

# Project-Level Air Toxics Analysis

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## ABSTRACT

As part of an environmental impact statement for a new interstate river crossing near Stillwater, MN, agency and environmental community concerns over the health impacts of transportation air toxics prompted the Minnesota Department of Transportation to perform an unprecedented project-level analysis. Various studies have shown a correlation between health impacts and proximity to transportation sources of air toxics. Six pollutants (termed priority mobile source air toxics, or MSATs) are considered by the Environmental Protection Agency (EPA) to dominate health risks: diesel particulate matter, Benzene, 1,3-Butadiene, Formaldehyde, Acetaldehyde, and Acrolein. Because of a lack of meaningful standards for permissible concentrations of MSATs, dispersion analysis (such as is done for CO and NOx) was not done. Instead, total emissions were quantified on three scales: regional, local, and corridor.

The EPA MOBILE 6.2 emissions model was run to determine emission rates for the six priority MSATs for various roadway types, speeds, and future analysis years. These were then combined with output from the regional travel demand forecasts to determine the emission of each MSAT for each link in the regional highway transportation network.

The following are selected findings from this research:

- Emission rates of 1,3-butadiene, acetaldehyde, acrolein, benzene, and formaldehyde are generally lower under higher operating speeds. Emissions are therefore sensitive to changes in vehicle miles traveled (VMT) and vehicle hours traveled.
- Direct emission rates of diesel particulates are not sensitive to roadway speed. Emissions are therefore sensitive only to changes in VMT.
- Long-term projected decreases in emission rates over time are much larger than the difference between any alternatives, even on a regionally significant project.
- Differences in total emissions between alternatives can be significant and quantifiable on a small area or corridor scale.
- A well-validated regional travel forecasting model is necessary to perform this type of analysis.

Transportation-related air toxics have become a great concern in the environmental community as a result of the threat to public health that they pose. Assessment of the air quality implications of highway projects will increasingly become dominated by air toxics issues. This study provides a valuable method for quantifying air toxics emissions associated with a project.

**Key words: air toxics—emissions—mobile source**

## BACKGROUND

This paper documents a study of air toxics emissions performed for the Minnesota Department of Transportation (Mn/DOT). The analysis was performed in conjunction with the Supplemental Final Environmental Impact Statement (SFEIS) for a new St. Croix River crossing near Stillwater, Minnesota. This document is a revision of an earlier analysis (dated February 2005), updated for the current preferred alternative.

In addition to the six criteria mobile-source pollutants (ozone, particulate matter, lead, carbon monoxide [CO], sulfur dioxide, and nitrogen dioxide) that are typically associated with transportation sources, the effects of another broad group of air pollutants known as air toxics have been an emerging concern. The Environmental Protection Agency (EPA) has identified 21 air toxics emitted by vehicles. The EPA has found that among these mobile source air toxics (MSATs), six pollutants dominate health risks. These compounds are known as priority MSATs:

- Diesel particulate matter
- Benzene
- 1,3-butadiene
- Formaldehyde
- Acetaldehyde
- Acrolein

While studies have shown that there may be a correlation between health effects and proximity to roads with dense traffic, there remains a great deal of uncertainty associated with quantifying specific impacts and health risks associated with potential highway projects. For criteria pollutants such as CO, the EPA has issued standards for exposure and accepted methods of modeling concentrations at potential receptor sites. Using these approved techniques, predicted concentrations can be compared with standards and a determination made as to whether a proposed transportation project will cause an air quality impact. However, there are no EPA standards for air toxics. In addition, there is no accepted method for modeling future concentrations at specific receptors.

Air quality analyses performed for highway projects commonly include both emission and dispersion modeling. Emission models quantify pollutant emissions per vehicle for various speeds in future years. Dispersion models use emissions and traffic data to predict pollutant concentrations. The EPA recently released an updated version of their mobile source emissions model (MOBILE 6.2), which includes the capability of performing emission modeling for air toxics. The Federal Highway Administration (FHWA) is currently evaluating the use of dispersion modeling to predict air toxic concentrations adjacent to roadways.

