APPENDIX J

AIR QUALITY ASSESSMENT

Air Quality Assessment
Dundas Street Corridor Improvements
Brant Street to Trafalgar Road
City of Burlington & Town of Oakville

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1.0 Introduction

1.1 Background

In order to facilitate Bus Rapid Transit (BRT) along Dundas Street, a dedicated bus lane is ultimately proposed in each direction on Dundas Street between Brant Street and Trafalgar Road (**Figure 1**). This section of road will be widened from 2 lanes in each direction to 3 lanes in each direction, with the exterior lane being used solely for transit buses ultimately, but will be used for High Occupancy Vehicle (HOV) / transit lanes in the interim. This section of the roadway runs approximately 17.5 km through the City of Burlington and the Town of Oakville.

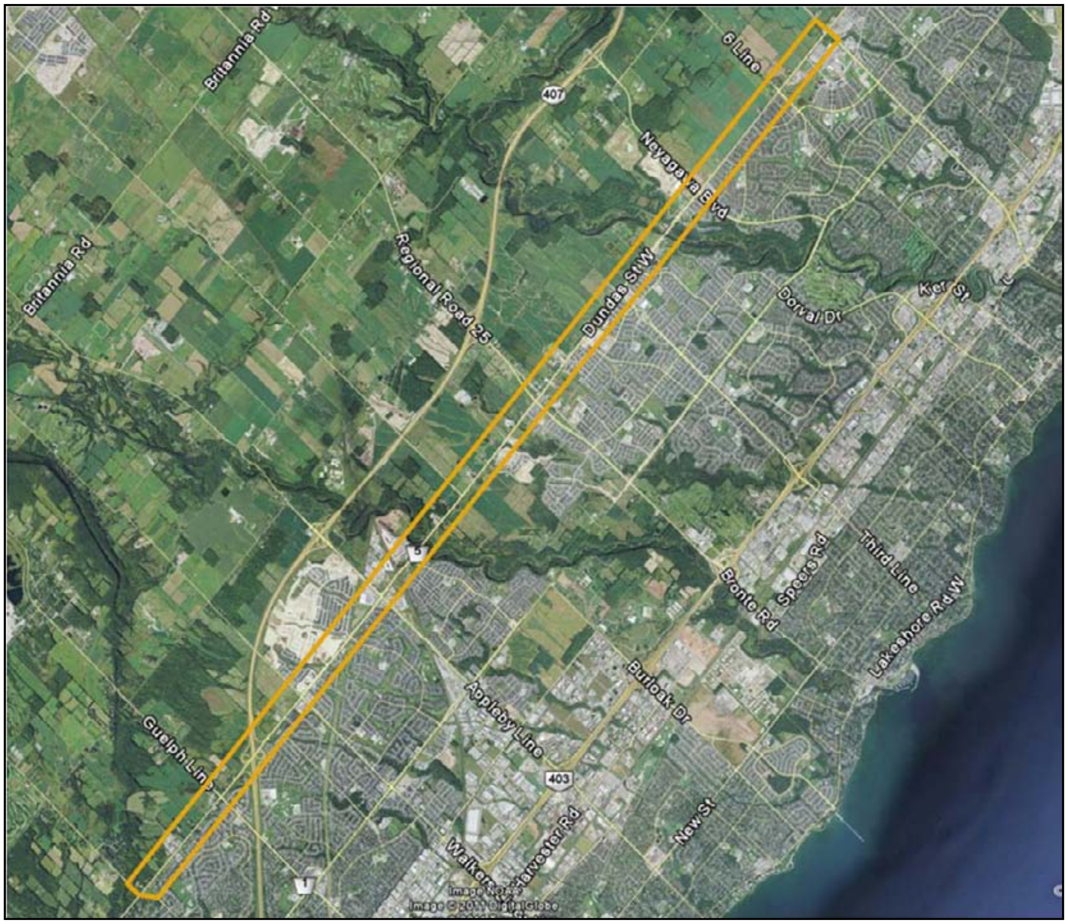


Figure 1: Study Area of Local Air Quality Assessment. (*Image from Google Earth*.)

1.2 Halton Region's Air Quality Initiatives

Halton Region understands the importance of air quality and its linkage to public health. With expected growth over the next 25 years, increased stresses on local air quality are anticipated as new vehicles, homes and workplaces are introduced to the community. In response to this expected growth, Halton Region has developed an air quality program that is directed at community emissions. This program includes:

- Air monitoring, including a Region owned air monitoring station in Milton;
- Airshed modelling;
- Policy development directed at the planning and development processes; and
- Health promotion directed at air quality and climate change as they relate to the built environment.

Halton Region's overall air quality initiatives include partnership with communities and corporations. Projects and programs include areas such as renewable energies, protection of natural areas, transportation and planning.

In terms of air quality issues related to roadway and vehicles, Halton Region believed that consideration of the potential for air quality impacts was crucial to formulating a comprehensive and effective Transportation Master Plan. The current Transportation Master Plan – The Road to Change 2031 included an air quality strategy to limit the impacts of mobile emissions. The key recommendations of the strategy include the following:

- Promote use of transit and Transportation Demand Management (TDM) measures (i.e., carpooling to reduce vehicle kilometres travelled and minimize road traffic congestion);
- Increase fuel efficiency in regional fleet management (e.g., alternative fuels, hybrid engines);
- Implement street sweeping and flushing near construction and industrial activities to minimize dirt trackout and subsequent suspension in the atmosphere;
- Maintain posted driving speeds (e.g., 50 - 80 km/h) to reduce tailpipe emissions, where possible;
- Promote on-street and off-street bicycle and walking trail networks, especially where public transit services are spatially or temporally inadequate;
- Develop design and roadway maintenance guidelines that improve air quality, such as wider paved shoulders and appropriate street and shoulder flushing to reduce dust emissions;
- Increase tree planting across the Region as an effective means of removing airborne contaminants;
- Develop a corporate model, to lead by example, in the reduction of vehicle travel/emissions and the reduction of air quality impacts from transportation sources; and
- Develop an education campaign to promote air quality. Programmes such as commuter challenges, tree planting events and walk/cycle days to work have successfully been implemented in other municipalities.

1.3 Study Objectives

Novus Environmental Inc. (Novus) was retained by MRC to conduct an air quality assessment for the proposed BRT lane on Dundas Street between Brant Street and Trafalgar Road under the ultimate condition (2031).

The objectives of this study are as follows:

- to predict the concentrations of selected contaminants resulting from road traffic on the road for the existing and future build scenarios (2031) - BRT lanes;
- to predict the combined effect of road traffic and ambient background concentrations at representative worst-case receptors; and
- to use these predictions to assess the potential impacts of the project to applicable guidelines.

Note: See separate reports for the air quality assessment of the future build scenarios (2021) - HOV / transit lanes.

2.0 Local Air Quality Assessment

This study looks at the potential impacts of increased vehicular traffic due to the addition of a BRT lane on Dundas Street. Potential impacts are assessed by predicting contaminant concentrations at sensitive land-uses adjacent to the road for the existing and future build scenarios. The contaminants chosen for this study are those commonly associated with motor vehicle emissions. Local meteorology, vehicle fleet distribution and characteristics, road type and traffic signals were all used in this assessment.

2.1 Contaminants of Interest from Motor Vehicles

The contaminants of interest from motor vehicles have largely been determined by scientists and engineers with United States and Canadian government agencies such as the U.S. Environmental Protection Agency (EPA), Ontario Ministry of Environment (MOE), Environment Canada (EC), Health Canada (HC), and the Ministry of Transportation Ontario (MTO). These contaminants are emitted due to fuel combustion, brake wear, tire wear, the breakdown of dust on the roadway, fuel leaks, evaporation and permeation, and refuelling leaks and spills and are illustrated below. Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions resulting from travel on a roadway. Instead, these emissions contribute to the overall background levels of the applicable contaminants.

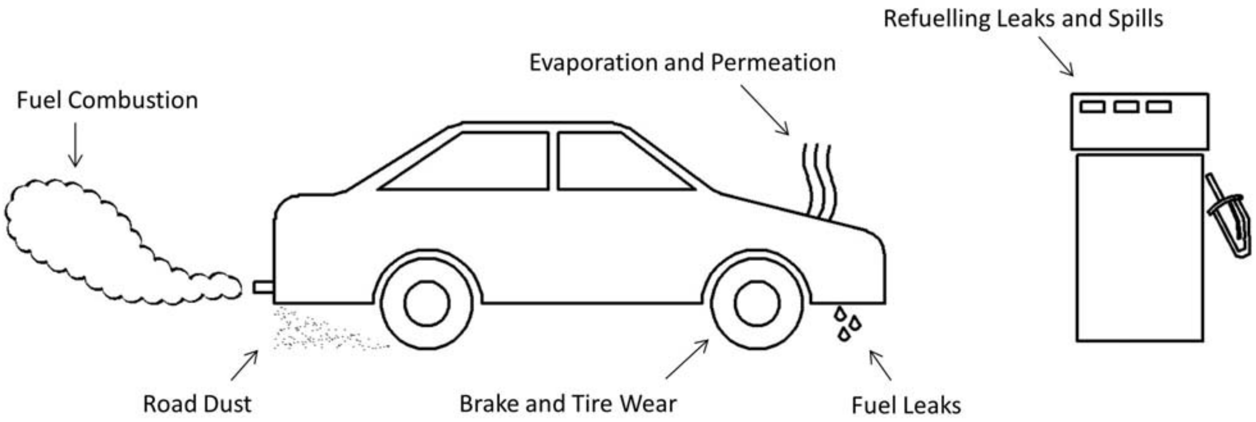


Figure 2: Motor Vehicle Emission Sources

The contaminants of interest from motor vehicles are categorized as Criteria Air Contaminants (CACs) and Volatile Organic Compounds (VOCs). The contaminants emitted during fuel combustion include all of the CACs and VOCs, and the contaminants emitted from brake wear, tire wear, and breakdown of road dust include the particulates. A summary these contaminants are provided in the following table.

Table 1: Contaminants of Interest

Criteria Air Contaminants (CACs)		Volatile Organic Compounds (VOCs)	
Name	**Symbol**	**Name**	**Symbol**
Nitrogen Dioxide	NO_2	Acetaldehyde	HCHO
Carbon Monoxide	CO	Acrolein	C_3H_4O
Fine Particulate Matter (<2.5 microns in diameter)	$PM_{2.5}$	Benzene	C_6H_6
Coarse Particulate Matter (<10 microns in diameter)	PM_{10}	1,3-Butadiene	C_4H_6
Total Suspended Particulate Matter (<44 microns in diameter)	TSP	Formaldehyde	CCHO

2.2 Applicable Guidelines

In order to assess the impact of the project, the predicted effects at sensitive receptors were compared to guidelines established by the government agencies and organizations. Relevant agencies and organizations in Canada and their applicable contaminant guidelines are:

- MOE Ambient Air Quality Criteria (AAQC)
- Health Canada/Environment Canada National Ambient Air Quality Objectives (NAAQOs)
- Canadian Council of Ministers of the Environment (CCME) Canada Wide Standards (CWSs)

Within the guidelines, the threshold value for each contaminant and its applicable averaging period was used to assess the maximum predicted effect at sensitive receptors derived from computer simulations. The applicable averaging periods for the contaminants of interest are based on 1, 8 and 24-hour acute (short-term) exposures. The threshold values and averaging periods used in this assessment are presented in **Table 2** below. It should be noted that the CWS for $PM_{2.5}$ is not based on the maximum threshold value. Instead, it is based on the average annual 98th percentile value, averaged over 3 consecutive years.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value (µg/m^3)	Source
NO_2	1	400	AAQC
	24	200	AAQC
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	30*	AAQC (CWS)
PM_{10}	24	50	Interim AAQC
TSP	24	120	AAQC
Acetaldehyde	24	500	AAQC
Acrolein	1	4.5	MOE Environmental Registry
	24	0.4	MOE Environmental Registry
Benzene	24	2.3	MOE Environmental Registry
1,3-Butadiene	24	10	MOE Environmental Registry
Formaldehyde	24	65	AAQC

* The CWS is based on the average annual 98th percentile concentration, averaged over three consecutive years.

2.3 Background (Ambient) Conditions

2.3.1 Overview

Background (ambient) conditions are contaminant concentrations that are exclusive of emissions from the existing or proposed project infrastructure. These emissions are typically the result of trans-boundary (macro-scale), regional (meso-scale), and local (micro-scale) emission sources and result due to both primary and secondary formation. Primary contaminants are emitted directly by the source and secondary contaminants are formed by complex chemical reactions in the atmosphere. Secondary pollution is generally formed over great distances in the presence of sunlight and heat and most noticeably results in the formation of fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3), also considered smog.

In Ontario, a significant amount of smog originates from emission sources in the United States and is the major contributor during smog events, usually occurring in the summer season (MOE, 2005). During smog episodes, the U.S. contribution to $PM_{2.5}$ can be as much as 90 percent near the southwest U.S. border and approximately 50 percent in the Greater Toronto Area (GTA). The effect of U.S. air pollution on Ontario on a high $PM_{2.5}$ day and on an average $PM_{2.5}$ spring/summer day is illustrated in the following figure.

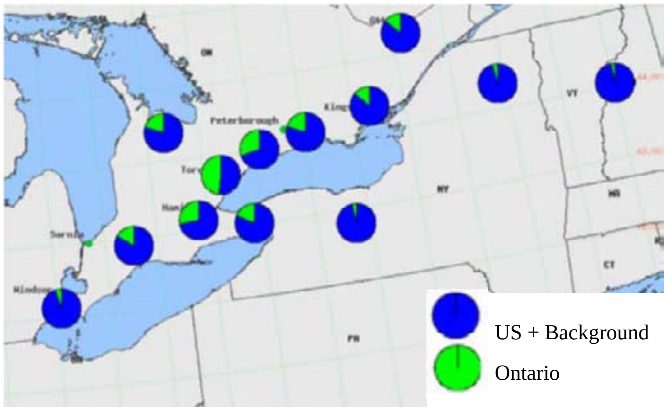
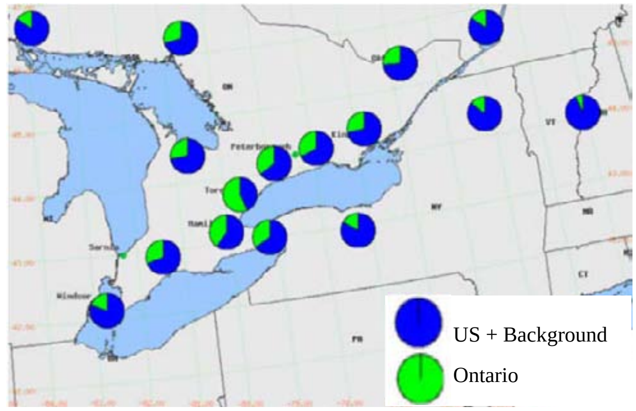
High $PM_{2.5}$ Days	Average $PM_{2.5}$ of Spring/Summer Season
	

Figure 3: Effect of Trans-boundary Air Pollution (MOE, 2005)

Air pollution is strongly influenced by weather systems (i.e., meteorology) that typically move out of central Canada into the mid-west of the U.S. then eastward to the Atlantic coast. This weather system generally produces winds with a southerly component that travel over major emission sources in the U.S. and result in the transport of pollution into Ontario. This phenomenon is demonstrated in the following figure and is based on a computer model run from the Weather Research and Forecasting (WRF) Model.

