TECHNICAL MEMORANDUM

ST. CROIX RIVER CROSSING FEIS AIR TOXICS ANALYSIS

PREPARED FOR

MINNESOTA DEPARTMENT OF TRANSPORTATION

PREPARED BY

SRF CONSULTING GROUP, INC.

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St. Croix River Crossing FEIS Air Toxics Analysis

This technical memorandum documents a study of air toxics emissions performed for the Minnesota Department of Transportation. 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 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 of 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 (MSAT), six pollutants dominate risk to health. These compounds are known as “priority MSAT”:

- 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. 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 includes 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 particular 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 road segments that are 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 yeild 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 they 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. Figure 1 shows the approximate boundaries of the study areas and segments. 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 that was 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.

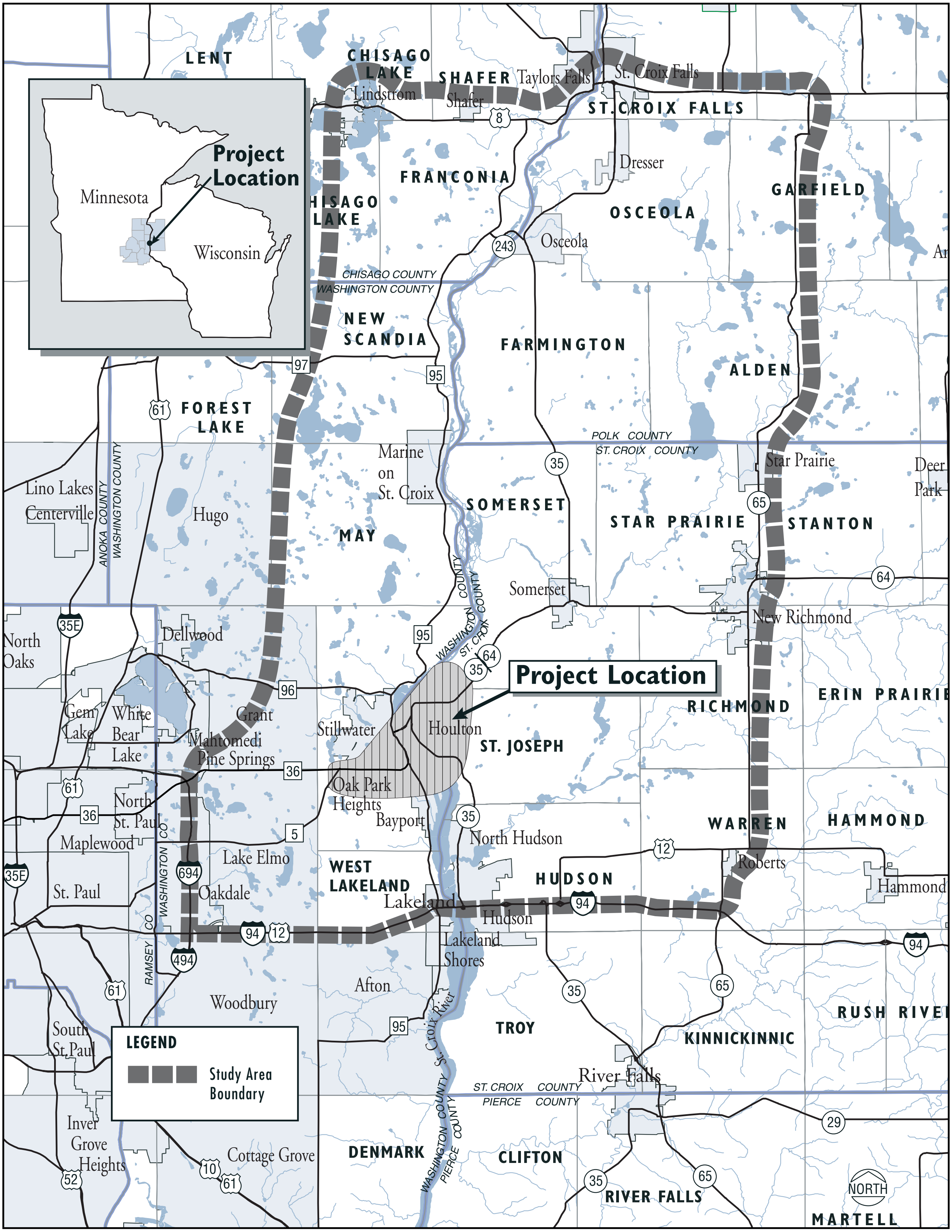
The definition of the study area is the area bounded by I-94 on the south, STH 65 on the east, the St. Croix county line and TH 8 to the north, and I-694, Washington CSAH 15 and Chisago CSAH 24 to the west. A map of the study area appears in Figure 1.

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 were selected from the top-ranked segments and were analyzed and reported separately. A map of the segments appears in Figure 2. Initially, only five segments were planned for analysis. The sixth (Stillwater Blvd.) was added to the analysis to represent a densely developed residential corridor.

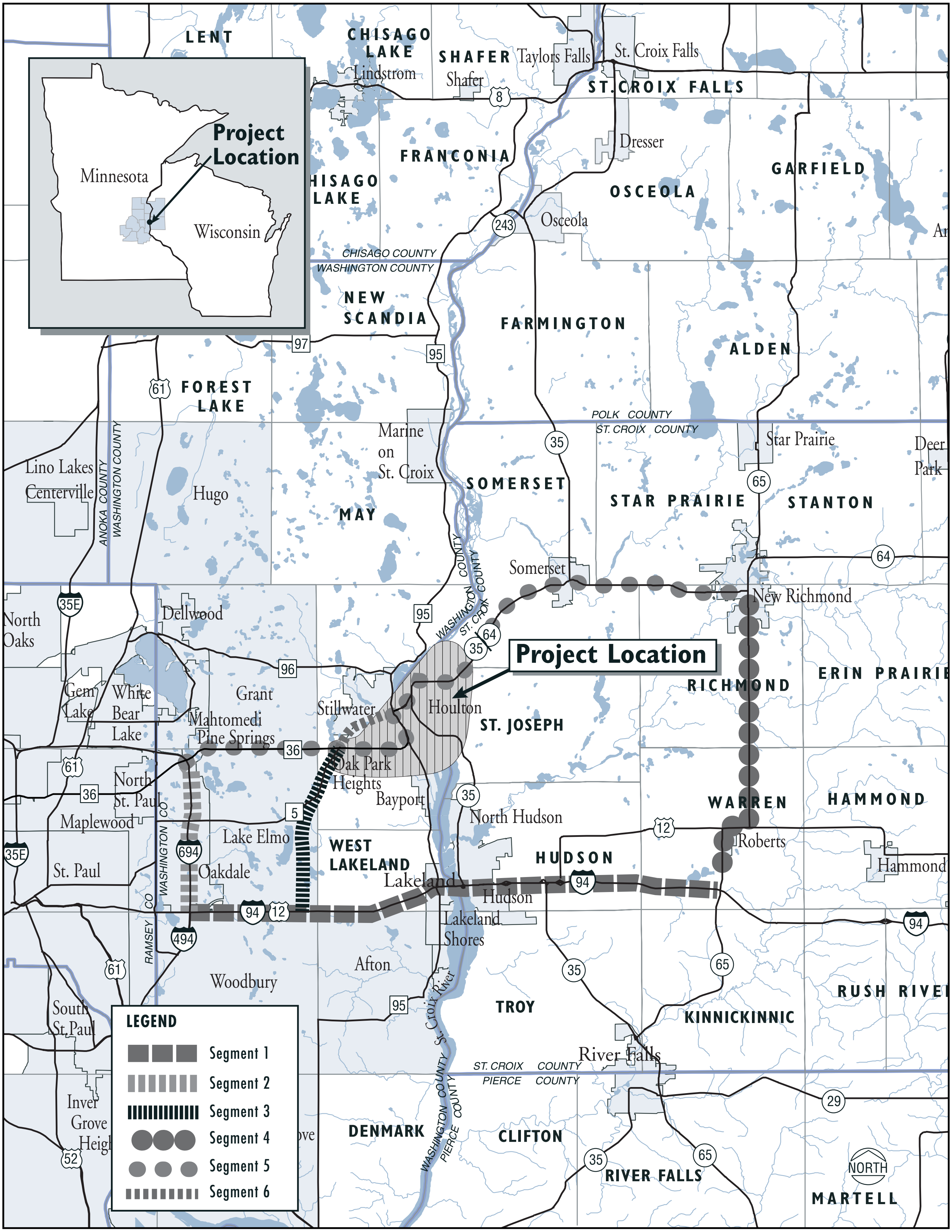
1. I-94 from I-694 to STH 65
2. I-694 from I-94 to TH 36
3. Manning Ave. / Stillwater Blvd. from I-94 to TH 36
4. STH 65 from I-94 to STH 64
5. TH 36 / STH 64 from I-694 to STH 65[1]
6. Stillwater Blvd. / Olive St. from TH 36 to Main St.

