or funds they (the agency) secure from somewhere else.
- The participants in the process need feedback and further updates; they want to know what is happening now with respect to the basin plan.

The rest of the themes identified during the interviews fall into the following three categories: The Process, The People and The Plan.

For more information, contact Paul Hoff or Liz Gelbmann.

Program-specific customer research

1993 Clean Water Partnership Survey (PCA interviews of project managers)

This is an August 1993 survey of customers involved with the Clean Water Partnership Program. The survey included detailed questions about the application process, project ranking and selection, project work plan, water quality and watershed assessments. It also asked several questions about the two main phases of the report, the diagnostic study and the implementation plan. Additional questions dealt with MPCA assistance to projects and areas where more assistance was needed.

1994 Tanks Program Focus Groups

The purpose of this research was to learn more about the needs of the Petroleum Storage Tank Program customers and identify opportunities for program improvement. Focus Groups were held in Bloomington, Owatonna, Marshall, White Bear Lake, Virginia and Little Falls. Each group was a mixture of tank owners, UST contractors, LUST consultants and neighbors to tank sites and environmentalists.

Major findings included:

- Small businesses, small local units of government and residents have significantly different service delivery needs than small businesses.
- Small businesses have trouble understanding the program, affording costs and managing consultants.
- Vast majority of customers favors regionalizing MPCA staff.
- Nearly all customers favor face-to-face visits with MPCA when small business is the customer and for cases with complex technical and enforcement issues. In most other cases, customers want to use the telephone of written communications (believe they are more efficient.)

1995 Small Business Assistance Program Survey

The MPCA sent a written survey in October 1995 to 267 randomly selected Small Business Assistance Program customers. Response rate was 39 percent. Among respondents, the program's customer service ranked very high, but business owners expressed frustration with the complexity of the air-permitting program. One survey question asked about whether or not small businesses were able to reduce emissions and/or wastes as a result of the compliance assistance they had received. Of those who responded, 38 percent said yes and 60 percent said they were not reducing emissions or wastes. Some expressed frustration at the fact that the regulations are complex and burdensome, but do not necessarily result in environmental improvements.

1996 Superfund Re-engineering Phase 1 (Prism, Inc. focus groups with MPCA staff)

Eight focus groups were conducted with Superfund staff, including a separate focus group for supervisors to gather input for use in determining the process to use for re-engineering Superfund. These focus groups were mostly about deciding a process for re-engineering (how to involve staff, etc.) rather than about how program re-engineering.

1996 Site Response Section Input and Response (Biko, Associate, Inc. telephone survey used for program re-engineering)

The MPCA contracted with Biko Associates, Inc. to conduct a telephone survey of its customers. The goal of the survey was to obtain the perceptions of customers about the Site Response Section program, how Site Response Section staff do their jobs and how the programs and staff performance can improve. These programs include the traditional Superfund program, the Voluntary Investigation and Cleanup Program and Site Assessment activities. For purposes of the survey, the MPCA divided their customers in to seven customer groups: environmental organizations and neighbors, industry, attorneys, consultants, development agencies, local government, and financial community/real estate development. A total of 49 people were interviewed from April 29-May 21, 1996, with an average of seven customers interviewed per customer group.

Survey topics included: site identification and assessment questions, site clean-up level questions, program funding questions, site clean-up cost questions, staff communication questions, specific customer group questions and summary questions (participants were given the opportunity to state what has been satisfying and frustrating about their involvement with the program).

Consensus of all respondents:

- Superfund program was generally considered a failure by all customer groups for widely varying reasons. VIC program was considered a success.
- Nearly all customer groups believed that MPCA staff were communicating well
- Funding sources for Superfund were prioritized similarly across all customer groups.
  The top priority was responsible parties and the bottom priority non-responsible landowners, with the exception of the neighborhood/environmental organizations group, which put state taxes at the bottom of the priority list.