During the inter-agency review process, the Minnesota Pollution Control Agency (MPCA) requested that Mn/DOT perform an air toxics analysis for this project. In researching this issue, Mn/DOT has found no precedent for a project-level air toxics analysis for a similar project. Methods used in this assessment were developed with the assistance of the MPCA and FHWA. The FHWA and EPA are in the process of developing potential methods to address this issue, but have not yet issued any formal guidance. In the absence of established methods or formal guidance, FHWA staff recommended that Mn/DOT use the MOBILE 6.2 emission model to calculate aggregate vehicle emissions in a study area for various conditions. The MPCA further recommended that the scale of the analysis include the road segments most affected by changes in traffic volumes as a result of the project. These methods can compare emission levels resulting from various future conditions on various geographic scales, but because dispersion modeling is not included, results do not yield exposure levels or assess whether changes in emissions are significant.

The FHWA is currently evaluating the use of dispersion modeling to predict air toxics hot spot concentrations adjacent to roadways. However, the FHWA has indicated that dispersion modeling methods for highway projects are not yet adequate and do not currently support dispersion modeling for air toxics.

## **METHODS**

### **Geographic Areas of Analysis**

Three geographic scales, the region, a study area, and individual roadway segments, were used to evaluate air toxics emissions. This was done to balance the desire to account for the entire impact of the project on air toxics emissions while still analyzing impacts on specific areas. To fully capture the effects of changes in traffic patterns to air toxics emissions, impacts in both Minnesota and Wisconsin were included in the analysis at all three scales.

#### *Region*

The area modeled for travel demand forecasts included the seven-county Twin Cities Metropolitan Area, southern Chisago County, St. Croix County, southern Polk County, and the portion of River Falls in Pierce County.

#### *Study Area*

This study area identifies a geographically well defined area where the greatest difference (between no-build and build) in traffic volumes occurs. It contains the major alternative river crossings to the north and south and major north-south roadways in Minnesota and Wisconsin. The study area accounts for approximately 70% of the difference in vehicle miles traveled between the no-build and build alternatives. The definition of the study area is the area bounded by I-94 on the south; STH 65 on the east; the St. Croix county line and TH 8 to the north; and I-694, Washington CSAH 15, and Chisago CSAH 24 to the west.

#### *Segments*

In addition to aggregate emissions calculated for the metro region and the study area, selected road segments were analyzed separately to assess changes in emissions on a smaller scale. The selected segments were chosen based on a ranking of analyzed roadways by the largest changes, either increases or decreases, in vehicle traffic volume from no-build to build conditions. A total of six road segments (listed below) were selected from the top-ranked segments and were analyzed and reported separately. Initially, only five segments were planned for analysis. The sixth (Stillwater Blvd.) was added to the analysis to represent a densely developed residential corridor.

1. I-94 from I-694 to STH 65
2. I-694 from I-94 to TH 36
3. Manning Ave./Stillwater Blvd. from I-94 to TH 36
4. STH 65 from I-94 to STH 64
5. TH 36/STH 64 from I-694 to STH 65 (existing alignment in the no-build alternative and the new alignment in the build alternative)
6. Stillwater Blvd./Olive St. from TH 36 to Main St.

## Emission Modeling Using MOBILE 6.2

The currently approved EPA mobile source emissions model is MOBILE 6.2. It is based on empirical vehicle data and incorporates weather conditions, vehicle fleet composition, fuel chemistry, and operating characteristics. The MOBILE 6.2 model was used to obtain emission factors (in grams/mile) for all six priority MSATs for various road speeds and types (freeway, arterial, ramp, and local roads).