[1] Segment 5 follows the existing alignment in the No-Build alternative and the new alignment in the Build Alternative.



Air Toxics: Study Area Boundary

Figure 1



Air Toxics: Specific Studied Segments

Figure 2

MOBILE 6.2 Emission Modeling

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 mode is used for producing emission factors for particulate matter than for the other air toxics, so some input values may not apply to all pollutants.

Atmospheric Variables

- Absolute Humidity: 75.0 grains/lb[2]
- Altitude: Low Altitude[3]
- Evaluation Month:
  - July (summer) and January (winter)
- Temperature:
  - Summer:
    - Minimum: 72 degrees Fahrenheit[4]
    - Maximum: 92 degrees Fahrenheit[5]
  - Winter
    - Minimum: 16 degrees Fahrenheit[6]
    - Maximum: 38 degrees Fahrenheit[7]

Fleet Variables

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

Fuel Variables

- Gasoline
  - Fuel Program: Conventional Gasoline East[8]
  - Oxygenated Fuels: Alcohol with a 99.9 Percent Market Share and 2.7 Percent Oxygen Content[9]
  - Reid Vapor Pressure: 9.0 lbs/square inch[10]
  - Aromatics: 18.5 Percent by Volume[11]
  - Benzene: 0.8 Percent by Volume[12]
  - Olefin: 7.1 Percent by Volume[13]
  - Percent Evaporated at 200 degrees Fahrenheit: 50.8 Percent
  - Percent Evaporated at 300 degrees Fahrenheit: 85.6 Percent
- Diesel
  - Diesel Sulfur
    - Winter: 290 parts-per-million[14]
    - Summer:
      - 2000: 300 parts-per-million[15]
      - 2010: 43 parts-per-million[16]
      - 2030: 43 parts-per-million[17]

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[2] Source: MPCA
[3] Source: MPCA
[4] Source: MPCA
[5] Source: MPCA
[6] Source: MPCA
[7] Source: MPCA
[8] Source: MPCA
[9] Source: MPCA
[10] Source: MPCA
[11] Source: Energy Information Administration, Office of Integrated Analysis and Forecasting
[12] Source: Energy Information Administration, Office of Integrated Analysis and Forecasting
[13] Source: Energy Information Administration, Office of Integrated Analysis and Forecasting
[14] Source: U.S. EPA: EPA420-B-03-002
[15] Source: U.S. EPA: EPA420-B-03-002
[16] Source: U.S. EPA: EPA420-B-03-002
[16] Source: U.S. EPA: EPA420-B-03-002

Reported particulate matter emissions are the total exhaust PM2.5 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. The operation of the forecast model is described in the Technical Memorandum on Travel Demand forecasts.

Emission factors generated from the MOBILE 6.2 model, combined with traffic volume and speed information from the travel forecasting model is 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, Acetaldyde 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 the following sections. 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.

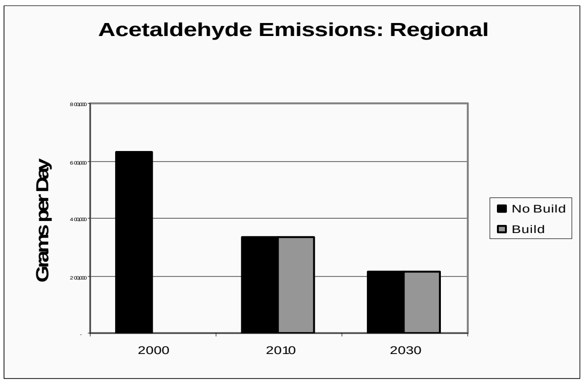
Results for the segment analyses also include vehicle miles traveled per mile of segment and average speed.

Metro Area

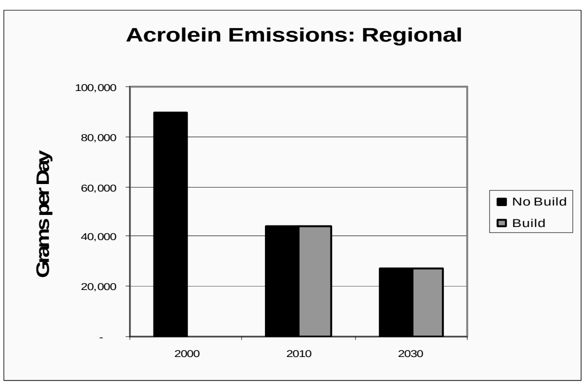
Table 1: Regional Air Toxics Emissions (grams/day)

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

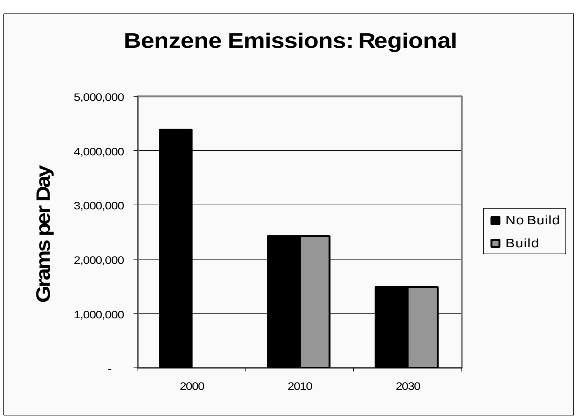
Regional Emissions Chart 1 - Acetaldehyde



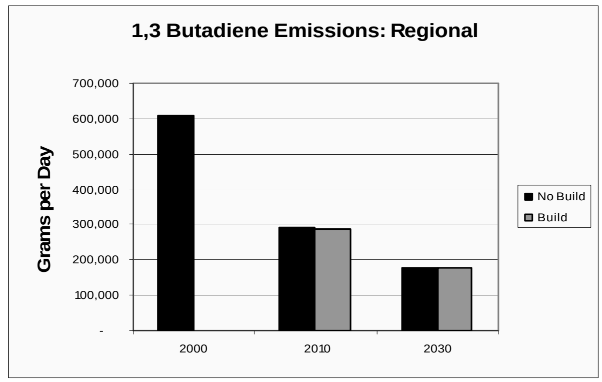
Regional Emissions Chart 2 - Acrolein



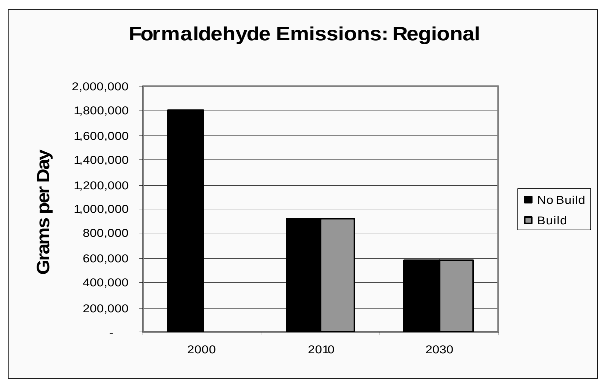
Regional Emissions Chart 3 -Benzene



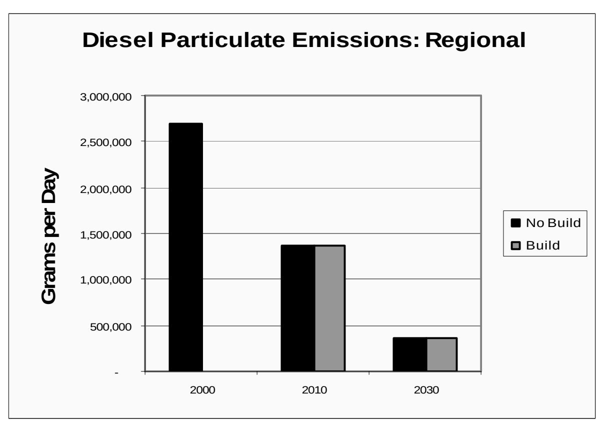
Regional Emissions Chart 4 - 1,3 Butadiene