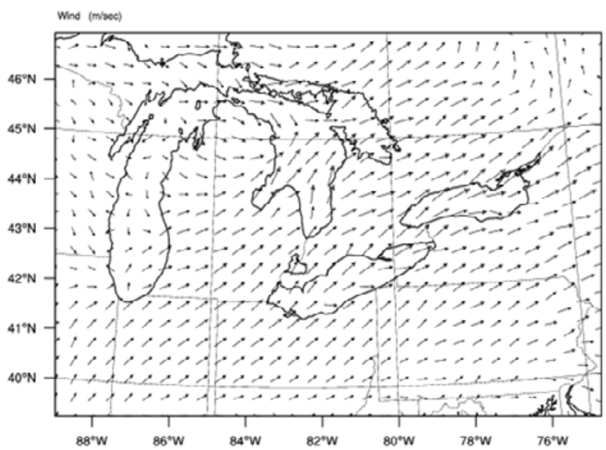


Figure 4: Typical Weather System during a Smog Episode

As discussed above, understanding the composition of background air pollution and its influences is important in determining the potential impacts of a project, considering that the majority of the combined concentrations are typically due to existing elevated ambient background levels. In this assessment, background conditions were characterized utilizing existing ambient monitoring data from MOE and NAPS (National Air Pollution Surveillance) Network stations and added to the modelled predictions in order to conservatively estimate the combined concentration.

2.3.2 Selection of Relevant Ambient Monitoring Stations

A review of ambient monitoring data from MOE and NAPS monitoring stations in relevant proximity to the study area was undertaken in order to help establish the background concentrations of the contaminants of interest. Five MOE and five NAPS monitoring stations were determined to be representative of background conditions in the study area. The representative MOE stations were Burlington, Oakville, Mississauga, Brampton and Toronto West. The representative NAPS stations were Kitchener, Toronto West, Brampton, Egbert and Windsor. Their locations relevant to the study area (highlighted yellow) are shown in **Figure 5** and station information can be found in **Table 3.**

Figure 5: Relevant MOE and NAPS Monitoring Stations

Table 3: Relevant MOE and NAPS Monitoring Station Information

City/Town	Station ID	Location	Operator	Contaminants
Burlington	44008	North Shore Blvd. E./Lakeshore Rd.	MOE	$PM_{2.5}$ | NO_2
Oakville	44017	Eighth Line/Glenashton Dr.	MOE	$PM_{2.5}$ | NO_2
Mississauga	46109	3359 Mississauga Rd. N.	MOE	$PM_{2.5}$ | NO_2
Brampton	46089	525 Main St. N	MOE	$PM_{2.5}$ | NO_2
Toronto West	35125	125 Resources Rd.	MOE	CO
Kitchener	61502	West Ave. & Homewood	NAPS	Benzene | 1,3-Butadiene
Toronto West	60413	Elmcrest Rd.	NAPS	Benzene | 1,3-Butadiene
Brampton	60428	525 Main St. N	NAPS	Benzene | 1,3-Butadiene
Egbert	64401	Simcoe RR56/Murphy Rd.	NAPS	Formaldehyde | Acetaldehyde
Windsor	60211	College Ave./Prince Rd.	NAPS	Formaldehyde | Acetaldehyde |Acrolein

Since the project study area is surrounded by many monitoring stations, a comparison of several stations was performed for the available data on a contaminant basis, to determine the worst-case representative background concentration. A comparison of all relevant monitoring stations is shown in **Section 2.3.3**. Selecting the worst-case concentration would result in conservative combined concentrations. Recently in Ontario, formaldehyde and acetaldehyde are only measured at the Egbert and Windsor stations and acrolein is measured only at Windsor. It is likely that acrolein concentrations from Windsor result in a conservative background concentration in this study area due to the large amount of industrial activity in the Windsor area.

2.3.3 Selection of Worst-Case Relevant Monitoring Station

Year 2005 to 2009 hourly ambient monitoring data, the most recent 5 years publically available, from the selected stations were statistically summarized for average, 90th percentile (90 percent of the dataset are less than or equal to the 90th percentile value), and maximum concentration for the desired averaging period, 1-hour, 8-hour or 24-hour. Average concentrations represent a typical background scenario, 90th percentile concentrations represent a typical worst-case background scenario, and maximum concentrations represent a worst-case background scenario. It should be noted that the 2005 to 2009 monitoring data was selected to coincide with 2005 to 2009 meteorological data for consistency in the dispersion modelling.

For the CACs, the station with the highest five year maximum value for each contaminant and averaging period was selected for the analysis. From a review of the VOC dataset, it was determined that due to the lack of hourly and daily background monitoring data, 90th percentile background concentrations for each VOC in the 5 year dataset would be calculated and used to determine the combined concentration. The station with the highest five year 90th percentile value for each VOC was selected for the analysis. This method was suggested by the MOE.

Table 4: Comparison of Background NO_2

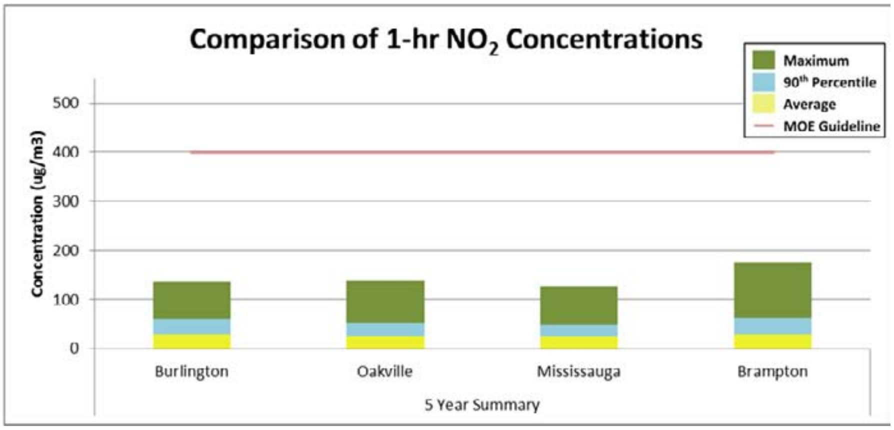
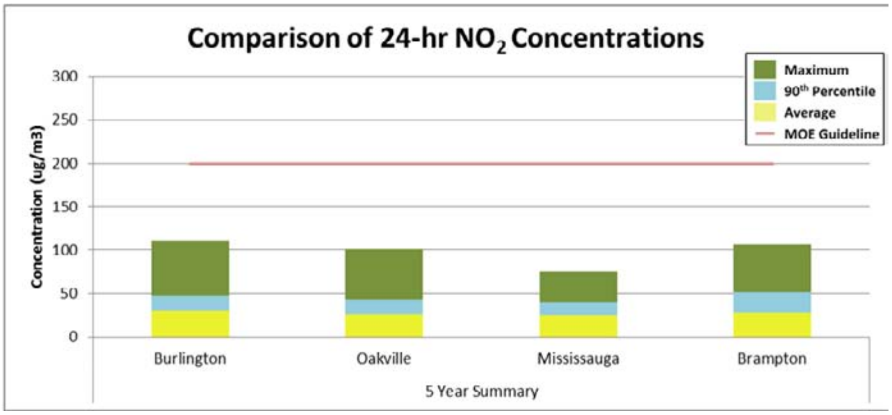
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Brampton Station on a 1-hour basis.
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Burlington Station on a 24-hour basis.

Table 5: Comparison of Background CO

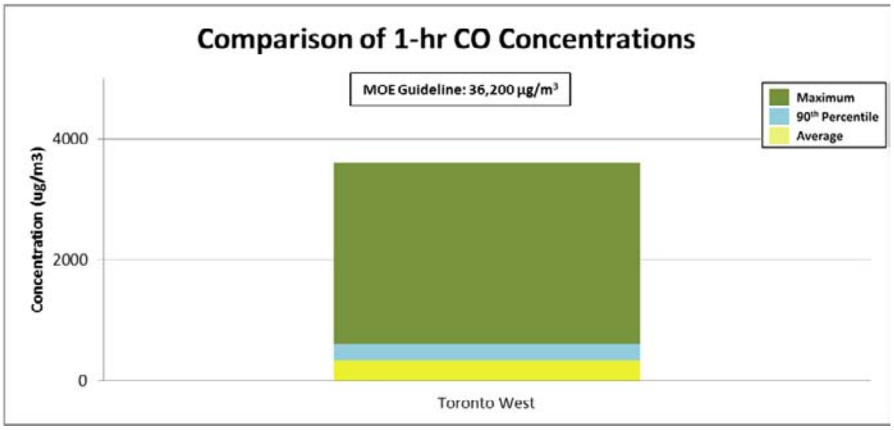
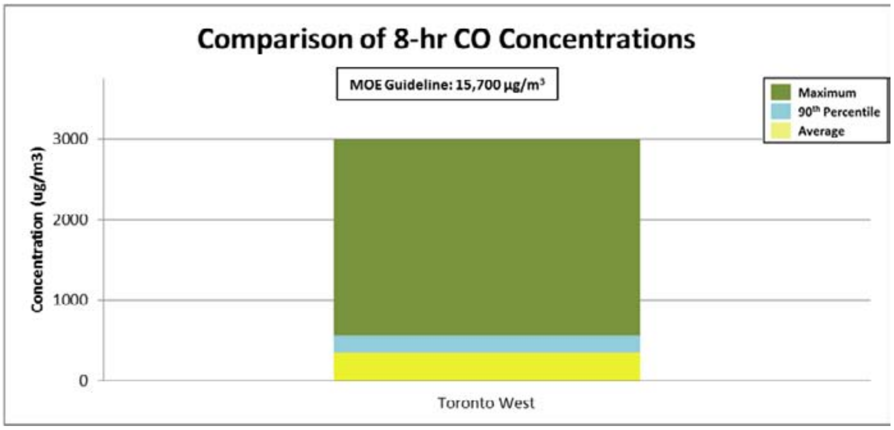
Statistical Analysis	Selection of Station
	**Conclusion:** Toronto West is the only representative station for the study area with ambient monitoring data for CO.
	**Conclusion:** Toronto West is the only representative station for the study area with ambient monitoring data for CO.

Table 6: Comparison of Background $PM_{2.5}$

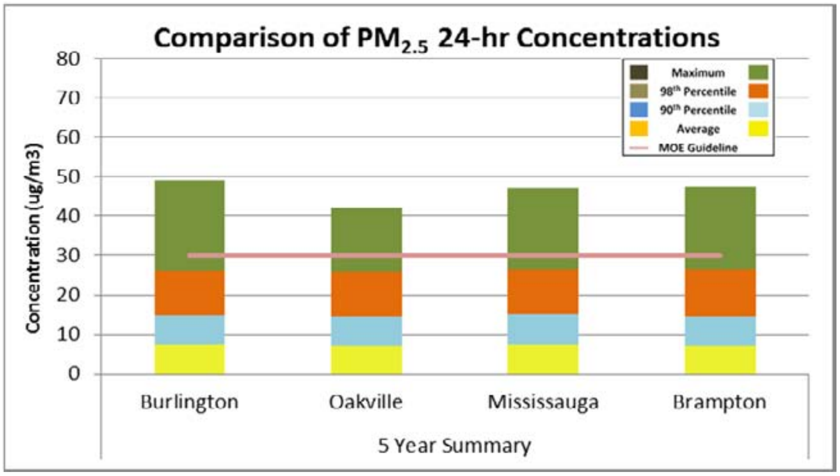
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Burlington Station on a 24-hour basis.

Table 7: Comparison of Background PM_{10}

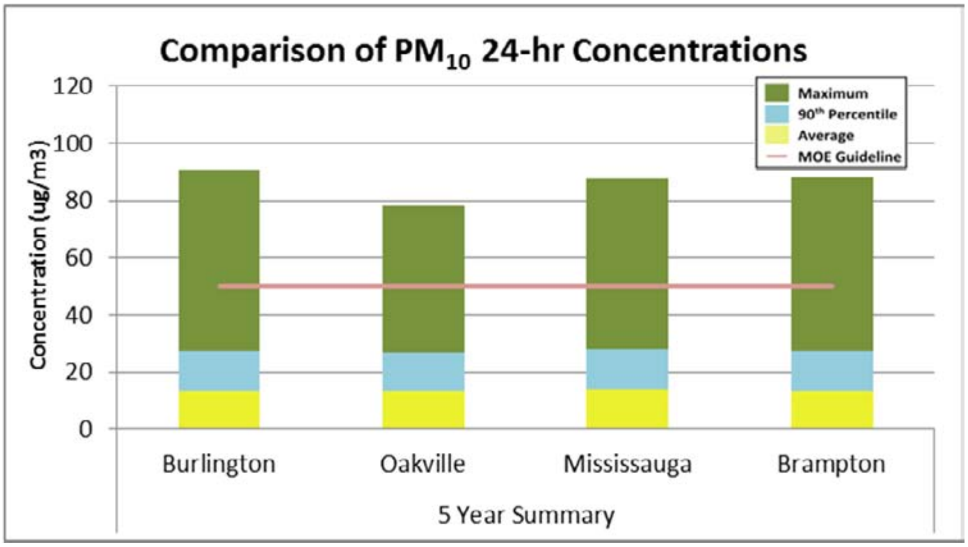
Statistical Analysis	Selection of Station
 **Note**: PM_{10} is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54. Lall et al. (2004)	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Burlington Station on a 24-hour basis.

Table 8: Comparison of Background TSP

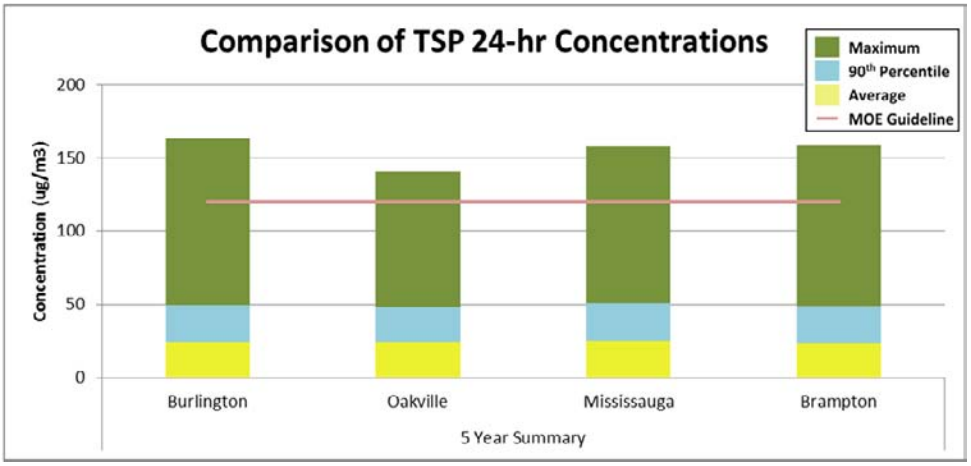
Statistical Analysis	Selection of Station
 **Note**: TSP is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}$/TSP ratio of 0.3. (Lall et al. 2004)	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Burlington Station on a 24-hour basis.

Table 9: Comparison of Background Acetaldehyde

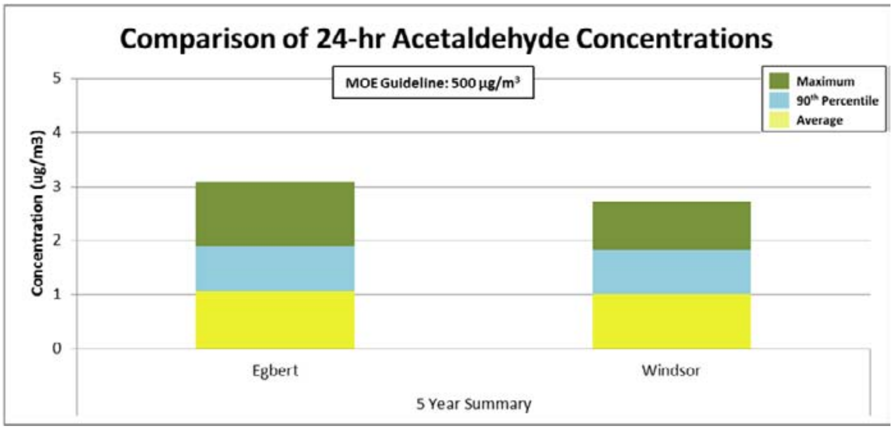
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Egbert Station.