Per MPCA approval, the local area-specific input variables listed below were used; default MOBILE 6.2 input values were used for all other variables. A different MOBILE 6.2 model is used to produce emission factors for particulate matter than the model used for the other air toxics, so some input values may not apply to all pollutants.

### *Atmospheric Variables*

- Absolute Humidity: 75.0 grains/lb
- Altitude: Low Altitude
- Evaluation month:
  - July (summer) and January (winter)
- Temperature:
  - Summer:
    - Minimum: 72° F
    - Maximum: 92° F
  - Winter
    - Minimum: 16° F
    - Maximum: 38° F

### *Fleet Variables*

- Vehicle age: Based on data provided by the MPCA on August 9, 2004

### *Fuel Variables*

- Gasoline
  - Fuel program: Conventional Gasoline East
  - Oxygenated fuels: Alcohol with a 99.9% Market Share and 2.7% Oxygen Content
  - Reid vapor pressure: 9.0 lbs/in.<sup>2</sup>
  - Aromatics: 18.5% by volume
  - Benzene: 0.8% by volume
  - Olefin: 7.1% by volume
  - Percent evaporated at 200° F: 50.8%
  - Percent evaporated at 300° F: 85.6%
- Diesel
  - Diesel sulfur
    - Winter: 290 parts-per-million
    - Summer:
      - \* 2000: 300 parts-per-million
      - \* 2010: 43 parts-per-million
      - \* 2030: 43 parts-per-million

Reported particulate matter emissions are the total exhaust PM 2.5 component of sulfate, organic carbon, and elemental carbon. Other reported air toxic emissions are the total gaseous emissions of that pollutant.

The MOBILE 6.2 model was run for four roadway types (arterial, freeway, ramp, local), sixteen speeds (2.5, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, and 65 mph), and three analysis years (2000, 2010, and 2030). The results of the analysis are presented in the appendix.

### Traffic Modeling

The MOBILE 6.2 model produces emission factors by facility type and speed. Facility types, congested speeds, and hourly traffic volumes were based on the regional travel demand forecast model, which was used to produce traffic forecasts for the project. Emission factors generated from the MOBILE 6.2 model, combined with traffic volume and speed information from the travel forecasting model, was used to calculate aggregate emissions within the study area or segment for the priority MSATs.

### RESULTS

In general, emission rates for the priority MSATs (benzene, 1,3-Butadiene, Formaldehyde, Acetaldehyde, and Acrolein) produced by the model are lower at higher operating speeds. MOBILE 6.2 emission rates for particulates are not sensitive to speeds or road types.

Results of the emissions analysis are presented in Tables 1 through 8. For each pollutant, an existing (year 2000) emission rate is listed along with predicted rates for years 2010 and 2030 no-build and build conditions. While emission rates vary considerably among pollutants, each pollutant shows a similar trend of decreasing emission rates significantly over time. Also similar is the relatively small difference in emission rates between the no-build and build conditions. Results for the segment analyses also include vehicle miles traveled per mile of segment and average speed.

**Table 1. Regional air toxics emissions (grams/day)**

Pollutant	2000	2010		2030	
		No-build	Build	No-build	Build
Acetaldehyde	630,779	335,509	334,716	212,767	212,264
Acrolein	89,682	44,155	44,045	27,136	27,068
Benzene	4,398,507	2,409,044	2,405,670	1,480,471	1,478,398
1,3 Butadiene	608,289	290,668	290,212	177,280	177,001
Formaldehyde	1,799,824	926,375	924,203	587,049	585,673
Diesel particulates	2,689,176	1,366,923	1,367,026	354,029	354,056

**Table 2. Study area air toxics emissions (grams/day)**

Pollutant	2000	2010		2030	
		No-build	Build	No-build	Build
Acetaldehyde	42,032	20,538	20,471	17,245	17,143
Acrolein	5,929	2,692	2,675	2,197	2,183
Benzene	295,404	150,007	149,784	121,109	120,928
1,3 Butadiene	40,766	18,034	17,985	14,472	14,432
Formaldehyde	119,808	56,674	56,332	47,578	47,291
Diesel particulates	184,548	87,846	88,567	29,606	29,849