Regional Emissions Chart 5 – Formaldehyde



Regional Emissions Chart 6 - Diesel Particulate

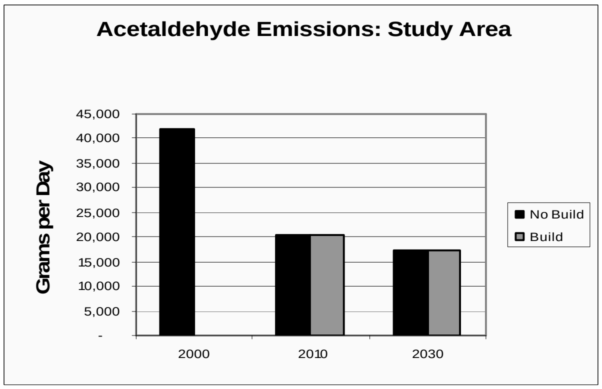


Study Area

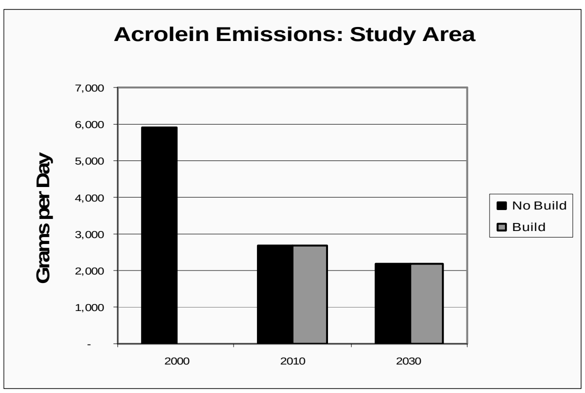
Table 2: Study Area Air Toxics Emissions (grams/day)

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

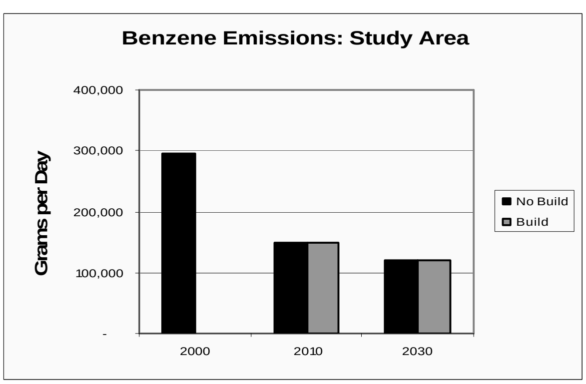
Study Area Emissions Chart 1 - Acetaldehyde



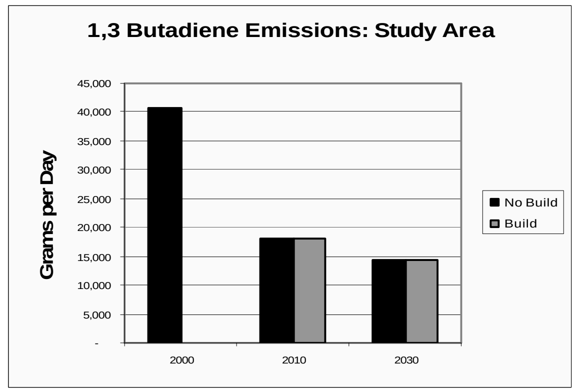
Study Area Emissions Chart 2 - Acrolein



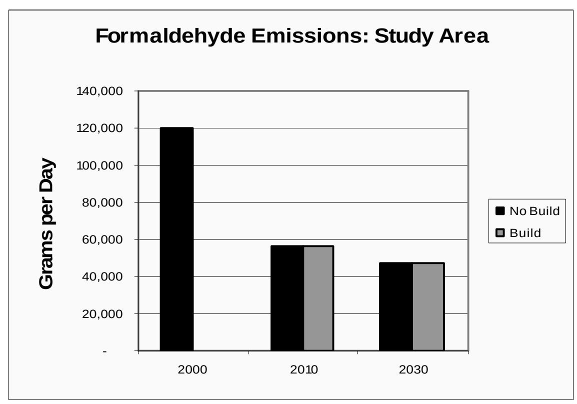
Study Area Emissions Chart 3 - Benzene



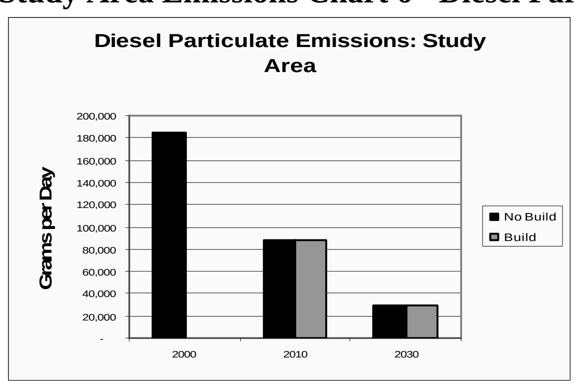
Study Area Emissions Chart 4 - 1,3 Butadiene



Study Area Emissions Chart 5 - Formaldehyde Emissions



Study Area Emissions Chart 6 - Diesel Particulate



Top 6 Segments

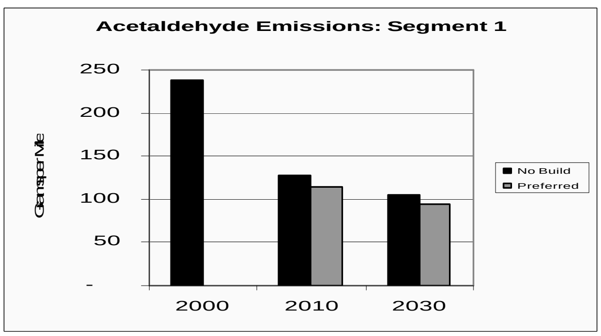
Emission results for the six analyzed segments are presented in the following Table. Emissions are presented in grams per mile per day (gpmd).

<u>Segment 1 (I-94 from I-694 to STH 65)</u>

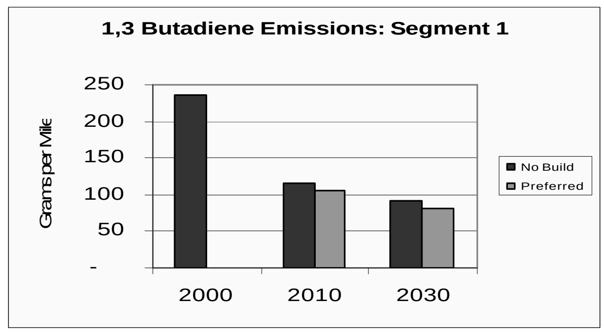
Table 3: Air Toxics Emissions for Segment 1 (grams/mile/day)

Segment	Pollutant	2000	2010		2030	
			No Build	Build	No Build	Build
1. I-94 from I-694 to STH 65	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

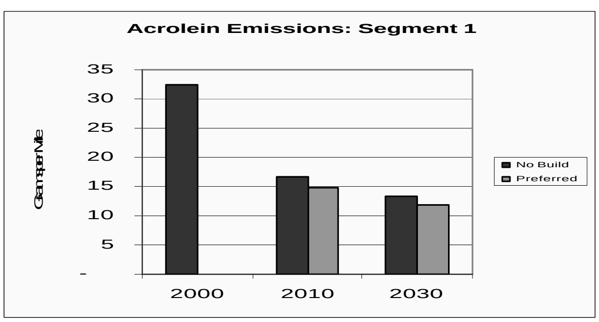
Segment 1 Chart 1: Acetaldehyde Emissions



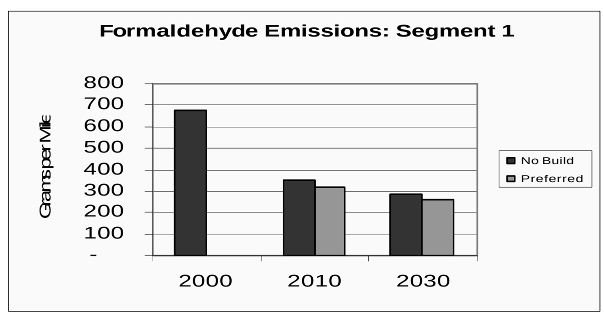
Segment 1 Chart 4: 1,3 Butadiene Emissions



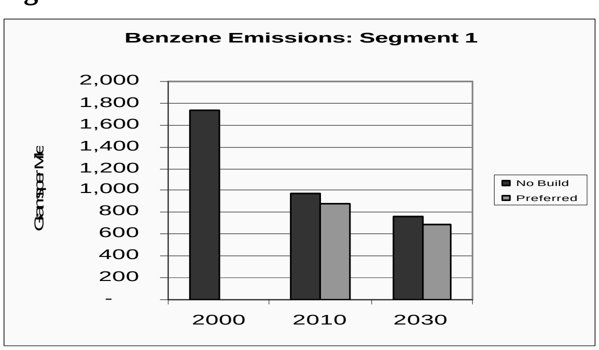
Segment 1 Chart 2: Acrolein Emissions



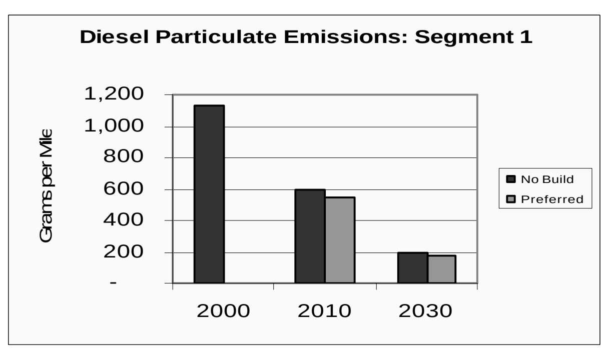
Segment 1 Chart 5: Formaldehyde Emissions