Table 10: Comparison of Background Acrolein

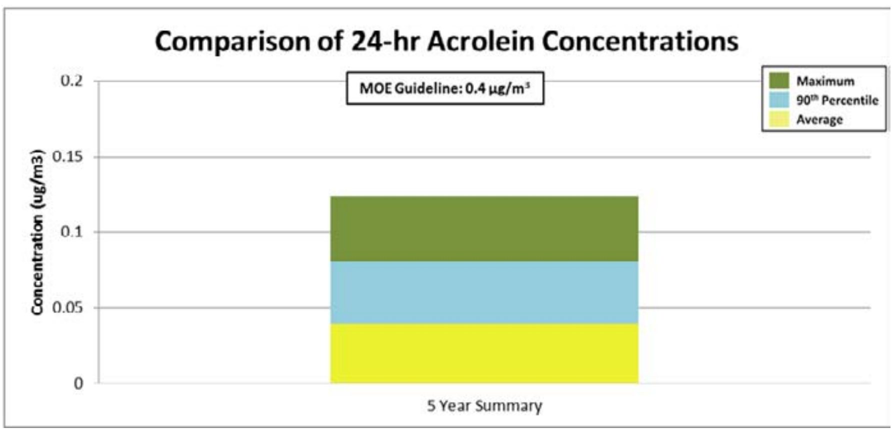
Statistical Analysis	Selection of Station
	**Conclusion:** Windsor is the only station at which ambient monitoring data for acrolein is collected.

Table 11: Comparison of Background Benzene

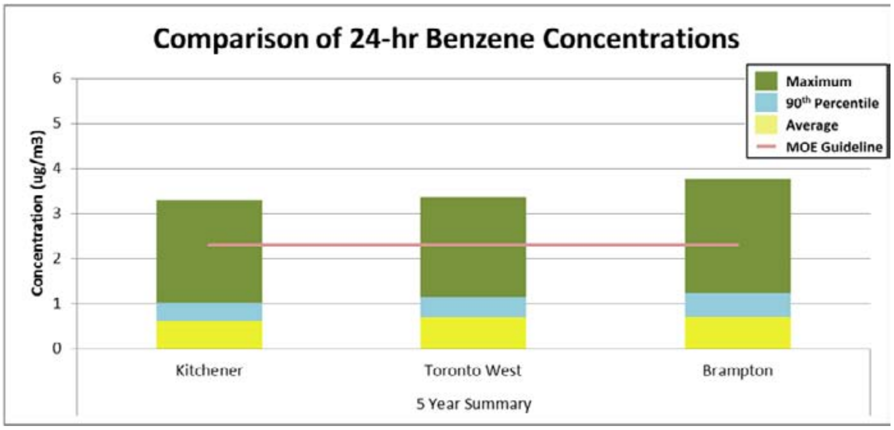
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Brampton Station.

Table 12: Comparison of Background 1,3-Butadiene

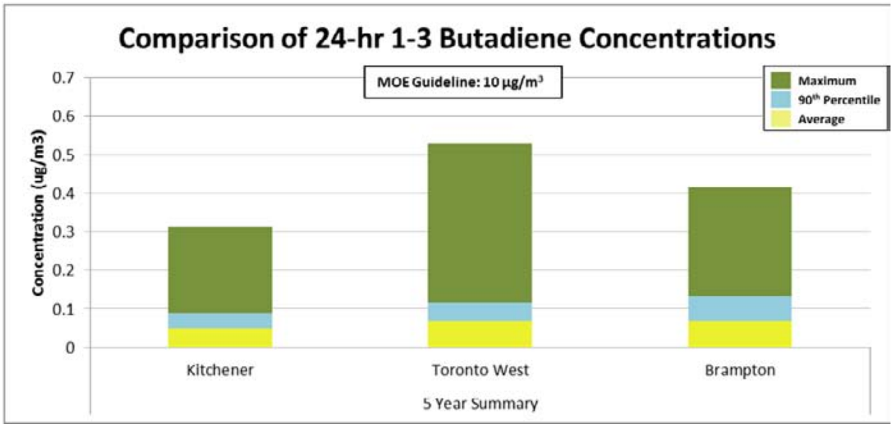
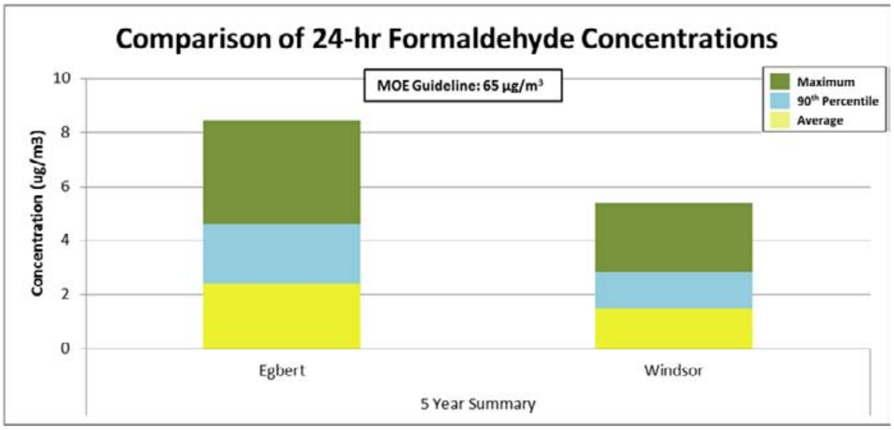
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Brampton Station.

Table 13: Comparison of Background Formaldehyde

Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Egbert Station.

2.3.4 Detailed Analysis of Selected Monitoring Stations

A detailed statistical analysis of the selected background monitoring station for each of the contaminants is presented below. Each site was summarized on a yearly basis and for the five year period. Where measurements exceeded the guideline, a frequency analysis was performed.

Table 14: Summary of Background NO_2

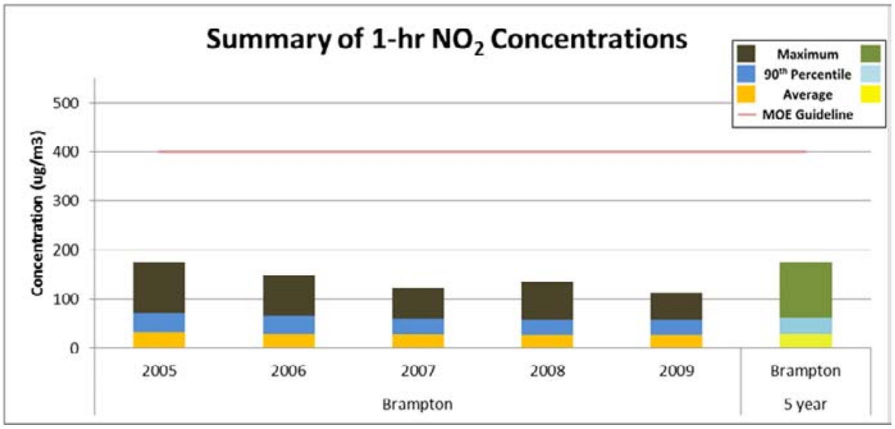
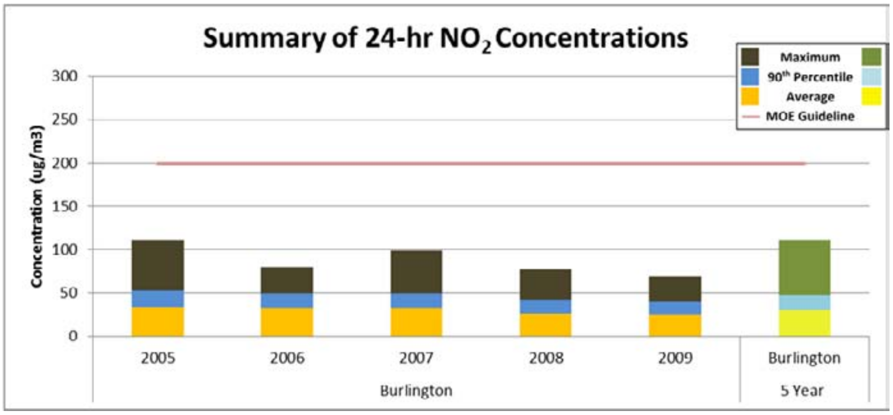
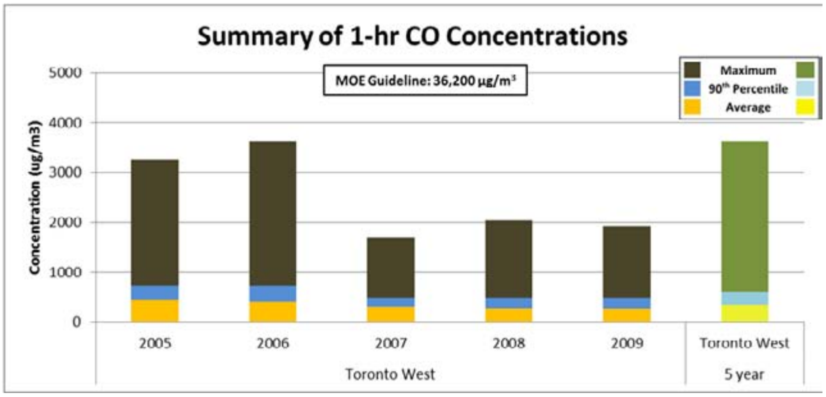
<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">
</td><th>Statistic</th><th>% of MOE Guideline</th></tr>
<tr><td>Maximum</td><td>44%</td></tr>
<tr><td>90th Percentile</td><td>15%</td></tr>
<tr><td>Average</td><td>7%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of ambient monitoring data from the Brampton Station indicated that background concentrations are well below the MOE Guideline on a 1-hour basis.</td></tr>
<tr><td rowspan="5">
</td><th>Statistic</th><th>% of MOE Guideline</th></tr>
<tr><td>Maximum</td><td>55%</td></tr>
<tr><td>90th Percentile</td><td>24%</td></tr>
<tr><td>Average</td><td>15%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of ambient monitoring data from the Brampton Station indicated that background concentrations are well below the MOE Guideline on a 24-hour basis.</td></tr>
</table>

Table 15: Summary of Background CO

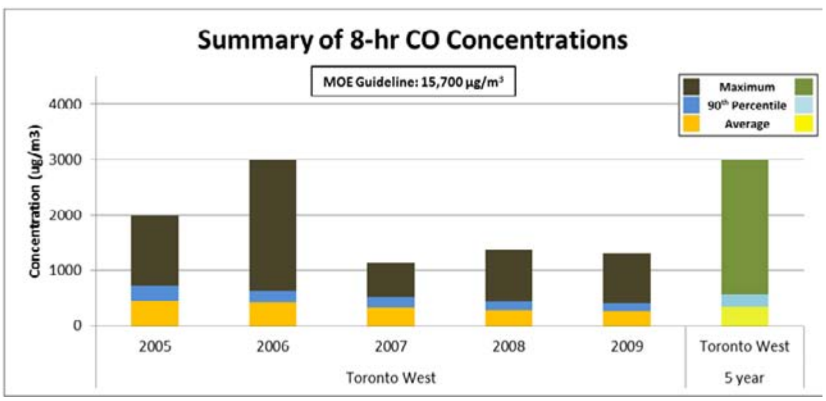
Statistical Analysis / Five Year Summary



Statistic	% of MOE Guideline
Maximum	10%
90th Percentile	2%
Average	1%

Conclusion:

A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the MOE guideline on a 1-hour basis.



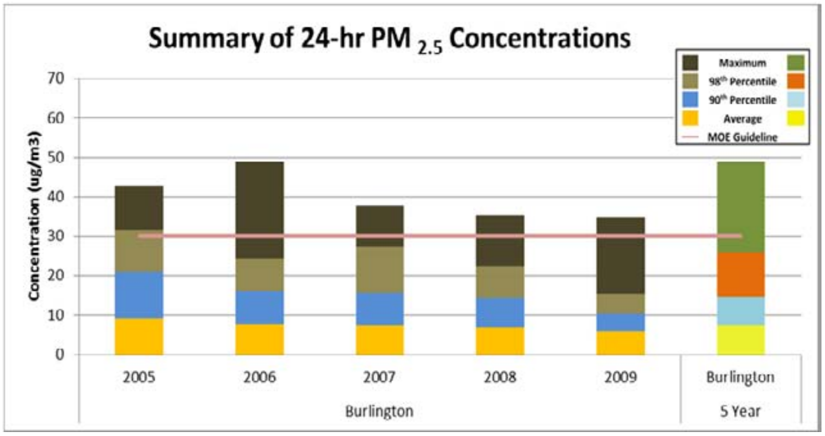
Statistic	% of MOE Guideline
Maximum	19%
90th Percentile	4%
Average	2%

Conclusion:

A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the MOE guideline on an 8-hour basis.

Table 16: Summary of Background $PM_{2.5}$

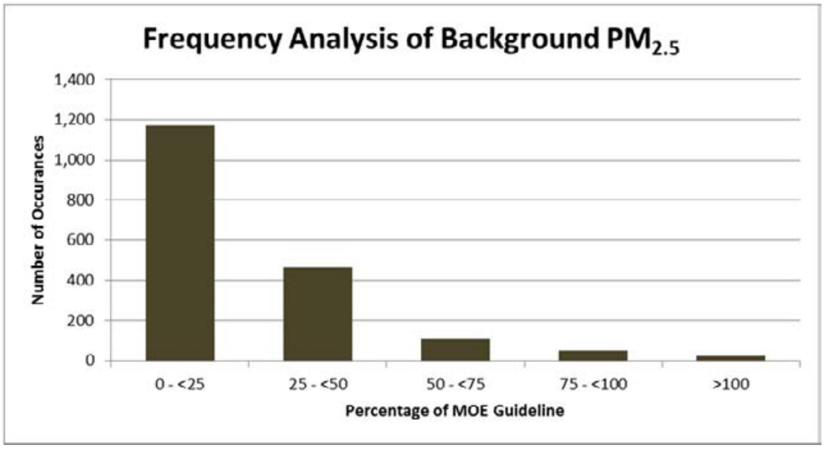
Statistical Analysis	Five Year Summary



Statistic	% of MOE Guideline
Maximum	163%
98th Percentile	87%
90th Percentile	49%
Average	24%

Conclusion:

A review of five years of ambient monitoring data from the Burlington Station indicated that the maximum background concentration exceeded the CWS on a 24-hour basis. However, the guideline for $PM_{2.5}$ is based on the 98th percentile value averaged over three consecutive years. Therefore, the highest 3 year average of 27.81 µg/m^{3} was below the guideline. However, frequency analysis was still conducted in order to show the number of days the background exceeded the guideline.