Areas of disagreement among respondents

- Respondents were split over whether the identification and prioritization processes were fair.
- Different customer groups had different perceptions about how staff could improve service. Responsible parties and associated professionals focused primarily on speeding up the process and consistent application of standards. Development professionals focused on shortfalls of the program related to property transfer and re-development. Environmental organizations and neighbors wanted more attention given to "the needs of the site and less to the interests of land owners."

Survey highlights

- Most respondents believe the existing clean-up efforts take between 3-10 years and that this is too long. Ideal time frames for most would be one to three years.
- Risk-based cleanup was endorsed by all groups, but with varying levels of comfort. The proposition to compromise clean-up levels to facilitate clean-up of more sites was generally rejected.
- One recommendation common to several customers groups was increasing proactive participation by a broader range of stakeholders. The existing public participation rules were labeled as perfunctory or a farce.
- Another common recommendation from virtually all customer groups was to return phone calls more promptly.

1996 **Site Response Program Activities** (Biko Associates, Inc., Core, Inc. Focus groups)

The MPCA contracted with Biko Associates, Inc. to conduct seven focus groups with a total of 66 of its customers between May 17 and June 7 1996. The purpose of the focus groups was to obtain the perception of customers about the Site Response Section programs, how Site Response Section Staff do their job and how the programs and staff performance could improve.

Areas of consensus across all focus groups

- All customers support the intent of Superfund
- In spite of its intent, the process primarily benefits lawyers and consultants by keeping them employed.
- The Superfund process needs to be simplified.
- Superfund is costly with more resources going into litigation than cleanup.
- The financial harm of retroactive joint and several liability on small business owners should be mimimized
- VIC is preferred to Superfund since it leads to faster cleanup and less litigation.

General recommendations for improving MPCA efforts

- Customers want to develop better working partnerships with the MPCA.
- MPCA staff could benefit from communications, customer-service and business skills training to improve consistency and efficiency.
- Involving the community early and continuously in the planning process for remediating contamination and assessing costs eliminated future conflict.
- Customer groups want to be more involved in setting priorities.
- The concept of "risk-based" needs to be clarified and customer groups would like to be involved in defining the term.

2000 MPCA Spill Survey: Status of Spill Preparedness by Large Companies in Minnesota (MPCA mail survey of large companies)

This was an MPCA mail survey conducted for the spills program that surveyed 23 representatives from large companies in Minnesota. Companies were selected because of their potential for serious spills. Response rate for the survey was 83 percent. The survey was designed to find out about each company's perception of their spill preparedness, their participation in Community Awareness and Emergency Response Groups, obstacles that prevent improvement of spill preparedness and how the MPCA might help large companies become better prepared for spill responses.

Findings:

- Overall, companies felt they were somewhat more prepared for spills at their headquarters than at operations away from their headquarters (such as railroads or pipelines).
- Companies felt they were well prepared to make quick and accurate notification and had up-to-date Spill Prevention and Response Plans. They were less confident of their ability to have the appropriate number of trained staff available, and the ability of contractors to arrive quickly at a spill. They also said they were not as likely to have strategies in place for spills in sensitive areas.
- The most often mentioned significant obstacles to maintaining or improving spill prevention and response were insufficient time for preparation and insufficient contractor capability.
- When company representatives chose options for how the MPCA might help companies become better prepared to respond to spills, they most often mentioned plan review with suggestions, training for spill prevention and response and training on regulations and procedures. The least popular options were unannounced spill response exercises, enforcement action accompanied by publicity and plan review with required changes.
- Eight of the 19 people who responded to the survey said that representatives from their company belonged to Community Awareness and Response groups.

2000 Small Business Assistance Program/MnTAP Survey of Automotive and Implement Businesses and Repair Shops in the Marshall District

The MPCA's Small Business Assistance Program and the Minnesota Technical Assistance Program sent this mail survey to 719 businesses in the Marshall District. The businesses surveyed were automotive collision and mechanical repair shops and agricultural implement repair shops. A total of 75 businesses returned the survey.

The survey was designed to see whether these businesses wanted assistance in finding companies to dispose of hazardous material and if they were aware of the materials exchange program. MnTAP and SBAP were also curious to see how and from where business owners receive regulatory information. Also, respondents were asked what methods of pollution prevention they use and what would be the most convenient time for them to attend workshops and have one-on-one assistance from MnTAP and SBAP.