**Table 3. Air toxics emissions for Segment 1 (grams/mile/day)**

<b>Pollutant</b>	<b>2000</b>	<b>2010</b>		<b>2030</b>	
		<b>No-build</b>	<b>Build</b>	<b>No-build</b>	<b>Build</b>
Acetaldehyde	238	128	115	105	94
Acrolein	32	17	15	13	12
Benzene	1,732	970	880	762	691
1,3 Butadiene	236	116	105	91	82
Formaldehyde	675	353	317	289	259
Diesel particulates	1,135	597	551	193	178
Vehicle miles	1,112,794	1,544,752	1,439,571	2,159,932	1,993,296
Average speed (mph)	63	59	61	46	55
Segment length (miles)	19	19	19	19	19

**Table 4. Air toxics emissions for Segment 2 (grams/mile/day)**

<b>Pollutant</b>	<b>2000</b>	<b>2010</b>		<b>2030</b>	
		<b>No-build</b>	<b>Build</b>	<b>No-build</b>	<b>Build</b>
Acetaldehyde	258	130	132	87	88
Acrolein	35	17	17	11	11
Benzene	1,878	989	1,004	640	650
1,3 Butadiene	256	118	120	76	77
Formaldehyde	731	359	364	239	243
Diesel particulates	1,224	604	614	165	167
Vehicle miles	307,685	400,636	409,098	472,850	480,272
Average speed (mph)	57	54	54	51	51
Segment length (miles)	5	5	5	5	5

**Table 5. Air toxics emissions for Segment 3 (grams/mile/day)**

<b>Pollutant</b>	<b>2000</b>	<b>2010</b>		<b>2030</b>	
		<b>No-build</b>	<b>Build</b>	<b>No-build</b>	<b>Build</b>
Acetaldehyde	72	28	32	19	22
Acrolein	10	4	4	2	3
Benzene	518	208	237	135	154
1,3 Butadiene	71	25	28	16	18
Formaldehyde	205	77	88	52	59
Diesel particulates	334	125	143	34	39
Vehicle miles	109,324	107,620	110,146	128,807	147,194
Average speed (mph)	44	42	42	39	40
Segment length (miles)	7	7	7	7	7

**Table 6. Air toxics emissions for Segment 4 (grams/mile/day)**

Pollutant	2000	2010		2030	
		No-build	Build	No-build	Build
Acetaldehyde	44	22	17	19	15
Acrolein	6	3	2	2	2
Benzene	315	162	128	139	109
1,3 Butadiene	43	19	15	16	13
Formaldehyde	125	60	46	53	41
Diesel particulates	204	98	78	35	28
Vehicle miles	122,901	155,734	111,978	243,268	193,103
Average speed (mph)	46	45	46	41	44
Segment length (miles)	12	12	12	12	12

**Table 7. Air toxics emissions for Segment 5 (grams/mile/day)**

Pollutant	2000	2010		2030	
		No-build	Build	No-build	Build
Acetaldehyde	89	40	60	29	43
Acrolein	12	5	8	4	6
Benzene	638	301	453	209	314
1,3 Butadiene	88	36	54	25	37
Formaldehyde	254	111	166	80	120
Diesel particulates	409	183	275	53	80
Vehicle miles	514,507	642,112	872,541	807,576	1,125,909
Average speed (mph)	44	44	47	38	42
Segment length (miles)	27	27	25	27	25

**Table 8. Air toxics emissions for Segment 6 (grams/mile/day)**

Pollutant	2000	2010		2030	
		No-build	Build	No-build	Build
Acetaldehyde	63	25	18	17	13
Acrolein	9	3	3	2	2
Benzene	426	181	132	119	86
1,3 Butadiene	59	22	16	14	10
Formaldehyde	179	70	50	48	34
Diesel particulates	256	105	77	30	22
Vehicle miles	38,578	41,937	32,067	50,725	37,190
Average speed (mph)	30	34	35	32	34
Segment length (miles)	3	3	3	3	3