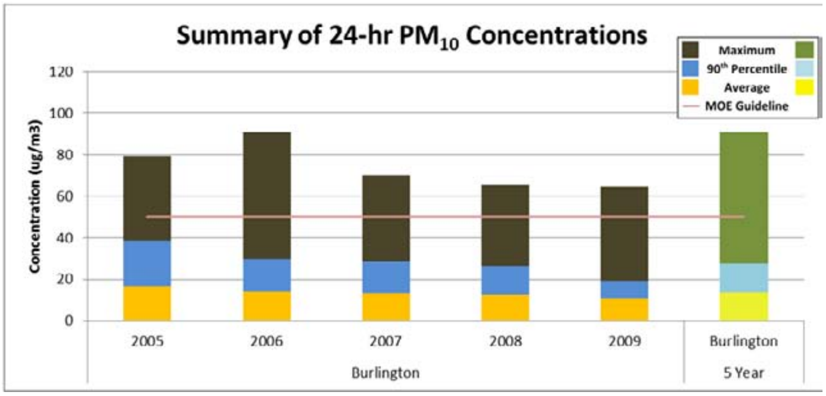
Number of Days Measured	Number of Days Exceeding MOE Guideline
1,818	23

Conclusion:

Frequency analysis determined that 24-hr concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the guideline 23 days over the 5 year period, with 11 days occurring in 2005. This means that the background concentration exceeded the guideline 1% of the time over the 5 year period.

Table 17: Summary of Background PM_{10}

Statistical Analysis



Note: PM_{10} is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54. (Lall et al., 2004)

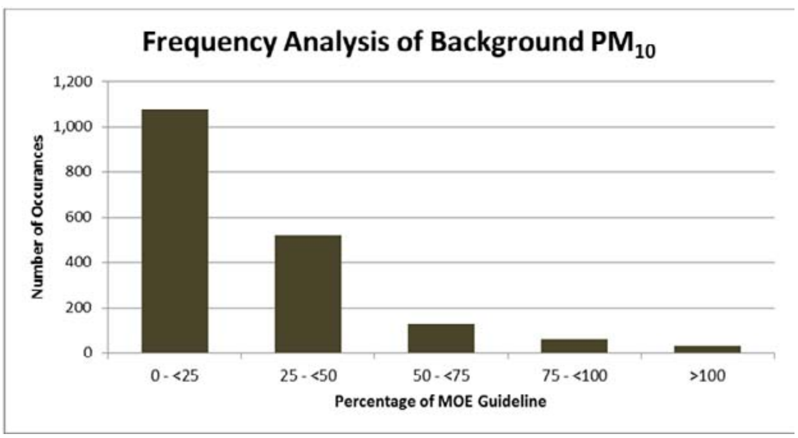
Five Year Summary

Statistic	% of MOE Guideline
Maximum	182%
90th Percentile	55%
Average	27%

Conclusion:

A review of five years of PM_{10} data calculated from $PM_{2.5}$ ambient monitoring data from the Burlington Station indicated that the estimated maximum background concentration exceeded the MOE guideline on a 24-hour basis. Therefore, frequency analysis was conducted to determine the number of days the estimated background exceeded the MOE guideline.

Statistical Analysis



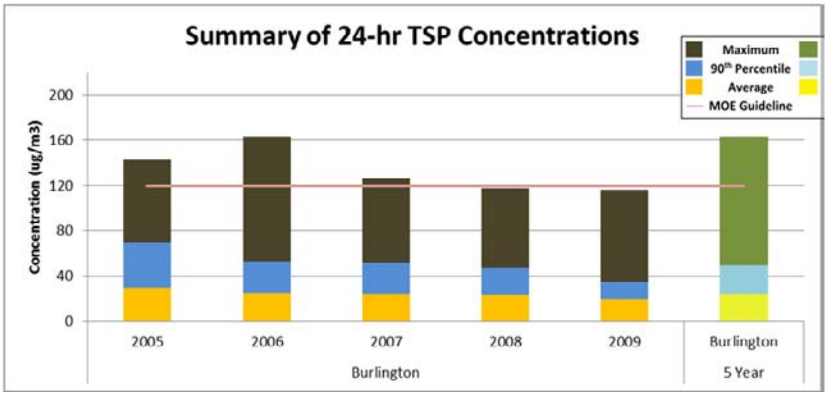
Five Year Summary

Number of Days Measured	Number of Days Exceeding MOE Guideline
1,818	30

Conclusion:

Frequency analysis determined that 24-hour concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the MOE guideline 30 days over the 5 year period, with 16 days occurring in 2005. This means that the background concentration exceeded the MOE guideline 2% of the time over the 5 year period.

Table 18: Summary of Background TSP

<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">

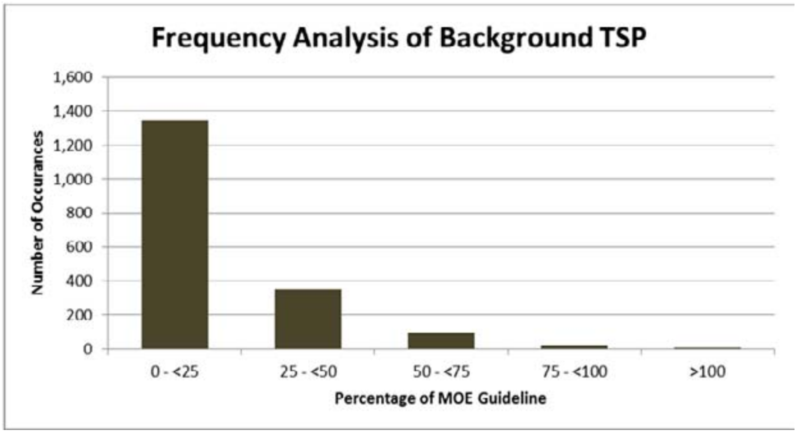
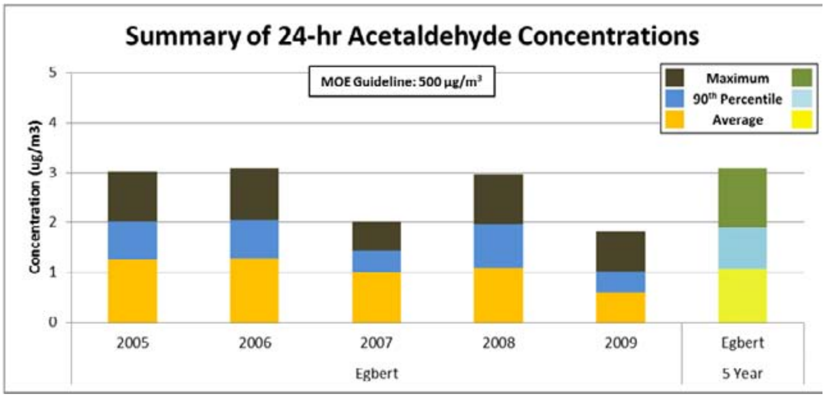
<u>Note:</u> TSP is not monitored in Ontario; therefore, background concentrations were estimated by applying a PM2.5/TSP ratio of 0.3. (Lall et al., 2004)</td><td>Statistic</td><td>% of MOE Guideline</td></tr>
<tr><td>Maximum</td><td>136%</td></tr>
<tr><td>90th Percentile</td><td>41%</td></tr>
<tr><td>Average</td><td>20%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of TSP data calculated from $PM_{2.5}$ ambient monitoring data from the Burlington Station indicated that the estimated maximum background concentration exceeded the MOE guideline on a 24-hour basis. Therefore, frequency analysis was conducted to determine the number of days the estimated background exceeded the guideline.</td></tr>
<tr><td rowspan="3">
</td><td>Number of Days Measured</td><td>Number of Days Exceeding MOE Guideline</td></tr>
<tr><td>1,818</td><td>6</td></tr>
<tr><td colspan="2">Conclusion:
Frequency analysis determined that 24-hour concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the MOE guideline 6 days over the 5 year period, with 3 days occurring in 2005. This means that the background concentration exceeded the MOE guideline <1% of the time over the 5 year period.</td></tr>
</table>

Table 19: Summary of Background Acetaldehyde

Statistical Analysis	Five Year Summary



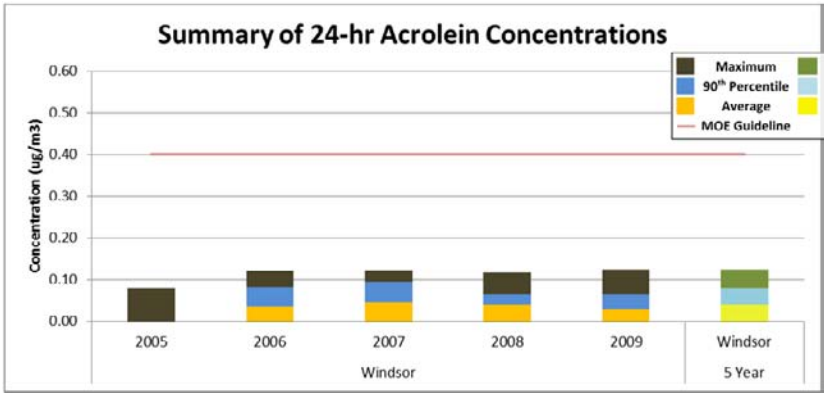
Statistic	% of MOE Guideline
Maximum	<1%
90th Percentile	<1%
Average	<1%

Conclusion:

A review of five years of data measured ambient monitoring data from the Egbert Station indicated that the maximum background concentration was well below the MOE guideline.

Table 20: Summary of Background Acrolein

Statistical Analysis	Five Year Summary



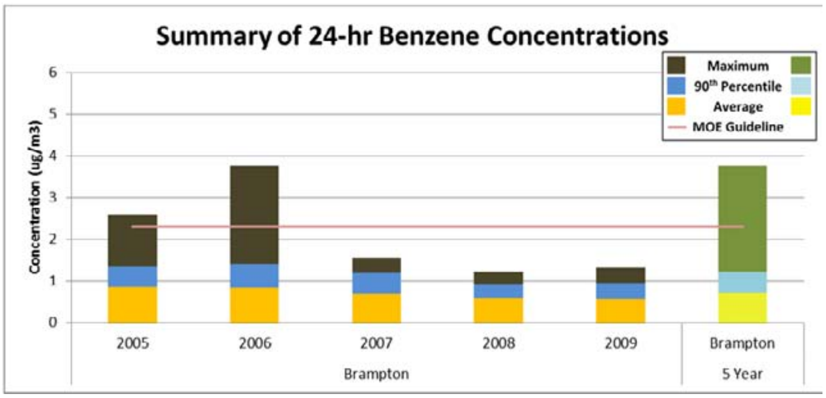
Statistic	% of MOE Guideline
Maximum	31%
90th Percentile	20%
Average	10%

Conclusion:

A review of five years of ambient monitoring data from the Windsor Station indicated that the maximum background concentration was well below the MOE guideline.

Table 21: Summary of Background Benzene

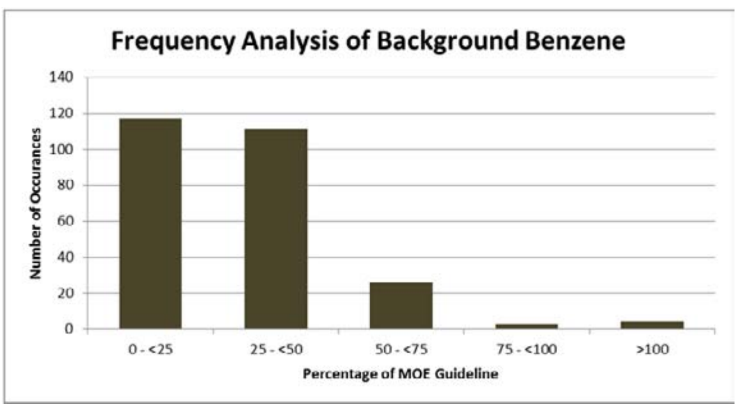
Statistical Analysis	Five Year Summary



Statistic	% of MOE Guideline
Maximum	164%
90th Percentile	53%
Average	31%

Conclusion:

A review of five years of ambient monitoring data from the Brampton Station indicated that the maximum background concentration exceeded the MOE guideline. Therefore, frequency analysis was conducted to determine the number of days the background exceeded the guideline.



Number of Days Measured	Number of Days Exceeding MOE Guideline
261	4

Conclusion:

Frequency analysis determined that concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the guideline 4 days over the 5 year period, with 3 days occurring in 2005. This means that the background concentration exceeded the MOE guideline 2% of the time over the 5 year period.

Table 22: Summary of Background 1,3-Butadiene

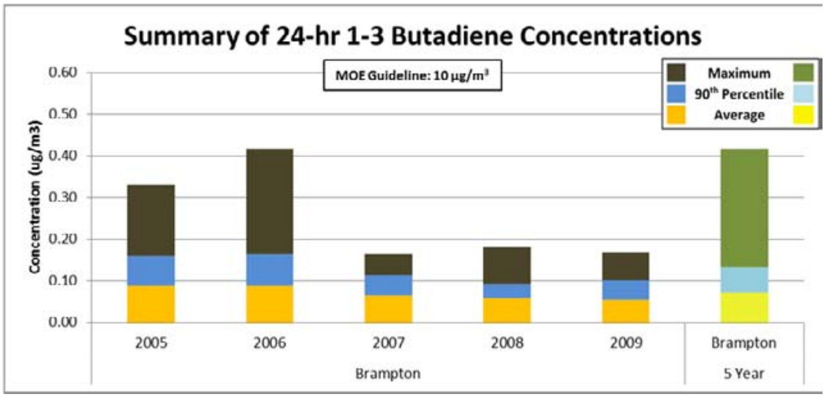
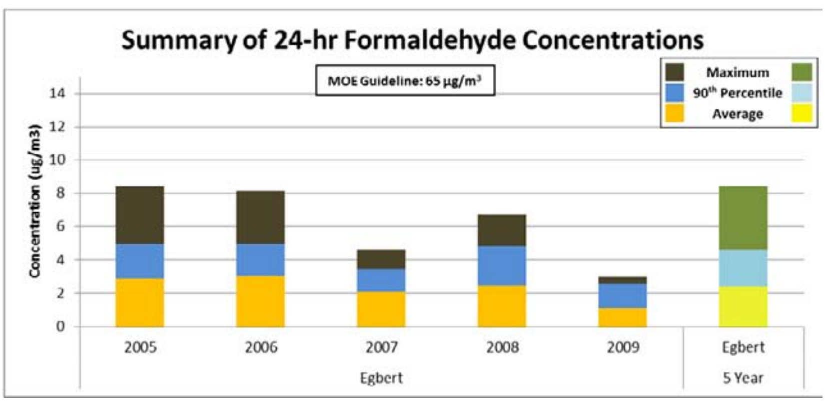
<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">
</td><th>Statistic</th><th>% of MOE Guideline</th></tr>
<tr><td>Maximum</td><td>4%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of ambient monitoring data from the Brampton Station indicated that the maximum background concentration was well below the MOE guideline.</td></tr>
</table>

Table 23: Summary of Background Formaldehyde

<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">
</td><th>Statistic</th><th>% of MOE Guideline</th></tr>
<tr><td>Maximum</td><td>13%</td></tr>
<tr><td>90th Percentile</td><td>7%</td></tr>
<tr><td>Average</td><td>4%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of ambient monitoring data from the Egbert Station indicated that the maximum background concentration was well below the MOE guideline.</td></tr>
</table>

2.3.5 Summary of Background Conditions

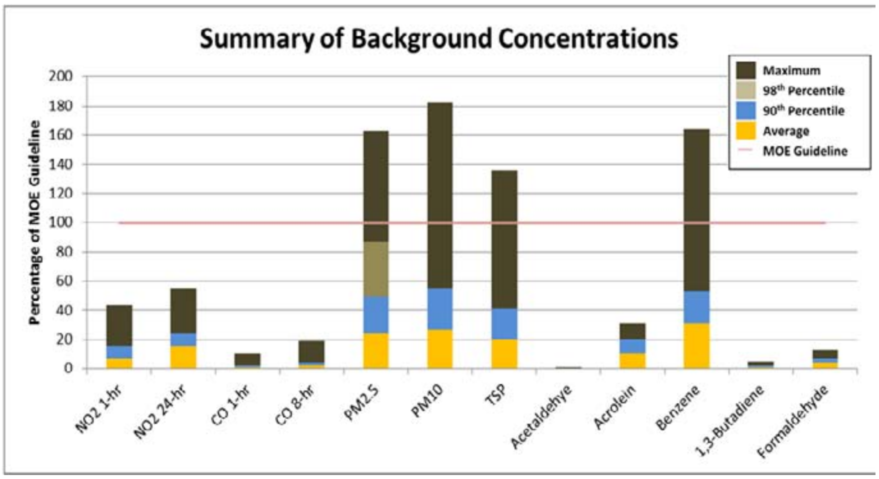
Based on a review of a Year 2005 to 2009 ambient monitoring dataset, all contaminants were below their respective MOE criteria with the exception of PM_{10}, TSP, and benzene. Benzene concentrations were based on actual measurements while PM_{10} and TSP concentrations were calculated based on their relationship to $PM_{2.5}$. It should be noted that even though the maximum concentration of $PM_{2.5}$ exceeded the CWS, the guideline for $PM_{2.5}$ is based on an average annual 98^{th} percentile concentration, averaged over 3 consecutive years. Therefore, it was determined that the maximum rolling 98^{th} percentile average was 27.81 $\mu g/m^3$, which is less than the guideline.