Findings:

- Most respondents did not care to receive assistance in finding used oil sorbent diposal or antifreeze recycling companies.
- Very few wanted help finding outlets for recycling or disposing of 13 other materials including batteries, electronic components and fluorescent lights.
- When asked how they receive information on the changing environmental regulations affecting their business, over half said through environmental bulletins and newsletters.
- Trade association publications or letters, waste haulers, and vendors and suppliers were another frequent source of information.
- Less than half of the respondents said their business currently receives what they consider accurate and clear information on waste reduction, recycling and environmental compliance.

- Close to two thirds of the respondents wanted to receive additional information in waste reduction, recycling and environmental compliance through newsletters and brochures. Very few of them wanted this information through demonstrations or information shared at a volunteer's business. Few wanted information through phone calls.
- Most respondents were most interested in waste reduction ideas specific to the auto/implement service industry and hazardous waste and air quality regulations and compliance.
- The pollution prevention methods included most in these business' shop activities were housekeeping and maintenance, and employee training.
- Most respondents cited a lack of capital and space limitations as the biggest reasons for not implementing pollution prevention activities.
- More than half of the 75 respondents were interested in reducing their energy costs.
- Approximately one third of the respondents were familiar with the material exchange program and another approximately two thirds said they were interested in learning more about the program.
- Respondents were asked how a workshop would best fit their schedule. Of those that answered this question, approximately 60, most of them preferred an evening meeting starting around 6 and lasting around 2 hours on any day of the week of any month of the year.
- When asked about having MnTAP or SBAP staff visit them at their shop for one-on-one help, most of the 50 some that answered, and had a preference, said they would prefer an early morning or evening meeting on Monday or Tuesday in January or November.

1999 Ground Water Monitoring and Assessment Program (GWMAP)

In September of 1999, exactly 130 surveys were mailed to county water planners or watershed district managers or other decision makers regarding ground water quality issues. The response rate was overwhelmingly positive with 55% of the surveys being returned completed. One of the purposes of the survey was to determine what planners believed to be the three most important ground water issues in their region.

Findings: The Three Most Important Ground Water Issues in Each Region of the State

Respondents were able to pick their top three ground water issues from a list of eleven choices.

- *Land use impacts to ground water* was the most common answer with 63.8% of respondents indicating it was one of their top three choices;

- *Septic systems that do not meet environmental standards* followed with 47.2%;
- *Wells that need to be abandoned* was one of the top three choices of 41.6% of the respondents; and
- *Land application of manure or other waste* followed with 38.8% indicating it was one of their top three choices.

Findings: Would you be willing to participate in a statewide monitoring effort at any of the following levels?

Respondents were given six options and were allowed to pick multiple answers.

- *Utilize information collected from the monitoring effort* was the most common answer with 66.7% of respondents indicating interest.
- *Help identify areas where monitoring wells can be installed* was the second most common answer with 56.9% of respondents indicating interest.
- *Help maintain and sample wells* was the third most common answer with 44.4% of respondents indicating interest.

Findings: How do you prefer getting ground water quality information?

Respondents were given six options for getting ground water quality information.

- *Direct mailings* was the most common answer with 68.0% of respondents choosing this option;
- *From the Internet* was the second most common answer with 37.5% of the responses; and.
- *Newsletters* was the third most common answer with 26% of respondents choosing this option.

Additional Findings:

- 84.7% of respondents said they have access to the Internet at their office;
- 40.3% of respondents said they had accessed the PCA's ground water web site; and
- 75.4% of respondents said they had received fact sheets or reports discussing ground water quality from the PCA.

The survey also included the following questions (the answers to which can be found in an available summary document):

- What ground water studies are currently being conducted in your area and who is conducting them?
- Is there local ground water quality information available for your region of the state that you would be willing to share? (Respondents were asked to briefly describe the type of information they have.)
- Please list any local experts or contacts for ground water quality issues.

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