## **CONCLUSIONS**

### **Trends in Emission Rates**

The results presented above show that on-road emissions of air toxics are expected to decline over the next two decades. Despite growth in overall traffic volume, improvements in vehicle emission controls and fuel re-formulation will result in reduced emissions of air toxics. Modeling results show that year 2010 emission rates will be 45% to 56% lower than year 2000 emission rates. Year 2030 emission rates will be 59% to 71% lower than year 2000 emission rates for the five gaseous priority MSATS while diesel particulate emission rates for year 2030 will be 84% to 87% lower than 2000 emission rates.

### **Project Effects**

Project effects on air toxics emissions are assessed by comparing emission rates for the no-build and build conditions. For large areas, the project effects are predictably small due to the dilution of local traffic changes in a larger road system. The results of this study also show a pronounced reduction in long-term emission rates for air toxics. Differences between the no-build and build conditions are relatively small compared to long-term trends. Over a large area, the project would reduce emission levels from the no-build condition. On a smaller scale, traffic pattern change could increase emissions in some areas while reducing emissions in others.

This study does not attempt to predict concentrations of air toxics and should not be used to assess whether changes in emission rates between the no-build and build conditions are significant. Therefore, no specific conclusions can be drawn regarding the potential for adverse effects as a result of the project.

### **Metro Area Emission Rates**

On a metro area scale, construction of the project would reduce gaseous priority air toxics emission rates for the years 2010 and 2030 by 0.14% to 0.25% compared to the no-build condition. Diesel particulates would be increased by 0.01% as a result of the project.

### **Study Area Emission Rates**

Construction of the project would reduce gaseous priority air toxics emission rates for the year 2010 by 0.15% to 0.64%. Year 2030 emission rates for the five gaseous priority MSATS would also be reduced by 0.15% to 0.63%. Diesel particulates would be increased by 0.82% as a result of the project.

### **Emission Rates along the Top Six Segments**

Changes in emission rates for the six studied road segments are discussed in the list below. Long-term trends are similar to those discussed for the study area and metro area, so this discussion addresses the comparison between the no-build and build conditions.

#### *Segment 1: I-94 from I-694 to STH 65*

Construction of the project would reduce traffic on this segment, thereby reducing MSAT emissions by 8% to 10%. The resulting 2030 emissions would be approximately 65% below year 2000 levels.

*Segment 2: I-694 from I-94 to TH 36*

Construction of the project would increase traffic on this segment and would increase MSAT emissions by 1% to 2%. The resulting 2030 emissions would be approximately 70% below year 2000 levels.

*Segment 3: Manning Ave./Stillwater Blvd. from I-94 to TH 36*

Construction of the project would increase traffic on this segment and would increase MSAT emissions by 14% to 16%. The resulting 2030 emissions would be approximately 75% below year 2000 levels.

*Segment 4: STH 65 from I-94 to STH 64*

Construction of the project would reduce traffic on this segment, thereby reducing MSAT emissions by 21% to 22%. The resulting 2030 emissions would be approximately 70% below year 2000 levels.

*Segment 5: TH 36/STH 64 from I-694 to STH 65*

Construction of the project would increase traffic on the existing portion of this segment and would construct a new alignment on a portion of this segment. Increased traffic on this segment would increase MSAT emissions by 50% to 51%. The resulting 2030 emissions would be approximately 60% below year 2000 levels.

*Segment 6: Stillwater Blvd./Olive St. from TH 36 to Main St.*

Construction of the project would reduce traffic on this segment, thereby reducing MSAT emissions by 23% to 28%. The resulting 2030 emissions would be approximately 85% below year 2000 levels.