From a review of the VOC dataset, it was determined that due to the lack of hourly and daily background monitoring data, 90th percentile background concentrations for each VOC in the 5 year dataset would be calculated and used to determine the combined concentration. However, the summary of ambient monitoring data presented in this section provides the statistics for all available data. This method was suggested by the MOE.

A summary of the background concentrations as a percentage of their respective MOE guidelines or CWS is presented in the following figure. Also presented is the number of days that the monitoring data was above the MOE guideline or CWS.

Table 24: Statistical Summary of Background Concentrations

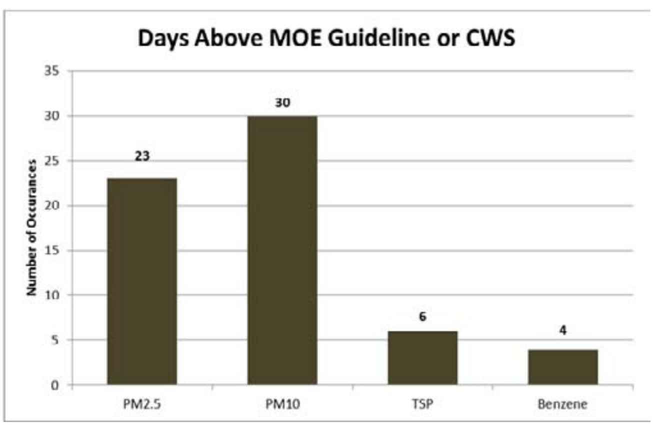
5 Year Statistical Summary | **% of Guideline**



Note: The $PM_{2.5}$ background concentration is in compliance with the CWS. The highest 3-year rolling average of the yearly 98th percentile concentration was calculated to be 27.81 µg/m^3 (2005-2007) or 93% of the standard.

Background:

NO_2 (1-hr)	44%
NO_2 (24-hr)	55%
CO (1-hr)	10%
CO (8-hr)	19%
$PM_{2.5}$	93%
PM_{10}	182%
TSP	136%
Acetaldehyde	<1%
Acrolein	31%
Benzene	164%
1,3-Butadiene	4%
Formaldehyde	13%



Days Above Guideline:

$PM_{2.5}$	23
PM_{10}	30
TSP	6
Benzene	4

2.4 Location of Sensitive Receptors Within The Study Area

Land uses which are defined as sensitive receptors for evaluating potential air quality effects are:

- Health care facilities;
- Senior citizens' residences or long-term care facilities;
- Child care facilities;
- Educational facilities;
- Places of worship; and
- Residential dwellings.

Seventy sensitive receptors were selected to represent worst-case impacts surrounding the project area along Dundas Street between Brant Street and Trafalgar Road. These sensitive receptors are summarized in **Table 25** and their locations on mapping are identified in**Figure 6** through **Figure 21**. In addition to sensitive receptors locations, the mapping also shows the existing scenario (i.e., aerial photograph) and the future build scenario in pink. Detailed figures showing each sensitive receptor's precise location in relation to the Roadway are presented in **Appendix A**. Distances in **Table 25** are measured from the Dundas Street edge of pavement to the closest façade of the sensitive receptor. Sensitive receptors adjacent to intersections are also measured from the Dundas Street edge of pavement and not from the side roads.

Table 25: Representative Worst-Case Sensitive Receptors

Receptor Number	Land-Use	Distance From Dundas Street at 6 Lanes (m)
R1	Residential	50
R2	Residential	25
R3	Residential	65
R4	Residential	27
R5	Residential	55
R6	Place of Worship	70
R7	Place of Worship	6
R8	Residential	24
R9	Residential	60
R10	Residential	55
R11	Residential	16
R12	Residential	55
R13	Residential	35
R14	Residential	53
R15	Residential	26
R16	Child Care Facility	23
R17	Residential	17
R18	Residential	12
R19	Residential	18
R20	Residential	15

Receptor Number	Land-Use	Distance From Dundas Street at 6 Lanes (m)
R21	Residential	12
R22	Residential	22
R23	Residential	13
R24	Residential	46
R25	Residential	40
R26	Residential	54
R27	Residential	14
R28	Residential	22
R29	Residential	16
R30	Residential	108
R31	Residential	15
R32	Residential	22
R33	Residential	17
R34	Residential	45
R35	Residential	15
R36	Residential	48
R37	Place of Worship	55
R38	Place of Worship	16
R39	Residential	22
R40	Residential	16
R41	Residential	35
R42	Place of Worship	4
R43	Residential	92
R44	Residential	42
R45	Residential	25
R46	Residential	27
R47	Residential	26
R48	Residential	25
R49	Residential	30
R50	Residential	24
R51	Residential	30
R52	Residential	25
R53	Residential	18
R54	Residential	33
R55	Residential	32
R56	Residential	22
R57	Residential	38
R58	Residential	372
R59	Residential	278
R60	Child Care Facility	415
R61	Educational Facility	164
R62	Residential	267

Receptor Number	Land-Use	Distance From Dundas Street at 6 Lanes (m)
R63	Residential	230
R64	Residential	25
R65	Residential	23
R66	Residential	19
R67	Residential	20
R68	Residential	18
R69	Residential	45
R70	Child Care Facility	18

Representative worst-case impacts will be predicted by the dispersion model at the sensitive receptors closest to the roadway. This is due to the fact that contaminant concentrations disperse significantly with downwind distance from the motor vehicles resulting in reduced contaminant concentrations. At approximately 500 m from the roadway, contaminant concentrations from the motor vehicles generally become indistinguishable from background levels. The maximum predicted contaminant concentrations at the closest sensitive receptors will usually occur during weather events which produce calm to light winds (< 3 m/s). During weather events with higher wind speeds, the contaminant concentrations disperse much more quickly.

Figure 6: Sensitive Receptors R1 to R6 and R62

Figure 7 : Sensitive Receptors R7 to R14, R60 and R61

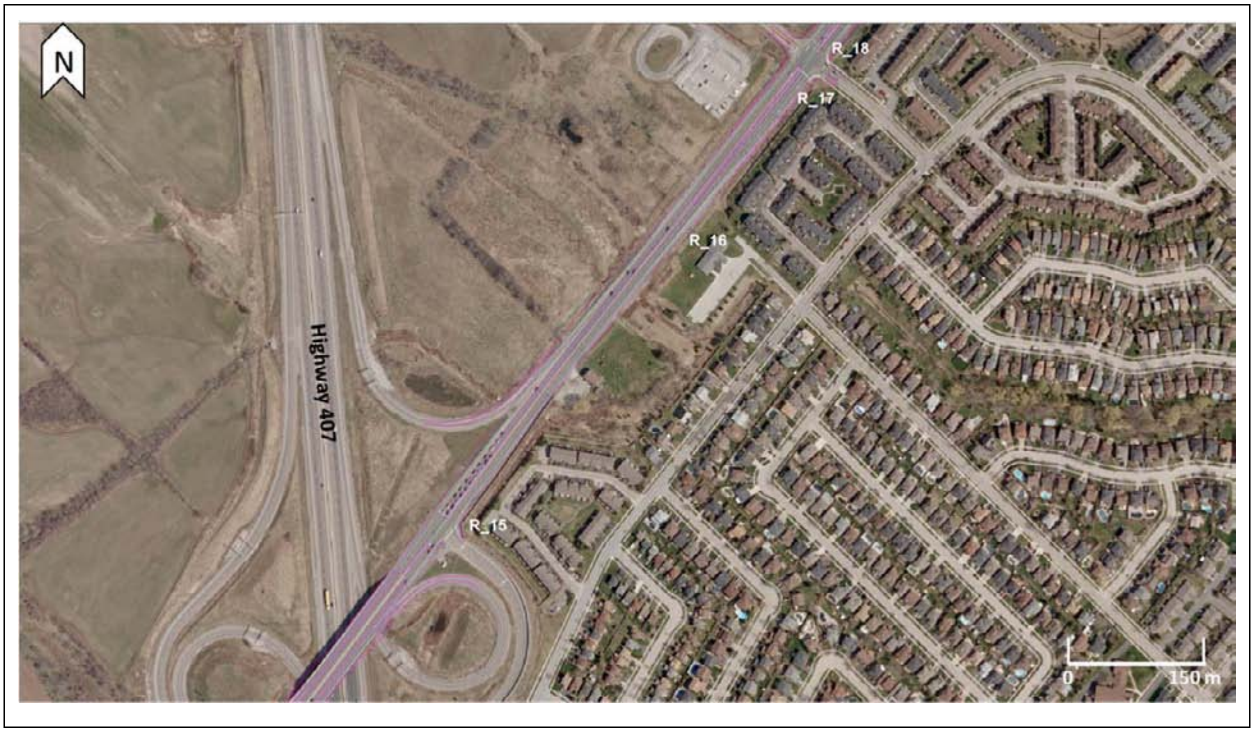


Figure 8 : Sensitive Receptors R15 to R18

Figure 9: Sensitive Receptors R19 to R23

Figure 10: Sensitive Receptors R24 to R29

Figure 11: Sensitive Receptors R30 to R31

Figure 12: Sensitive Receptors R32 to R33

Figure 13: Sensitive Receptors R34 to R36

Figure 14: Sensitive Receptors R37 to R43

Figure 15: Sensitive Receptors R44 to R47 and R59

Figure 16: Sensitive Receptors R48 to R51

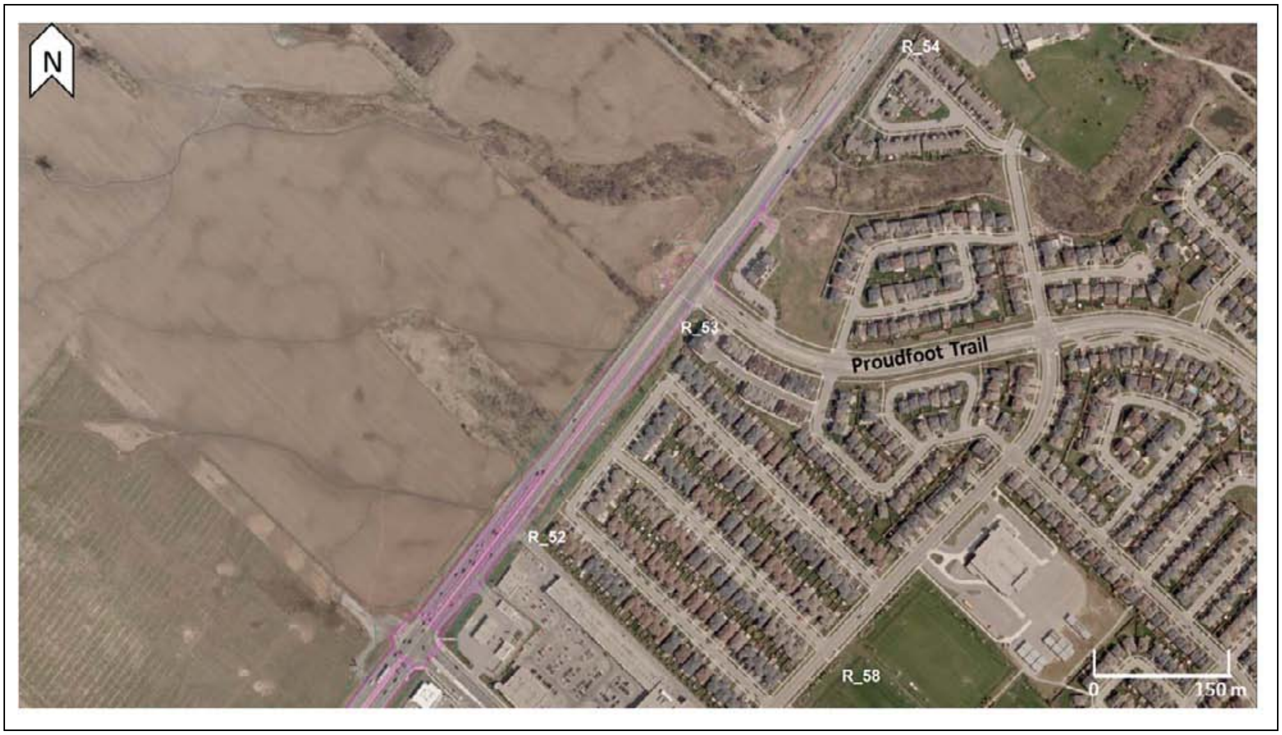


Figure 17: Sensitive Receptors R52 to R54 and R58

Figure 18: Sensitive Receptors R55 to R57

Figure 19: Sensitive Receptors R63 to R65

Figure 20: Sensitive Receptors R66 to R67

Figure 21: Sensitive Receptors R68 to R70

2.5 Road Traffic Data

Existing (Year 2011) road traffic volumes were provided by MRC. Traffic data was provided in the form of hourly movement counts from every intersection along the study area. AM and PM peak factors were used to obtain AADT (annual average daytime traffic) values from the movement counts which were used in the traffic assessment. Hourly traffic distributions as well as Eastbound and Westbound distributions were estimated from turning counts made for an entire day, presented in 15 minute increments. Future traffic volumes were predicted by applying a growth factor to the hourly data and assuming that the peak hour conversion rates remained the same from 2011, as directed by MRC. The growth factor used was 1.5 times the current traffic volumes on the off-peak direction with no growth in the peak direction. For example, Eastbound AM traffic is assumed to already be at the roadways capacity while Westbound traffic was multiplied by 1.5 to convert from 2011 to 2031 traffic volumes. A similar approach was taken for PM traffic data with the Eastbound traffic being considered off-peak. The traffic data used in the assessment are summarized in the following tables.