Segment 1 Chart 3: Benzene Emissions



Segment 1 Chart 6: Diesel Particulate Emissions

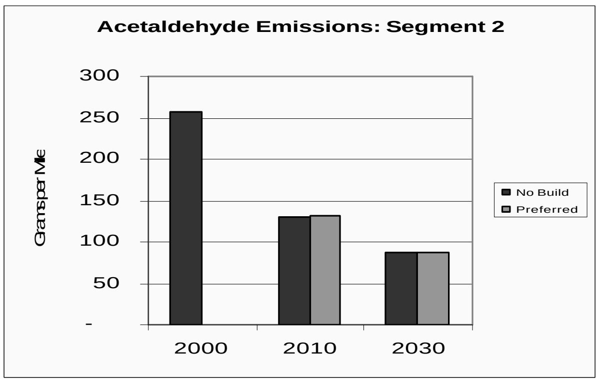


Segment 2 (I-694 from I-94 to TH 36)

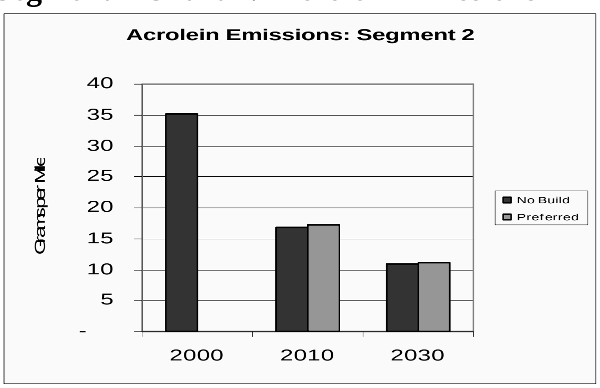
Table 4: Air Toxics Emissions for Segment 2 (grams/mile/day)

Segment	Pollutant	2000	2010		2030	
			No Build	Build	No Build	Build
2. I-694 from I-94 to TH 36	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

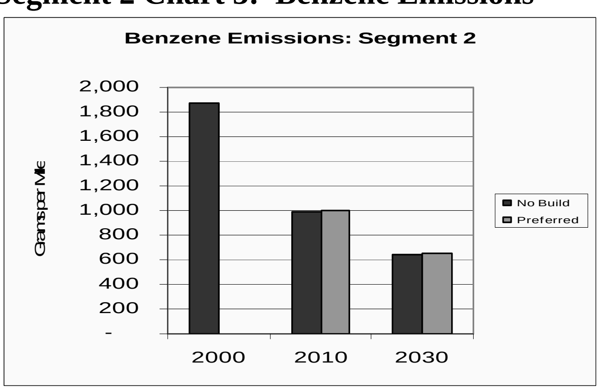
Segment 2 Chart 1: Acetaldehyde Emissions



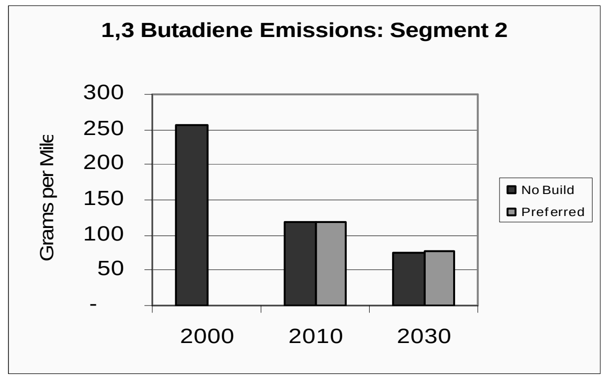
Segment 2 Chart 2: Acrolein Emissions



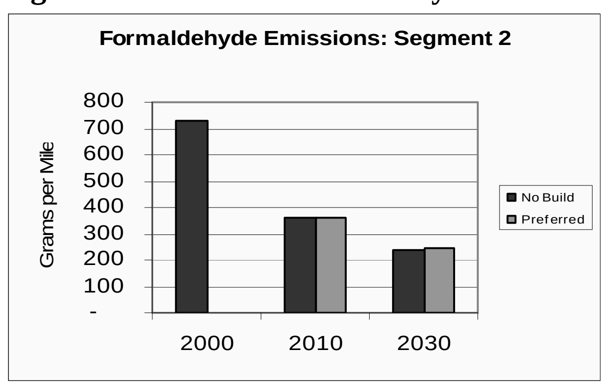
Segment 2 Chart 3: Benzene Emissions



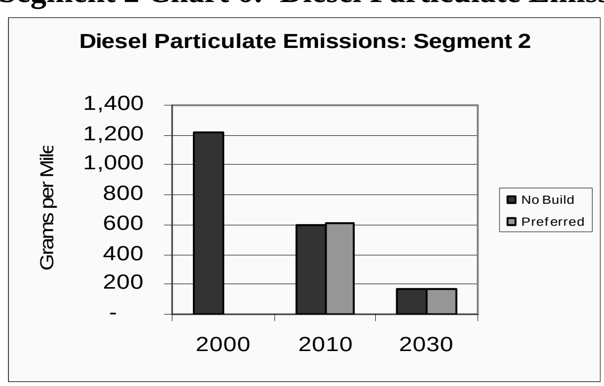
Segment 2 Chart 4: 1,3 Butadiene Emissions



Segment 2 Chart 5: Formaldehyde Emissions



Segment 2 Chart 6: Diesel Particulate Emissions

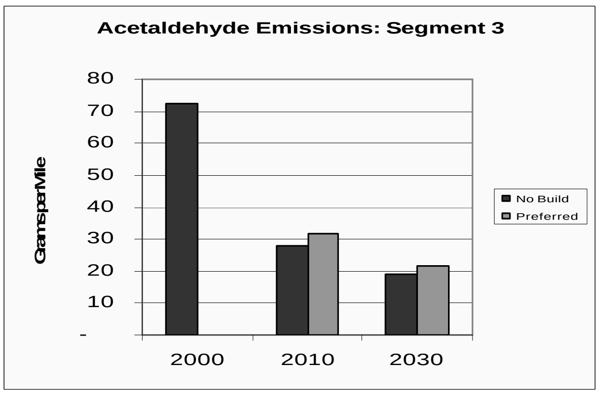


Segment 3 (Manning Ave. / Stillwater Blvd. from I-94 to TH 36)

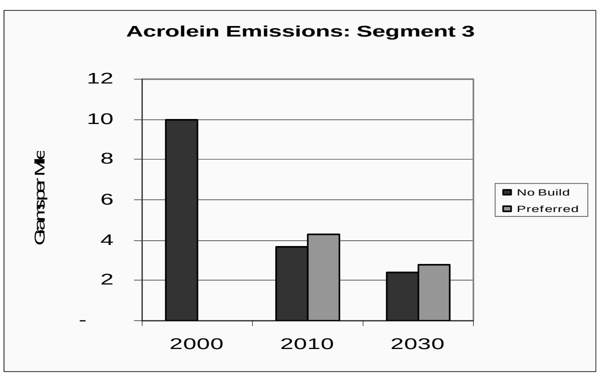
Table 5: Air Toxics Emissions for Segment 3 (grams/mile/day)

Segment	Pollutant	2000	2010		2030	
			No Build	Build	No Build	Build
3. Manning Ave. / Stillwater Blvd. from I-94 to TH 36	Acetaldehyde	72	28	32	19	22
	Acrolein	10	4	4	2	3
	Benzene	518	208	237	135	154
	1,3Butadiene	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

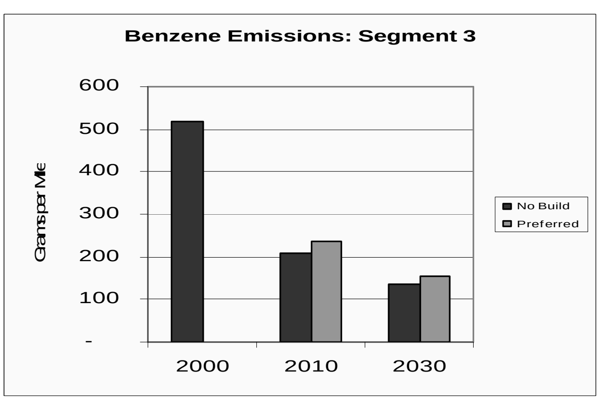
Segment 3 Chart 1: Acetaldehyde Emissions



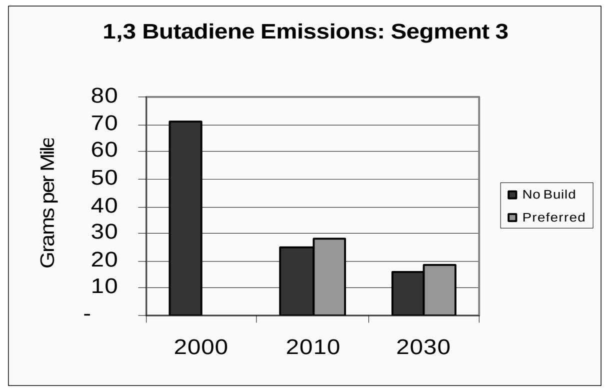
Segment 3 Chart 2: Acrolein Emissions



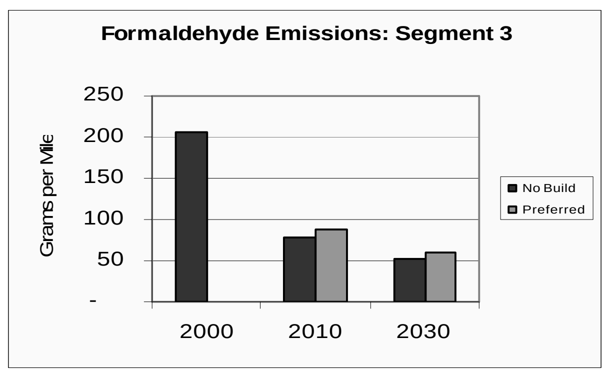
Segment 3 Chart 3: Benzene Emissions



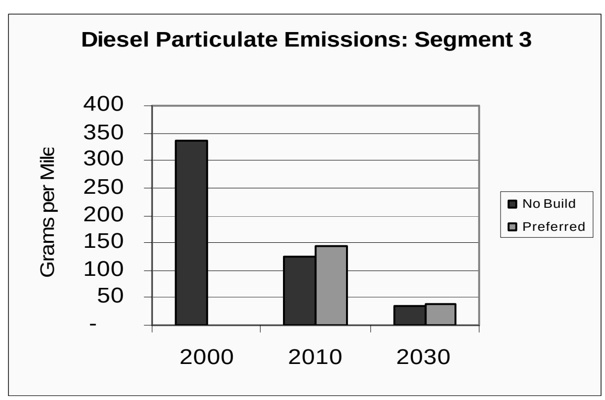
Segment 3 Chart 4: 1,3 Butadiene Emissions



Segment 3 Chart 5: Formaldehyde Emissions



Segment 3 Chart 6: Diesel Particulate Emissions

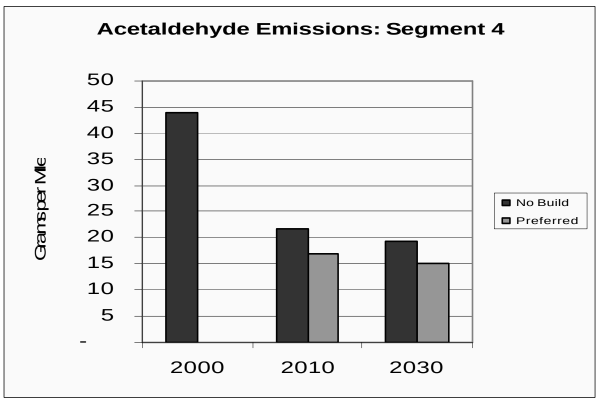


Segment 4 (STH 65 from I-94 to STH 64)

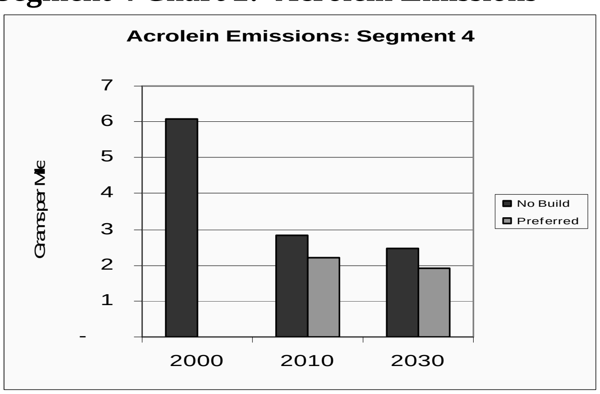
Table 6: Air Toxics Emissions for Segment 4 (grams/mile/day)

Segment	Pollutant	2000	2010		2030	
			No Build	Build	No Build	Build
4. STH 65 from I-94 to STH 64	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

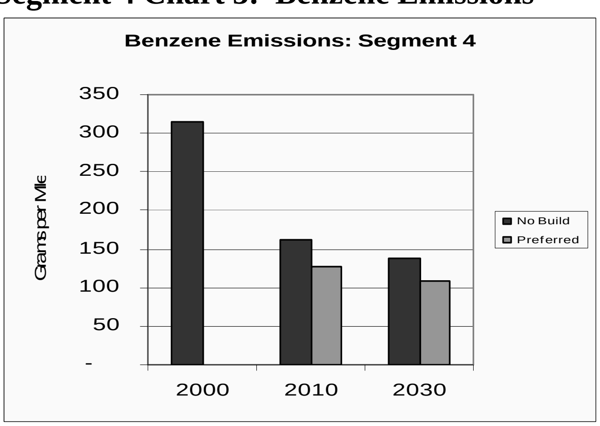
Segment 4 Chart 1: Acetaldehyde Emissions



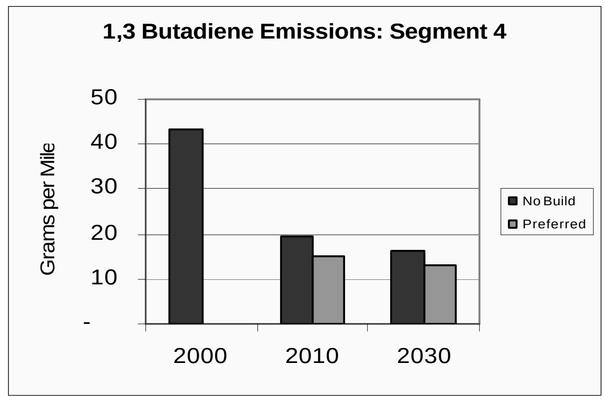
Segment 4 Chart 2: Acrolein Emissions



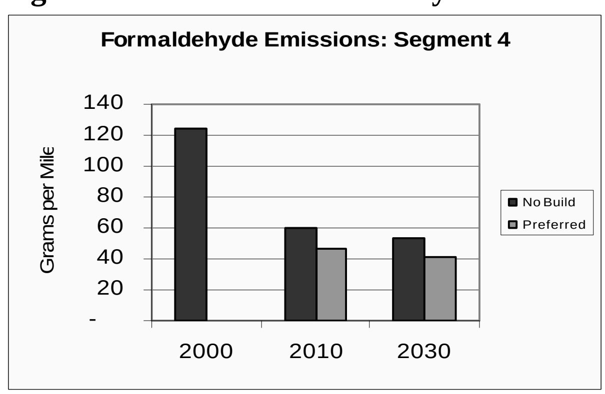
Segment 4 Chart 3: Benzene Emissions



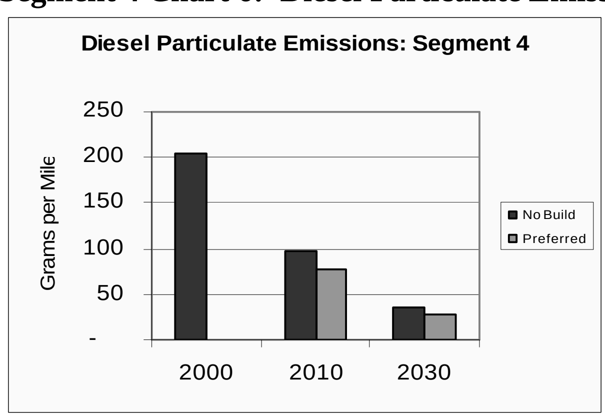
Segment 4 Chart 4: 1,3 Butadiene Emissions



Segment 4 Chart 5: Formaldehyde Emissions



Segment 4 Chart 6: Diesel Particulate Emissions

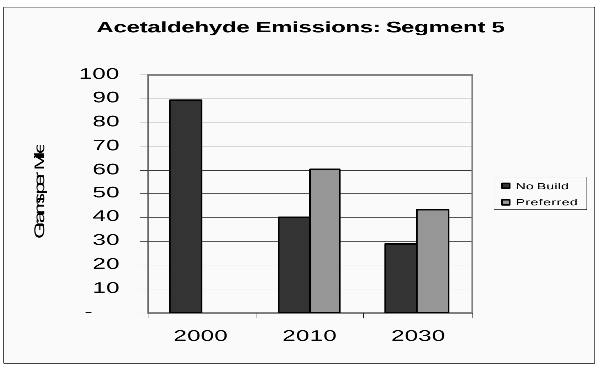


Segment 5 (TH 36 / STH 64 from I-694 to STH 65)