Table 26: Existing (2011) and Future Build (2031) Traffic Patterns for Dundas Street

Section	2011 AADT's		2031 AADT's	
	Eastbound	Westbound	Eastbound	Westbound
Brant Street to Eaglesfield Drive	16203	13341	18498	15207
Eaglesfield Drive to Blackwood Street	15218	13084	17265	14853
Blackwood Street to Guelph Line	15700	13569	17853	15498
Guelph Line to Hwy 407	17582	15192	20074	17242
Hwy 407 to Northampton Boulevard	17614	16121	21243	19269
Northampton Boulevard to Walkers Line	18489	15967	22052	18767
Walkers Line to Berwick Drive	17546	15237	20614	17961
Berwick Drive to Weslock Drive	19634	17551	22896	20442
Weslock Drive to Millcroft Park Drive	20627	17196	24033	19917
Millcroft Park Drive to Appleby Line	21301	18854	23914	21911
Appleby Line to Sutton Drive	20354	19953	22995	23529
Sutton Drive to Tremaine Road	20185	17844	22549	20460
Tremaine Road to Zenon Road	19165	17285	21491	19662
Zenon Road to Valleyridge Drive	20901	18393	23904	10714
Valleyridge Crive to Bronte Road	19977	15970	22847	18237
Bronte Road to Postmaster Drive	17258	15814	20108	18818
Postmaster Drive to Third Line	17058	14791	19656	17270
Third Line to Proudfoot Trail	20418	17567	23481	19923
Proudfoot Trail to Fourth Line	25420	19459	29526	21989
Fourth Line to Lions Valley Park Road	24612	17903	28700	20660
Lions Valley Park Road to Neyagawa Boulevard	22961	18232	26630	21492
Neyagawa Boulevard to Towne Boulevard	15575	13280	18257	15920
Towne Boulevard to Harman Gate	16499	14258	19099	16722
Harman Gate to Sixth Line	18777	14978	21493	17391
Sixth Line to Oak Park Boulevard	17393	15491	19885	17845
Oak Park Boulevard to Trafalgar Road	18260	14317	21303	16815

Also provided by MRC were the combined direction bus volumes for the peak hour, split into two sections of the roadway: From Brant Street to Third Line and from Third Line to Trafalgar Road. The bus volumes provided for this assessment are presented in **Table 27**. The bus lane traffic volumes were processed the same way as the roadway traffic volumes to convert from peak hour to AADT values, as discussed above.

Table 27: Future (2031) Bus Lane Traffic Volumes

Section	2031 Peak Hour Bus Volume (Combined Direction)
Brant Street to Third Line	6
Third Line to Trafalgar Rd	18

Vehicle fleet distribution was provided by MRC in the form of medium and heavy duty percentages of 1.1% and 2.2%, respectively. Hourly traffic distributions were derived from the 15 minute traffic counts provided by MRC. These hourly traffic volumes were used to determine average hourly traffic distributions for Dundas Street as well as the side streets, which were applied in the dispersion model. These distributions are shown in the table below.

Table 28: Hourly Traffic Distributions

Hour	Eastbound (%)	Westbound (%)
1	0.95%	1.55%
2	0.37%	0.83%
3	0.18%	0.30%
4	0.13%	0.20%
5	0.24%	0.16%
6	0.56%	0.16%
7	2.68%	0.49%
8	8.79%	1.86%
9	11.88%	3.84%
10	9.23%	5.17%
11	6.71%	4.06%
12	4.98%	3.74%
13	4.92%	4.35%
14	4.83%	4.69%
15	4.77%	5.23%
16	4.92%	6.90%
17	5.26%	9.72%
18	6.12%	11.19%
19	6.93%	11.11%
20	5.68%	8.82%
21	3.82%	5.68%
22	2.48%	4.47%
23	2.08%	3.26%
24	1.50%	2.21%

Signal timing for the intersections was also provided by MRC. Signal timing was provided in two sections: all intersections East of Tremaine Road and all intersections West of Tremaine Road. These Timings are shown in **Table 29**. For the actuated side-street signals 25% to 45% green light timing was provided. To assess the most conservative conditions it was assumed that all side streets had 45% of green light time.

Table 29: Signal Times for Dundas Street

	AM Cycle Length (s)	PM Cycle Length	Red Light Time (s)	Clearance Lost Time (s)
East of Tremaine Road	120	120	54	2
West of Tremaine Road	180	150	81(AM); 67.5(PM)	2

2.6 Assessment Approach

2.6.1 General Approach

The general assessment approach was as follows:

1) Concentrations from Dundas Street at the representative receptors were predicted using modelling software on an hourly basis for a five-year period, using 2005-2009 meteorological data from Toronto Pearson International Airport.
2) Hourly ambient concentrations for all available contaminants were determined from MOE and NAPS datasets for the most representative locations.
3) Combined concentrations were determined by adding modelled and background (i.e., ambient data) together on an hourly basis. For ambient data which was not available in hourly form (VOC's), predicted roadway concentrations were added to the 90^{th} percentile of the aggregated data described above.
4) Maximum 1-hour, 8-hour and 24-hour predicted combined concentrations were determined for comparison with the applicable guidelines.

Computer simulations to determine project impacts were conducted using emission and dispersion models published by the U.S. Environmental Protection Agency (U.S. EPA).

2.6.2 Meteorological Data

2005-2009 hourly meteorological data was obtained from Toronto Pearson International Airport and upper air data was obtained from the Buffalo Niagara International Airport. The combined data was processed using Lakes Environmental's PCRAMMET software program which prepares meteorological data for use with the CAL3QHCR model. A wind frequency diagram (wind rose) is shown in **Figure 22**. As can be seen in this figure, predominant winds are from the southwesterly through northerly directions.

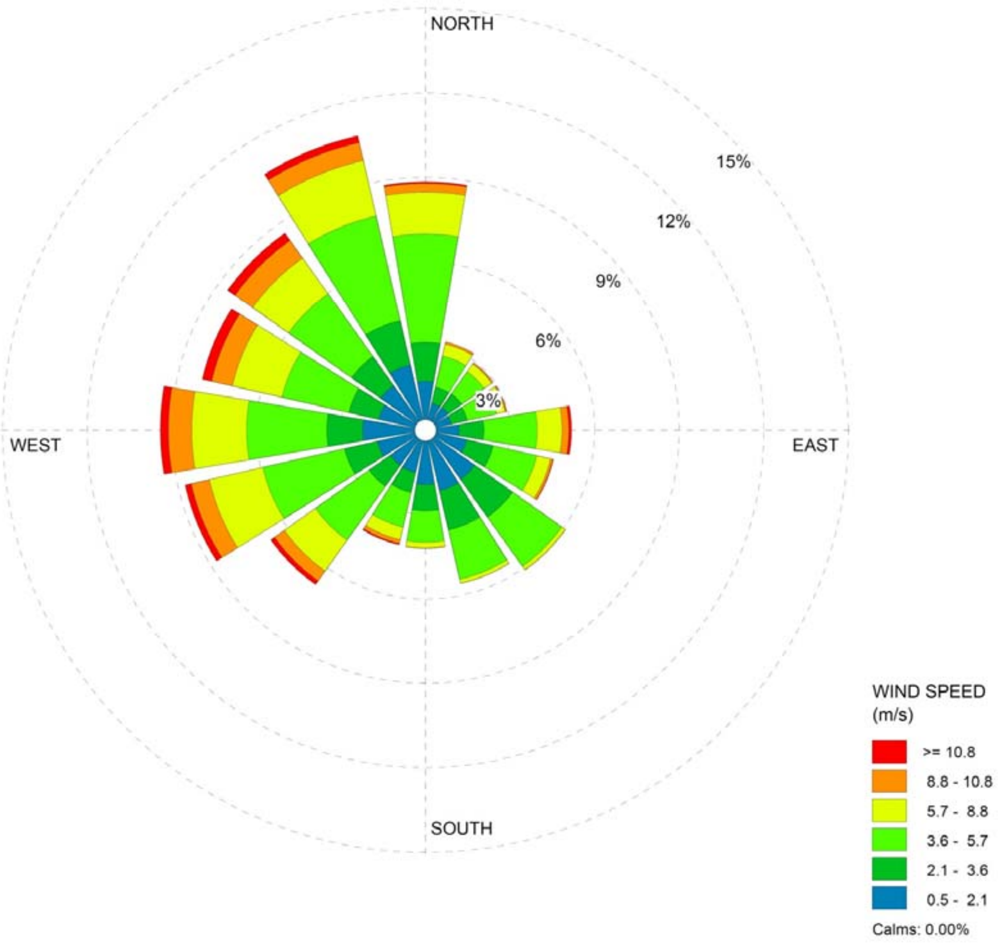


Figure 22: Wind Frequency Diagram for Toronto Pearson Airport

2.6.3 Motor Vehicle Emission Rates

MOVES is a computer program that provides estimates of current and future emission rates from motor vehicles based on a variety of factors such as local meteorology and vehicle fleet composition. MOVES 2010a, released in August 2010, is the U.S. EPA's latest tool for estimating vehicle emissions due to the combustion of fuel, brake and tire wear, fuel evaporation, permeation and refuelling leaks. The model is based on "an analysis of millions of emission test results and considerable advances in the Agency's understanding of vehicle emissions and… accounts for changes in emissions due to proposed standards and regulations". For this project, MOVES was used to estimate vehicle emissions based on vehicle type, road type, model year, and vehicle speed. **Table 30** specifies the major inputs into MOVES.

Table 30: MOVES Input Parameters

Parameter	Input
Scale	Custom County Domain
Meteorology	The following values were obtained from meteorological data from Toronto Pearson International Airport for the years 2005 to 2009. Temperature; Relative humidity;
Years	2011 (existing) and 2031 (future build)
Geographical Bounds	Custom County Domain
Fuels	Compressed Natural Gas / Diesel Fuels / Gasoline Fuels Note that MOVES assumes a default distribution for each fuel type within the vehicle class.
Source Use Types	Combination Long-haul Truck / Combination Short-haul Truck / Intercity Bus / Light Commercial Truck / Motor Home / Motorcycle / Passenger Car / Passenger Truck / Refuse Truck / School Bus / Single Unit Long-haul Truck / Single Unit Short-haul Truck / Transit Bus
Road Type	Rural Unrestricted Access
Pollutants and Processes	NO_2 / CO / $PM_{2.5}$ / PM_{10} / Acetaldehyde / Acrolein / Benzene / 1,3-Butadiene / Formaldehyde. TSP can't be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.
Vehicle Age Distribution	MOVES defaults based on years selected.

Upon processing of the MOVES outputs, the worst-case emission rates (highest monthly value) were used for input into the dispersion model. **Table 31** and **Table 32** present the outputted emission factors for the entire vehicle fleet based on the provided medium and heavy duty percentages, 1.1% and 2.2%, respectively. These values were modelled on the existing lanes on Dundas Street in 2011 and 2031. **Table 33** presents the outputted emission rates for the buses only, which were modelled on the proposed bus lanes in 2031.

Table 31: MOVES Output Emission Factors for Year 2011 (g/VMT)

Contaminant	Speed (km/hr)						
	Idle	30	40	50	60	70	80
NO_2	0.8691	0.1419	0.1241	0.1145	0.1083	0.1058	0.1038
CO	46.07	7.6731	5.7271	5.3410	4.9446	4.4337	4.2865
$PM_{2.5}$ Total	0.3472	0.0674	0.0498	0.0445	0.0381	0.0325	0.0297
PM_{10} Total	0.3677	0.1140	0.0840	0.0717	0.0598	0.0466	0.0405
TSP[1]	0.3677	0.1140	0.0840	0.0717	0.0598	0.0466	0.0405
Acetaldehyde	0.0476	0.0044	0.0031	0.0027	0.0025	0.0021	0.0019
Acrolein	0.00291	0.00034	0.00025	0.00018	0.00015	0.00014	0.00012
Benzene	0.0971	0.0090	0.0065	0.0057	0.0050	0.0042	0.0039
1,3-Butadiene	0.01599	0.00142	0.00102	0.00089	0.00079	0.00067	0.00062
Formaldehyde	0.06464	0.00561	0.00389	0.00340	0.00306	0.00259	0.00240

1 – Note that TSP cannot be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

Table 32: Vehicle Fleet MOVES Output Emission Factors for Year 2031 (g/VMT)

Contaminant		Speed (km/hr)					
	Idle	30	40	50	60	70	80
NO_2	0.3711	0.0550	0.0506	0.0480	0.0441	0.0445	0.0435
CO	13.1241	4.3048	3.6191	3.4848	3.1534	2.9081	2.8349
$PM_{2.5}$ Total	0.1854	0.0355	0.0307	0.0266	0.0228	0.0195	0.01798
PM_{10} Total	0.2005	0.0740	0.0648	0.0536	0.0437	0.0332	0.0283
TSP[1]	0.2005	0.0740	0.0648	0.0536	0.0437	0.0332	0.0283
Acetaldehyde	0.0066	0.0010	0.0009	0.0008	0.0007	0.0006	0.0005
Arolein	0.00032	0.00005	0.00004	0.00004	0.00003	0.00003	0.000023
Benzene	0.0126	0.0023	0.0020	0.0018	0.0015	0.0013	0.0012
1,3-Butadiene	0.00206	0.00033	0.00029	0.00026	0.00022	0.00019	0.00017
Formaldehyde	0.00707	0.00100	0.00086	0.00077	0.00066	0.00055	0.00051

1 – Note that TSP cannot be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

Table 33: Transit Bus MOVES Output Emission Factors for Year 2031 (g/VMT)

Contaminant	Speed (km/hr)	
	Idle	60
NO_2	6.09	0.376
CO	5.14	1.46
$PM_{2.5}$ Total	0.221	0.0350
PM_{10} Total	0.228	0.0819
TSP[1]	0.228	0.0819
Acetaldehyde	0.163	0.001
Acrolein	0.00198	0.000121
Benzene	0.00733	0.000697
1,3-Butadiene	0.00353	0.000232
Formaldehyde	0.0425	0.00234

2.6.4 Re-suspended Particulate Matter Emission Rates

A large portion of roadway particulate matter emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the roadway. These emissions are estimated using empirically derived values presented by the U.S. EPA in their AP-42 report. The emissions factors for re-suspended particulate matter were estimated by using the following equation from U.S. EPA's Document AP-42 report, Chapter 13.2.1.3 and are summarized in **Table 34**:

$$E = k(sL)^{0.91} * (W)^{1.02}$$

Where: E = the particulate emission factor

K = the particulate size multiplier

sL = silt loading

W = average vehicle weight (Assumed 3 Tons based on Toyota fleet data and US EPA vehicle weight and distribution)

Table 34: Re-suspended Particulate Matter Emission Factors

Roadway AADT	K ($PM_{2.5}$/PM_{10}/TSP)	sL (g/m^3)	W (Tons)	E (g/VMT)		
				$PM_{2.5}$	PM_{10}	TSP
<500	0.25/1.0/5.24	0.6	3	0.503	2.015	10.561
500-5,000	0.25/1.0/5.24	0.2	3	0.185	0.741	3.886
5,000-10,000	0.25/1.0/5.24	0.06	3	0.061	0.247	1.299
>10,000	0.25/1.0/5.24	0.015	3	*0.033*	0.132	0.691

2.6.5 Air Dispersion Modelling Using CAL3QHCR

The U.S. EPA's CAL3QHCR dispersion model, based on the Gaussian plume equation, was specifically designed to predict air quality impacts from roadways using site specific meteorological data, vehicle emissions, traffic data, and signal data. The model input requirements include roadway geometry, sensitive receptor locations, meteorology, traffic volumes and motor vehicle emission rates as well as some contaminant physical properties such as settling and deposition velocities. CAL3QHCR uses this information to calculate hourly concentrations which are then used to determine 1-hour, 8-hour and 24-hour averages for the contaminants of interest at the identified sensitive receptor locations. **Table 35** provides the major inputs used in CAL3QHCR. The emission rates used in the model were the outputs from the MOVES and AP-42 models, weighted for the medium and heavy-duty fleet percentages provided. The outputs of CAL3QHCR are presented in the results section.