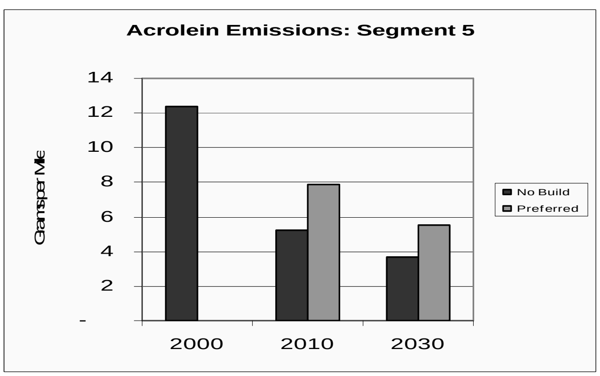
Table 7: Air Toxics Emissions for Segment 5 (grams/mile/day)

Segment	Pollutant	2000	2010		2030	
			No Build	Build	No Build	Build
5. TH 36 / STH 64 from I-694 to STH 65	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

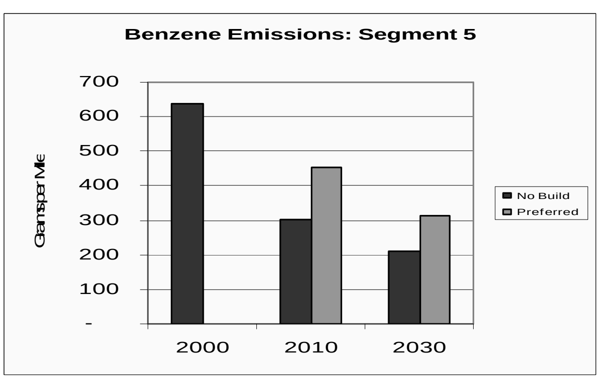
Segment 5 Chart 1: Acetaldehyde Emissions



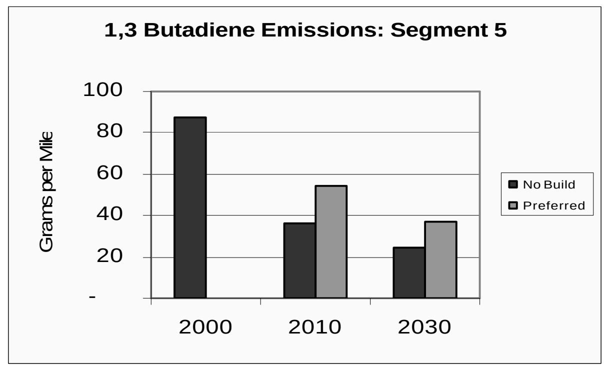
Segment 5 Chart 2: Acrolein Emissions



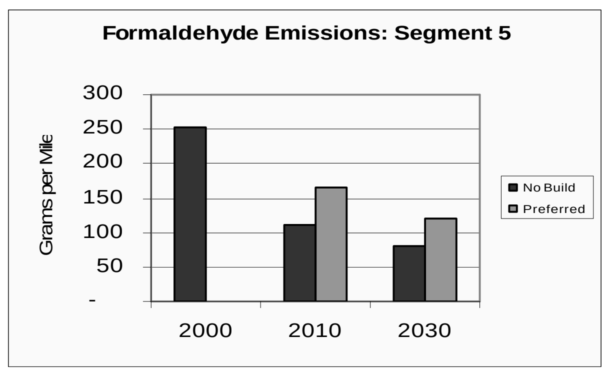
Segment 5 Chart 3: Benzene Emissions



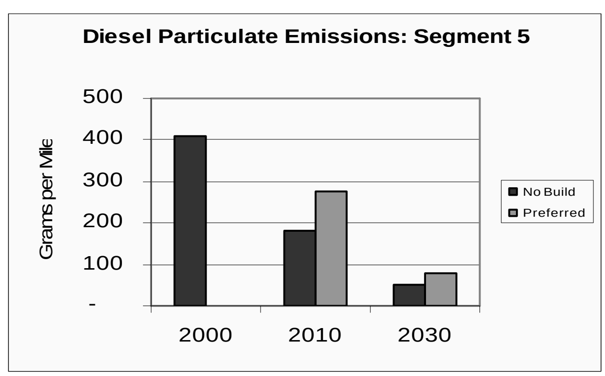
Segment 5 Chart 4: 1,3 Butadiene Emissions



Segment 5 Chart 5: Formaldehyde Emissions



Segment 5 Chart 6: Diesel Particulate Emissions

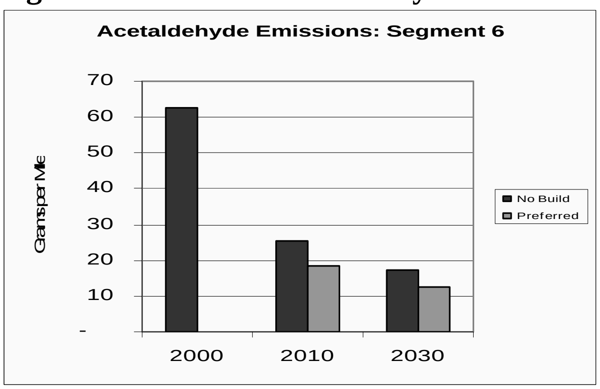


Segment 6 (Stillwater Blvd. / Olive St. from TH 36 to Main St.)

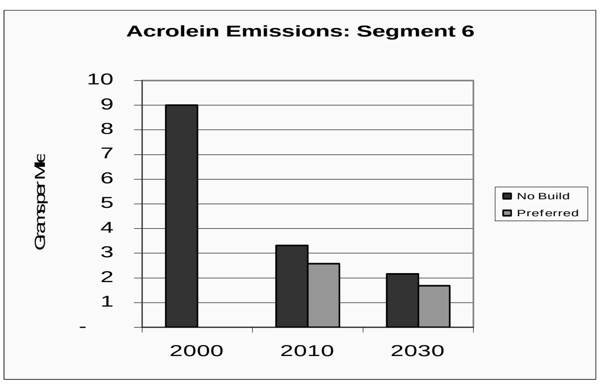
Table 8: Air Toxics Emissions for Segment 6 (grams/mile/day)

Segment	Pollutant	2000	2010		2030	
			No Build	Build	No Build	Build
6. Stillwater Blvd. / Olive St. from TH 36 to Main St.	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

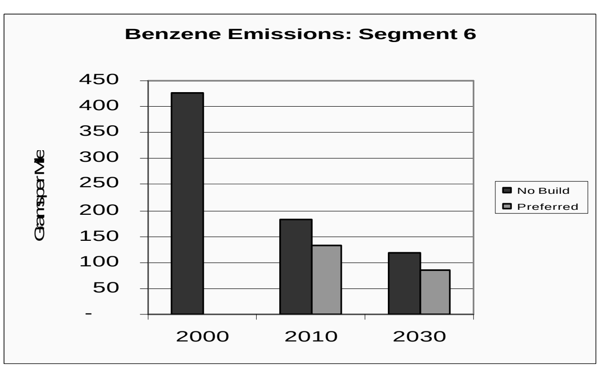
Segment 6 Chart 1: Acetaldehyde Emissions