Table 35: CAL3QHCR Model Input Parameters

Parameter	Input
Free-Flow Link Traffic Data	Hourly traffic distributions were applied to the AADT traffic volumes in order to input traffic volumes in vehicles/hour. Emission rates from the MOVES output were inputted in grams/VMT.
Queue Link Traffic Data	Average signal cycle length: 120 s/150 s/180 s Average red time length: 54 s/67.5 s/81 s Clearance lost time: 2 s Approach traffic volume: hourly AADT values, as described above Idle emission factor: output from MOVES, in grams/hour Saturation flow rate: 1600 vehicles/hour (default value) Signal type: Actuated Arrival type: Average Progressing
Meteorological Data	2005-2009 data from Toronto Pearson International Airport
Deposition Velocity	$PM_{2.5}$: 0.08 cm/s PM_{10}: 0.2 cm/s TSP: 0.15 cm/s NO_2: 0.1 cm/s CO: 0.03 cm/s VOC's: 0 cm/s[3]
Settling Velocity	$PM_{2.5}$: 0.02 cm/s PM_{10}: 0.3 cm/s TSP: 1.8 cm/s CO, NO_2, and VOC's: 0 cm/s
Surface Roughness	The land type surrounding the project site is categorized as 'Low Intensity Residential'. The average surface roughness for all seasons of 52 cm was applied in the model.
Vehicle Emission Rate	Emission rates calculated in MOVES and AP-42 were inputted in g/VMT

2.7 Detailed Modelling Results

Presented below are the modelling results for the existing and future build scenarios, based on 5 years of meteorological data. For each CAC and VOC contaminant, combined concentrations are presented along with the relevant contribution due to the background and roadway. Results in this section are presented for the worst-case sensitive receptor (see **Table 36**), which was identified as the maximum combined concentration for the future build scenario. Results for all modelled receptors are provided in **Appendix A**. A maximum $PM_{2.5}$ concentration contour plot and concentration profiles for each contaminant are provided for a worst-case section of the Dundas Street in order to graphically display results. These figures present concentrations from the roadway only, and are exclusive of background concentrations. These plots show how contaminant concentration decreases as a function of distance from the roadway. It should be noted that the maximum roadway concentration at any sensitive receptor often occurs infrequently and actually may only occur for one hour or day over the 5 year period.

Table 36: Worst-Case Sensitive Receptor for 2031 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	R42
	24-hour	R21
CO	1-hour	R42
	8-hour	R17
$PM_{2.5}$	24-hour	R70
PM_{10}	24-hour	R70
TSP	24-hour	R70
Acetaldehyde	24-hour	R21
Acrolein	24-hour	R21
Benzene	24-hour	R21
1,3-Butadiene	24-hour	R21
Formaldehyde	24-hour	R21

2.7.1 Criteria Air Contaminants

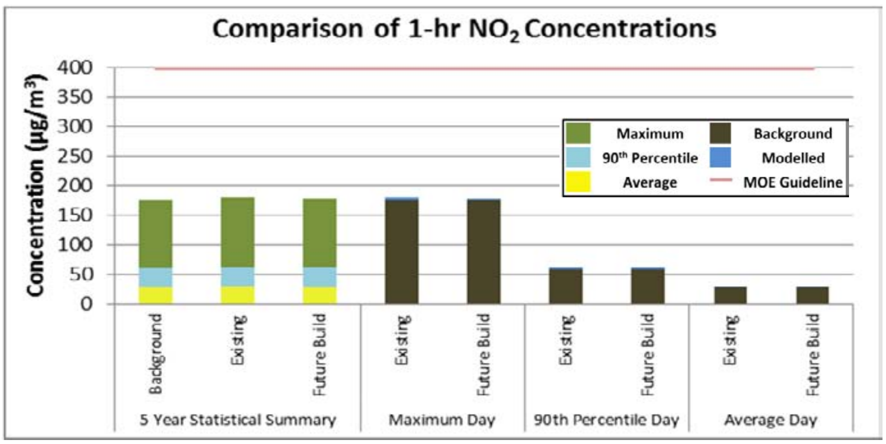
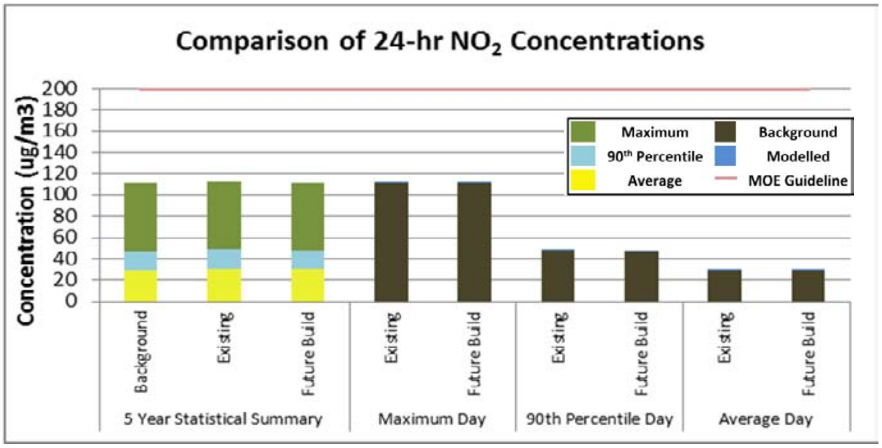
Coincidental hourly modelled Roadway and background CAC concentrations were added to derive the combined concentration for each hour over a 5 year period. Statistical analysis in the form of maximum, 90^{th} percentile, and average combined concentrations were calculated for the worst-case sensitive receptor for each contaminant and are presented below. The maximum combined concentration was then used to assess compliance with MOE guidelines or CWS. If excesses of the guideline were predicted, frequency analysis was undertaken in order to estimate the number of occurrences above the guideline. Provided below are the modelling results for the CACs: CO, NO_2, $PM_{2.5}$, PM_{10} and TSP.

2.7.1.1 Nitrogen Dioxide

Table 37 presents the combined concentrations for 1-hour and 24-hour NO_2 based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *Both the maximum 1-hour and 24-hour NO_2 combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 37: Summary of Existing and 2031 Future Build NO_2

Statistical Analysis	5 Year Summary of Future Build	
	**% of MOE Guideline:**	
	Maximum	45%
	90th Percentile	16%
	Average	7%
	Roadway Contribution:	
	Maximum	1%
	90th Percentile	5%
	Average	1%
	Change from Existing Scenario:	
	Maximum	-1%
	90th Percentile	-1%
	Average	-1%
	**% of MOE Guideline:**	
	Maximum	56%
	90th Percentile	24%
	Average	15%
	Roadway Contribution:	
	Maximum	1%
	90th Percentile	4%
	Average	2%
	Change from Existing Scenario:	
	Maximum	-1%
	90th Percentile	No change
	Average	-1%

Conclusions:

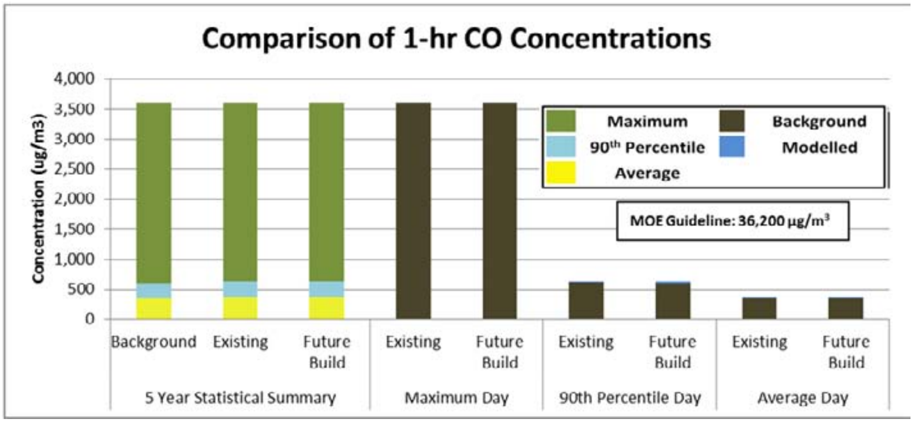
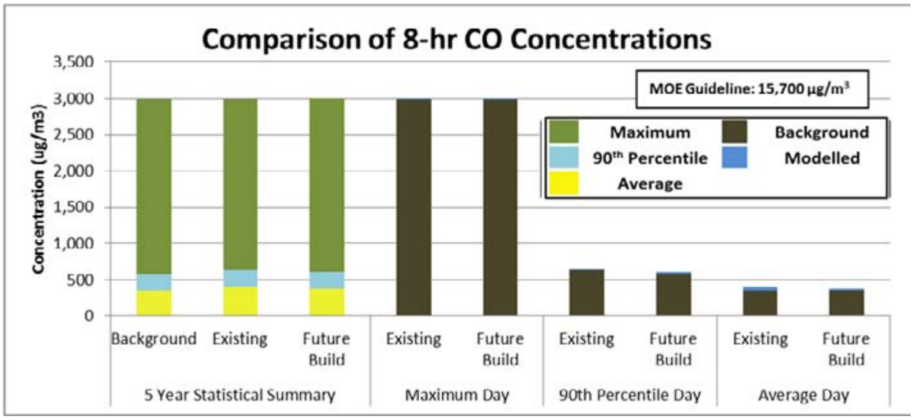
- All combined concentrations were below their respective MOE guidelines.
- The contribution from the roadway to the combined concentrations was 5% or less.
- There was an improvement of approximately 1% from the existing scenario.

2.7.1.2 Carbon Monoxide

Table 38 presents the combined concentrations for 1-hour and 24-hour CO based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *Both the maximum 1-hour and 8-hour CO combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 38: Summary of Existing and 2031 Future Build CO

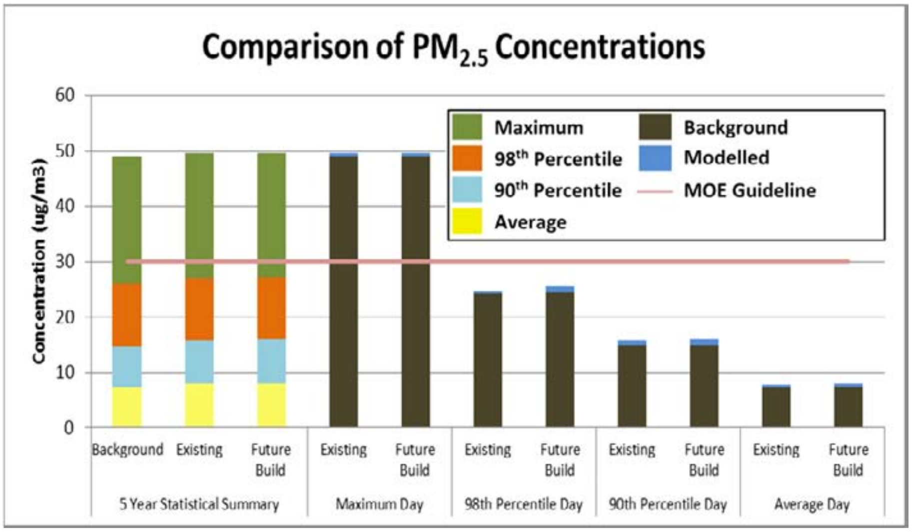
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>10%</td></tr>
<tr><td>90th Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>9%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>No change</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>19%</td></tr>
<tr><td>90th Percentile</td><td>4%</td></tr>
<tr><td>Average</td><td>3%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td>4%</td></tr>
<tr><td>Average</td><td>10%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td>-3%</td></tr>
<tr><td>Average</td><td>5%</td></tr>
<tr><td colspan="3">Conclusions:
• All combined concentrations were below their respective MOE guidelines.
• The contribution from the roadway to the combined concentrations was 10% or less.
• The change from the existing scenario was 5% or less.</td></tr>
</table>

2.7.1.3 Fine Particulate Matter ($PM_{2.5}$)

Table 39 presents the existing and future build combined concentrations alongside the background concentrations for 24-hour $PM_{2.5}$ based on 5 years of meteorological data. The results conclude that:

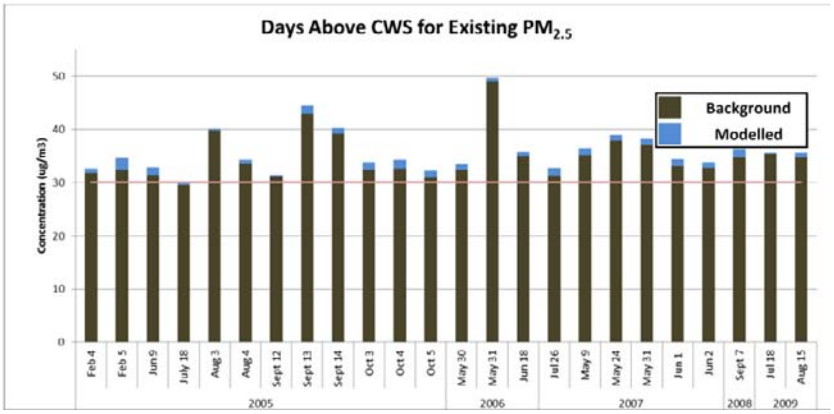
- *The average annual 98^th^ percentile 24-hour $PM_{2.5}$ combined concentration, averaged over three consecutive years for the existing and future build scenarios was below the CWS.*

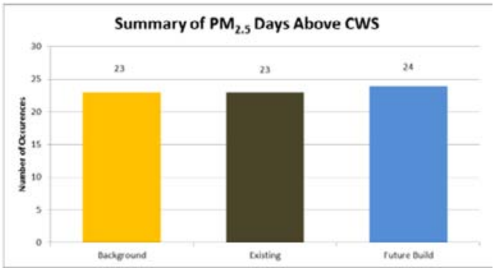
Table 39: Summary of Existing and 2031 Future Build $PM_{2.5}$

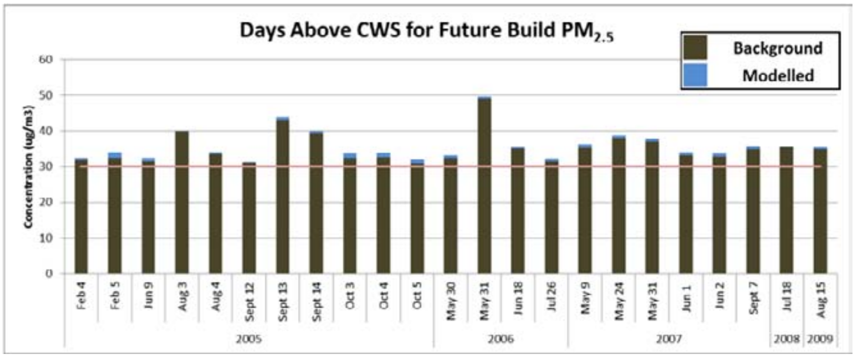
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="16">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>166%</td></tr>
<tr><td>98th Percentile</td><td>90%</td></tr>
<tr><td>90th Percentile</td><td>53%</td></tr>
<tr><td>Average</td><td>27%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>98th Percentile</td><td>6%</td></tr>
<tr><td>90th Percentile</td><td>7%</td></tr>
<tr><td>Average</td><td>8%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>98th Percentile</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="3">Conclusions:

The $PM_{2.5}$ results are in compliance with the CWS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 29.0 $\mu g/m^3$ (years 2005 to 2007) or 97% of the CWS.
The contribution from the roadway to the combined concentrations was 8% or less.
The change from the existing scenario was 1% or less.
Since there were days where elevated $PM_{2.5}$ concentrations were experienced, frequency analysis was conducted to show that elevated concentrations were not frequent over a 5 year period. This analysis is presented in Table 40.
</td></tr>
</table>

Table 40: 5 Year Frequency Analysis of Existing and 2031 Future Build $PM_{2.5}$







Conclusions:

- One additional day above the CWS is expected due to the project over a 5 year period.
- For the future build scenario the combined concentrations only exceeded the CWS 1% of the time.