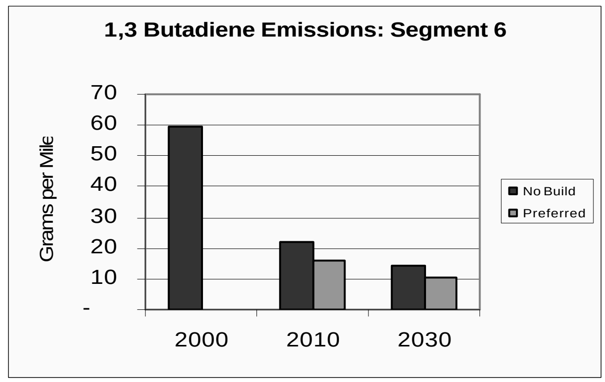
Segment 6 Chart 2: Acrolein Emissions



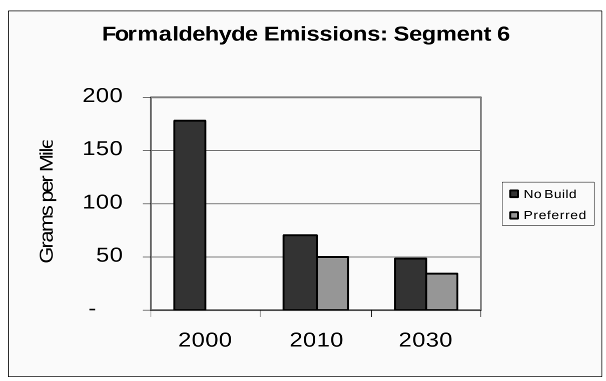
Segment 6 Chart 3: Benzene Emissions



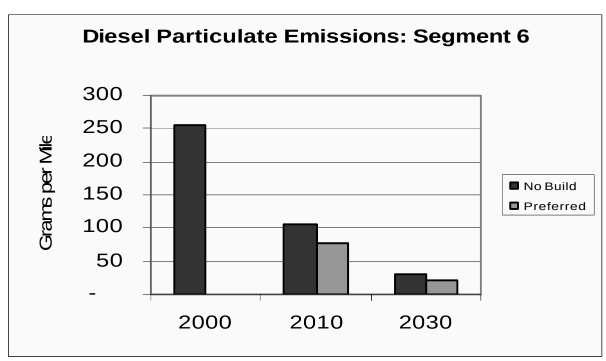
Segment 6 Chart 4: 1,3 Butadiene Emissions



Segment 6 Chart 5: Formaldehyde Emissions



Segment 6 Chart 6: Diesel Particulate Emissions



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 along with fuel re-formulation will result in reduced emissions of air toxics. Modeling results show that year 2010 emission rates will be 45 to 56 percent lower than year 2000 emission rates. Year 2030 emission rates will be 59 to 71 percent 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 percent 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 show a pronounced reduction in long term emission rates for air toxics. Differences between the No Build and Build are relatively small compared to these long term trends. Over a large area, the project would reduce emission levels from the No Build condition. On a smaller scale, changes in traffic patterns could increase emissions in some areas while reducing emissions in other areas.

This study does not attempt to predict concentrations of air toxics, therefore it 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 Rate

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

Study Area Emission Rates

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

Emission Rates Along Top 6 Segments

Changes in emission rates for the six studied road segments are discussed below. Long-term trends are similar to those discussed for the study area and metro area so this discussion addresses comparison from No Build to 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 percent. The resulting 2030 emissions would be approximately 65 percent 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 percent. The resulting 2030 emissions would be approximately 70 percent 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 percent. The resulting 2030 emissions would be approximately 75 percent 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 percent. The resulting 2030 emissions would be approximately 70 percent 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 percent. The resulting 2030 emissions would be approximately 60 percent 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 percent. The resulting 2030 emissions would be approximately 85 percent below year 2000 levels.

APPENDIX

Acetaldehyde Emission Factors (mg/mi)

Roadway	Speed (mph)	2000 Summer	2000 Winter	2010 Summer	2010 Winter	2030 Summer	2030 Winter
Local	All	10.7	13.5	4.4	5.4	2.6	3.0
Ramp	All	7.8	10.7	3.0	3.9	1.7	2.1
Arterial	2.5	26.7	32.9	10.1	12.1	5.9	6.6
Arterial	3	24.0	29.7	9.2	11.0	5.4	6.0
Arterial	4	20.6	25.6	8.0	9.7	4.7	5.3
Arterial	5	18.5	23.2	7.4	8.9	4.3	4.9
Arterial	10	12.8	16.5	5.3	6.5	3.1	3.6
Arterial	15	10.2	13.4	4.2	5.3	2.5	2.9
Arterial	20	8.6	11.6	3.6	4.6	2.1	2.5
Arterial	25	7.6	10.4	3.1	4.1	1.9	2.3
Arterial	30	7.0	9.7	2.9	3.8	1.7	2.1
Arterial	35	6.5	9.1	2.7	3.6	1.6	2.0
Arterial	40	6.2	8.8	2.5	3.4	1.5	1.9
Arterial	45	6.1	8.6	2.5	3.3	1.5	1.8
Arterial	50	5.9	8.4	2.4	3.2	1.4	1.8
Arterial	55	5.8	8.3	2.3	3.2	1.4	1.8
Arterial	60	5.8	8.2	2.3	3.2	1.4	1.8
Arterial	65	5.8	8.1	2.3	3.1	1.4	1.8
Freeway	2.5	25.2	31.1	9.5	11.4	5.6	6.2
Freeway	3	23.7	29.3	9.0	10.8	5.3	5.9
Freeway	4	20.3	25.3	7.9	9.5	4.6	5.2
Freeway	5	18.2	22.8	7.2	8.7	4.2	4.8
Freeway	10	12.2	15.8	5.0	6.2	2.9	3.4
Freeway	15	9.6	12.6	3.9	4.9	2.3	2.7
Freeway	20	8.4	11.3	3.4	4.4	2.0	2.4
Freeway	25	7.6	10.4	3.1	4.1	1.8	2.2
Freeway	30	7.1	9.8	2.9	3.8	1.7	2.1
Freeway	35	6.6	9.2	2.7	3.6	1.6	2.0
Freeway	40	6.3	8.9	2.6	3.4	1.5	1.9
Freeway	45	6.2	8.7	2.5	3.3	1.5	1.9
Freeway	50	6.0	8.5	2.4	3.3	1.4	1.8
Freeway	55	6.0	8.4	2.4	3.2	1.4	1.8
Freeway	60	5.9	8.3	2.4	3.2	1.4	1.8
Freeway	65	5.9	8.3	2.4	3.2	1.4	1.8

Acrolein Emission Factors (mg/mi)

Roadway	Speed (mph)	2000 Summer	2000 Winter	2010 Summer	2010 Winter	2030 Summer	2030 Winter
Local	All	1.6	2.2	0.6	0.7	0.3	0.4
Ramp	All	1.0	1.5	0.4	0.5	0.2	0.3
Arterial	2.5	4.1	5.3	1.3	1.7	0.7	0.9
Arterial	3	3.7	4.8	1.2	1.5	0.7	0.8
Arterial	4	3.2	4.2	1.0	1.3	0.6	0.7
Arterial	5	2.9	3.8	0.9	1.2	0.5	0.6
Arterial	10	2.0	2.7	0.7	0.9	0.4	0.5
Arterial	15	1.5	2.1	0.5	0.7	0.3	0.4
Arterial	20	1.2	1.7	0.4	0.6	0.3	0.3
Arterial	25	1.1	1.5	0.4	0.5	0.2	0.3
Arterial	30	1.0	1.4	0.4	0.5	0.2	0.3
Arterial	35	0.9	1.3	0.3	0.5	0.2	0.3
Arterial	40	0.8	1.2	0.3	0.4	0.2	0.2
Arterial	45	0.8	1.2	0.3	0.4	0.2	0.2
Arterial	50	0.8	1.1	0.3	0.4	0.2	0.2
Arterial	55	0.7	1.1	0.3	0.4	0.2	0.2
Arterial	60	0.7	1.1	0.3	0.4	0.2	0.2
Arterial	65	0.7	1.1	0.3	0.4	0.2	0.2
Freeway	2.5	3.8	5.0	1.2	1.6	0.7	0.8
Freeway	3	3.6	4.8	1.2	1.5	0.6	0.8
Freeway	4	3.1	4.1	1.0	1.3	0.6	0.7
Freeway	5	2.8	3.7	0.9	1.2	0.5	0.6
Freeway	10	1.9	2.5	0.6	0.8	0.4	0.4
Freeway	15	1.4	2.0	0.5	0.7	0.3	0.3
Freeway	20	1.2	1.7	0.4	0.6	0.2	0.3
Freeway	25	1.1	1.5	0.4	0.5	0.2	0.3
Freeway	30	1.0	1.4	0.4	0.5	0.2	0.3
Freeway	35	0.9	1.3	0.3	0.5	0.2	0.3
Freeway	40	0.8	1.2	0.3	0.5	0.2	0.2
Freeway	45	0.8	1.2	0.3	0.4	0.2	0.2
Freeway	50	0.8	1.2	0.3	0.4	0.2	0.2
Freeway	55	0.8	1.1	0.3	0.4	0.2	0.2
Freeway	60	0.8	1.1	0.3	0.4	0.2	0.2
Freeway	65	0.8	1.1	0.3	0.4	0.2	0.2

Benzene Emission Factors (mg/mi)

Roadway	Speed (mph)	2000 Summer	2000 Winter	2010 Summer	2010 Winter	2030 Summer	2030 Winter
Local	All	51.7	82.0	20.7	33.4	11.8	18.2
Ramp	All	46.1	78.1	16.9	29.2	9.3	15.0
Arterial	2.5	152.4	227.4	56.1	84.5	31.4	44.1
Arterial	3	133.9	201.5	49.9	75.6	27.9	39.5
Arterial	4	110.9	169.2	42.0	64.6	23.6	33.8
Arterial	5	97.0	149.8	37.3	57.9	21.0	30.4
Arterial	10	63.9	103.4	25.4	41.0	14.3	21.6
Arterial	15	50.4	84.4	20.2	33.7	11.5	17.8
Arterial	20	43.6	74.7	17.6	30.0	10.0	15.9
Arterial	25	39.5	68.8	16.0	27.7	9.1	14.7
Arterial	30	37.4	65.6	15.1	26.6	8.6	14.1
Arterial	35	35.6	63.0	14.5	25.6	8.3	13.7
Arterial	40	35.1	62.2	14.2	25.2	8.2	13.6
Arterial	45	34.7	61.4	14.0	24.9	8.1	13.5
Arterial	50	34.4	60.8	13.8	24.6	8.1	13.4
Arterial	55	34.1	60.1	13.7	24.3	8.0	13.4
Arterial	60	33.9	59.6	13.6	24.1	8.0	13.4
Arterial	65	33.7	59.1	13.5	23.9	8.0	13.3
Freeway	2.5	143.8	215.3	53.0	80.0	29.6	41.8
Freeway	3	133.6	201.1	49.5	75.2	27.7	39.3
Freeway	4	110.6	168.8	41.7	64.1	23.4	33.5
Freeway	5	96.7	149.4	37.0	57.4	20.8	30.1
Freeway	10	60.1	98.0	23.6	38.6	13.2	20.1
Freeway	15	46.0	78.1	18.2	30.9	10.2	16.1
Freeway	20	41.6	71.9	16.6	28.7	9.3	15.0
Freeway	25	39.4	68.7	15.8	27.5	8.9	14.5
Freeway	30	38.0	66.5	15.3	26.7	8.7	14.1
Freeway	35	36.4	64.2	14.7	25.9	8.4	13.8
Freeway	40	36.0	63.4	14.4	25.5	8.3	13.7
Freeway	45	35.6	62.6	14.2	25.2	8.2	13.6
Freeway	50	35.2	61.9	14.0	24.9	8.2	13.5
Freeway	55	35.0	61.3	13.9	24.6	8.1	13.5
Freeway	60	34.7	60.7	13.7	24.4	8.1	13.5
Freeway	65	34.7	60.6	13.7	24.3	8.1	13.5

1,4 Butadiene Emission Factors (mg/mi)

		2000		2010		2030	
Roadway	Speed (mph)	Summer	Winter	Summer	Winter	Summer	Winter
Local	All	8.9	11.9	3.2	4.2	1.8	2.3
Ramp	All	7.3	10.4	2.5	3.5	1.4	1.8
Arterial	2.5	25.2	31.8	8.4	10.4	4.8	5.4
Arterial	3	22.3	28.3	7.5	9.3	4.3	4.9
Arterial	4	18.6	23.9	6.4	8.0	3.6	4.2
Arterial	5	16.3	21.3	5.7	7.2	3.3	3.8
Arterial	10	10.8	14.7	3.9	5.1	2.2	2.7
Arterial	15	8.5	12.0	3.1	4.2	1.8	2.2
Arterial	20	7.3	10.6	2.7	3.7	1.5	1.9
Arterial	25	6.6	9.7	2.4	3.4	1.4	1.8
Arterial	30	6.2	9.2	2.3	3.2	1.3	1.7
Arterial	35	5.8	8.7	2.2	3.1	1.2	1.6
Arterial	40	5.7	8.6	2.1	3.0	1.2	1.6
Arterial	45	5.6	8.4	2.1	3.0	1.2	1.6
Arterial	50	5.5	8.3	2.0	2.9	1.2	1.6
Arterial	55	5.5	8.2	2.0	2.9	1.2	1.6
Arterial	60	5.4	8.1	2.0	2.9	1.2	1.6
Arterial	65	5.4	8.1	2.0	2.9	1.2	1.6
Freeway	2.5	23.8	30.1	8.0	9.8	4.5	5.1
Freeway	3	22.1	28.1	7.5	9.2	4.2	4.8
Freeway	4	18.4	23.7	6.3	7.9	3.6	4.1
Freeway	5	16.2	21.1	5.6	7.1	3.2	3.7
Freeway	10	10.3	14.1	3.7	4.8	2.1	2.5
Freeway	15	7.9	11.3	2.8	3.9	1.6	2.0
Freeway	20	7.1	10.3	2.6	3.5	1.5	1.9
Freeway	25	6.6	9.7	2.4	3.4	1.4	1.8
Freeway	30	6.3	9.3	2.3	3.2	1.3	1.7
Freeway	35	5.9	8.9	2.2	3.1	1.3	1.6
Freeway	40	5.8	8.7	2.1	3.1	1.2	1.6
Freeway	45	5.7	8.6	2.1	3.0	1.2	1.6
Freeway	50	5.6	8.4	2.1	3.0	1.2	1.6
Freeway	55	5.6	8.3	2.0	2.9	1.2	1.6
Freeway	60	5.5	8.3	2.0	2.9	1.2	1.6
Freeway	65	5.5	8.3	2.0	2.9	1.2	1.6

Formaldehyde Emission Factors (mg/mi)

		2000		2010		2030	
Roadway	Speed (mph)	Summer	Winter	Summer	Winter	Summer	Winter
Local	All	31.2	39.4	12.3	15.1	7.3	8.4
Ramp	All	22.2	30.3	8.2	10.8	4.7	5.8
Arterial	2.5	77.7	96.0	28.2	33.7	16.4	18.2
Arterial	3	69.9	86.7	25.6	30.8	15.0	16.7
Arterial	4	60.1	75.0	22.4	27.1	13.1	14.7
Arterial	5	54.3	67.9	20.5	24.8	12.0	13.5
Arterial	10	37.5	48.1	14.6	18.0	8.6	9.9
Arterial	15	29.5	38.7	11.6	14.6	6.9	8.0
Arterial	20	24.8	33.3	9.9	12.6	5.8	6.9
Arterial	25	21.8	29.8	8.7	11.3	5.1	6.2
Arterial	30	19.9	27.6	7.9	10.4	4.7	5.8
Arterial	35	18.5	25.9	7.3	9.8	4.4	5.4
Arterial	40	17.7	25.0	7.0	9.4	4.2	5.2
Arterial	45	17.2	24.3	6.8	9.1	4.1	5.1
Arterial	50	16.8	23.8	6.6	8.9	4.0	5.0
Arterial	55	16.5	23.4	6.4	8.8	3.9	4.9
Arterial	60	16.4	23.2	6.4	8.7	3.9	4.9
Arterial	65	16.4	23.1	6.4	8.7	3.9	5.0
Freeway	2.5	73.3	90.7	26.6	31.9	15.5	17.2
Freeway	3	68.9	85.6	25.2	30.3	14.7	16.4
Freeway	4	59.2	73.9	22.0	26.5	12.8	14.4
Freeway	5	53.3	66.8	20.1	24.3	11.7	13.2
Freeway	10	35.8	46.1	13.9	17.1	8.1	9.3
Freeway	15	27.8	36.8	10.9	13.7	6.4	7.5
Freeway	20	24.1	32.5	9.5	12.2	5.6	6.7
Freeway	25	21.8	29.8	8.6	11.2	5.1	6.1
Freeway	30	20.2	27.8	8.0	10.5	4.7	5.8
Freeway	35	18.8	26.2	7.4	9.9	4.4	5.4
Freeway	40	18.0	25.3	7.1	9.5	4.2	5.3
Freeway	45	17.5	24.6	6.8	9.2	4.1	5.1
Freeway	50	17.1	24.1	6.7	9.0	4.0	5.0
Freeway	55	16.9	23.8	6.6	8.9	4.0	5.0
Freeway	60	16.8	23.7	6.5	8.9	4.0	5.0
Freeway	65	16.8	23.6	6.5	8.9	4.0	5.0

Diesel Particulate Emission Factors (g/mi)

Year	Vehicle Type	Summer	Winter
2000	Light Duty Diesel Vehicle	0.2360	0.2382
	Light Duty Diesel Truck	0.1747	0.1792
	Heavy Duty Diesel Vehicle	0.4681	0.4917
	Composite of all Diesel Vehicles	0.4587	0.4815
2010	Light Duty Diesel Vehicle	0.0494	0.0537
	Light Duty Diesel Truck	0.0400	0.0468
	Heavy Duty Diesel Vehicle	0.1541	0.1802
	Composite of all Diesel Vehicles	0.1508	0.1763
2030	Light Duty Diesel Vehicle	0.0088	0.0114
	Light Duty Diesel Truck	0.0092	0.0140
	Heavy Duty Diesel Vehicle	0.0257	0.0410
	Composite of all Diesel Vehicles	0.0252	0.0402