It should be understood that infrequent days above the guideline due to background is a common occurrence in all of Southwestern Ontario and is unavoidable due to long-range transport of contaminants from the United States.

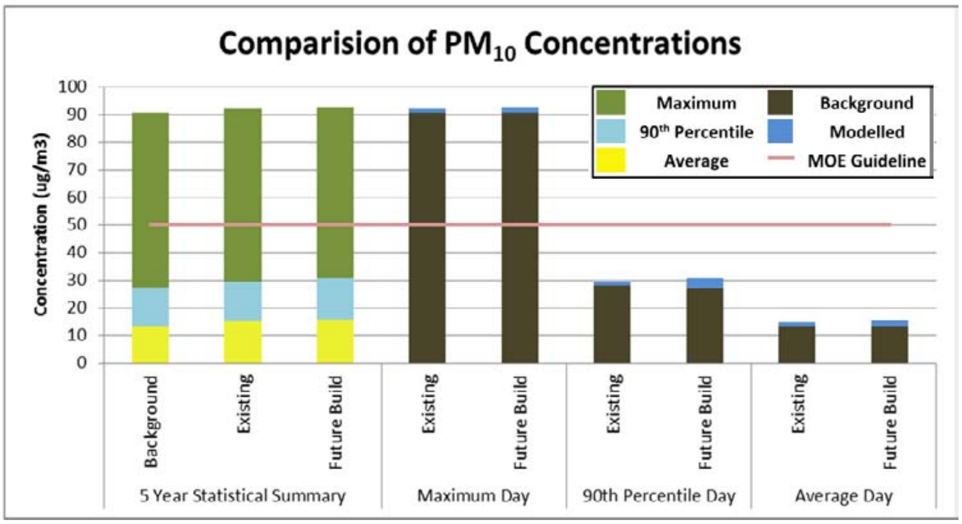
2.7.1.4 Coarse Particulate Matter (PM_{10})

Table 41 presents the existing and future build combined concentrations alongside the background concentrations for 24-hour PM_{10} based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr PM_{10} combined concentrations for the existing and future build scenarios exceeded the MOE guideline.*

Table 41: Summary of Existing and 2031 Future Build PM_{10}

Statistical Analysis

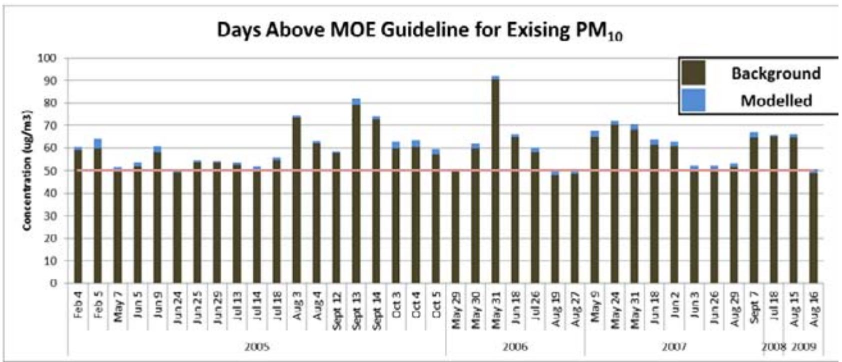


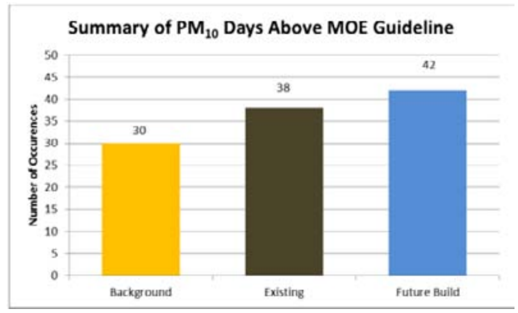
5 Year Summary of Future Build	
% of MOE Guideline:	
Maximum	185%
90th Percentile	62%
Average	52%
Roadway Contribution:	
Maximum	2%
90th Percentile	13%
Average	11%
Change from Existing Scenario:	
Maximum	1%
90th Percentile	4%
Average	4%

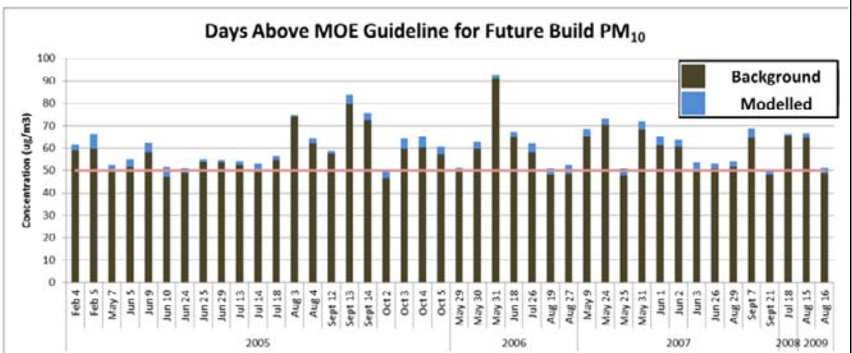
Conclusions:

- The maximum PM_{10} combined concentration exceeded the MOE guideline.
- The contribution from the roadway to the combined concentrations was 13% or less.
- The change from the existing scenario was 4% or less.
- Since there were days where PM_{10} concentrations were above the MOE guideline, frequency analysis was conducted to show that elevated concentrations were not frequent over a 5 year period. This analysis is presented in **Table 42.**

Table 42: 5 Year Frequency Analysis of Existing and 2031 Future Build PM_{10}







Conclusions:

- 4 additional days above the MOE guideline are expected due to the project over a 5 year period.
- For the future build scenario the combined concentrations only exceeded the MOE guideline 2% of the time.

It should be remembered that PM_{10} background concentrations were derived based on their relationship to $PM_{2.5}$ since PM_{10} is not monitored in Ontario. Therefore, considering that there were high days of $PM_{2.5}$ it was also anticipated that there would be high days PM_{10}.

2.7.1.5 Total Suspended Particulate Matter (TSP)

Table 43 presents the existing and future build combined concentrations alongside the background concentrations for 24-hour TSP based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hour TSP combined concentrations for the existing and future build scenarios exceeded the MOE guideline.*

Table 43: Summary of Existing and 2031 Future Build TSP

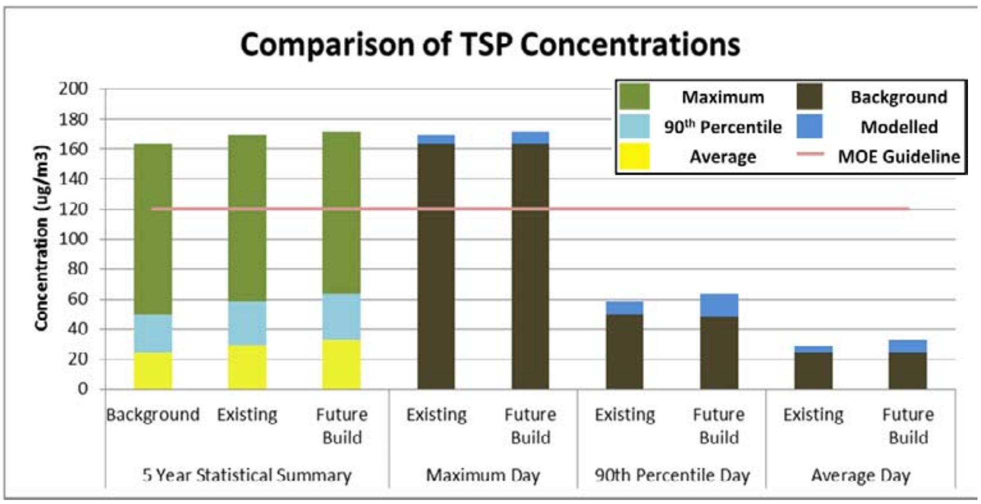
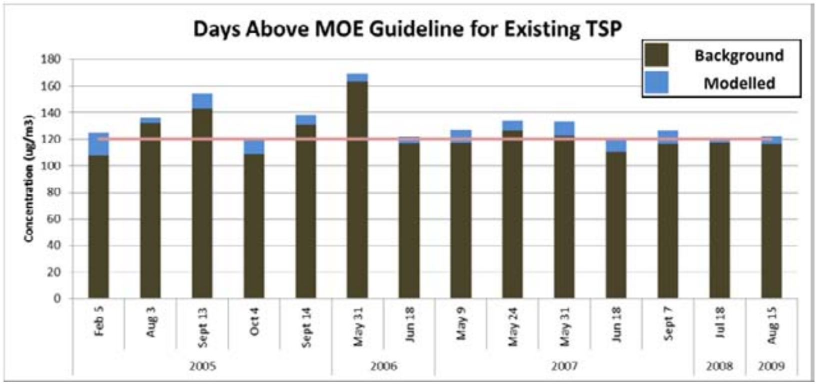
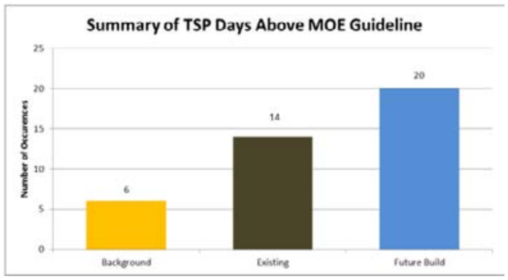
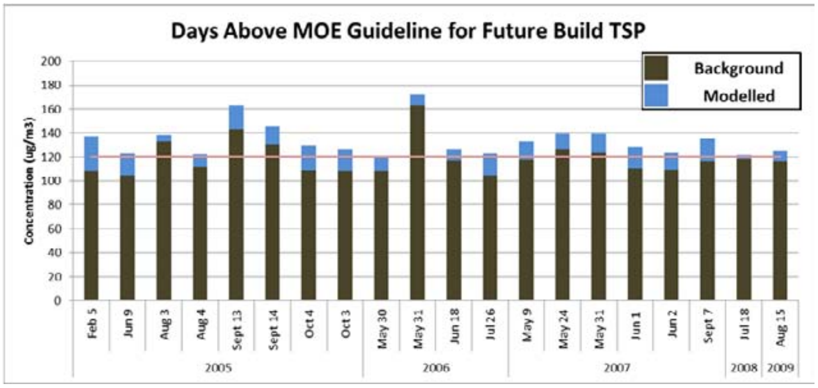
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>148%</td></tr>
<tr><td>90th Percentile</td><td>52%</td></tr>
<tr><td>Average</td><td>28%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>9%</td></tr>
<tr><td>90th Percentile</td><td>17%</td></tr>
<tr><td>Average</td><td>25%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>4%</td></tr>
<tr><td>90th Percentile</td><td>9%</td></tr>
<tr><td>Average</td><td>14%</td></tr>
<tr><td colspan="3">Conclusions:
• The maximum TSP combined concentration exceeded the MOE guideline.
• The contribution from the roadway to the combined concentrations was 25% or less.
• The change from the existing scenario was 14% or less.
• Since there were days where TSP concentrations were above the MOE guideline, frequency analysis was conducted to show that elevated concentrations were not frequent over a 5 year period. This analysis is presented in Table 44.</td></tr>
</table>

Table 44: 5 Year Frequency Analysis of Existing and 2031 Future Build TSP







Conclusions:

- 6 additional days above the MOE guideline are expected due to the project over a 5 year period.
- For the future build scenario the combined concentrations only exceeded the MOE guideline 1% of the time.

It should be remembered that TSP background concentrations were derived based on their relationship to $PM_{2.5}$ since TSP is not monitored in Ontario. Therefore, considering that there were elevated days of $PM_{2.5}$ it was also anticipated that there would be elevated days TSP.

2.7.2 Volatile Organic Compounds (VOCs)

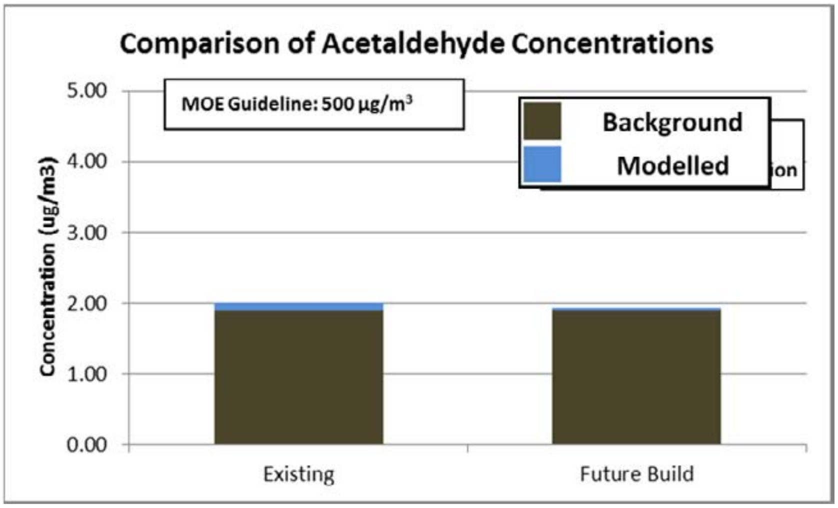
Due to the lack of hourly and daily background monitoring data, statistical analysis (maximum, 90th percentile, and average) could not be conducted. Instead, the 90th percentile background concentration for each VOC was calculated from available data in the 5 year dataset. The 90th percentile background concentration was then added to the maximum modelled roadway concentration in order to estimate a reasonable worst-case combined concentration. The combined concentration was then used to assess compliance with MOE guidelines. Provided below are the modelling results for the VOCs: acetaldehyde, acrolein, benzene, 1,3-butadiene and formaldehyde.

2.7.2.1 Acetaldehyde

Table 45 presents the combined concentrations for 24-hour acetaldehyde based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour acetaldehyde combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 45: Summary of Existing and 2031 Future Build Acetaldehyde

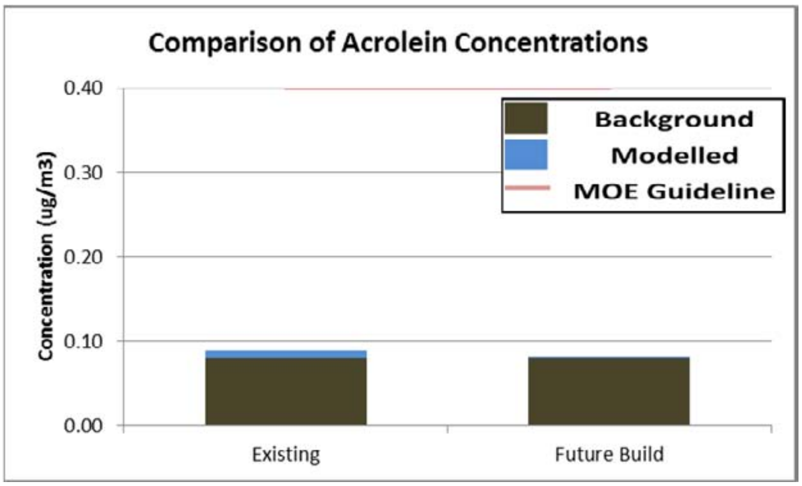
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>2%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>-4%</td></tr>
<tr><td>90th Percentile</td><td>-2%</td></tr>
<tr><td>Average</td><td>-1%</td></tr>
<tr><td colspan="3">Conclusions:
The maximum acetaldehyde combined concentration was below the MOE guideline.
The contribution from the roadway to the combined concentrations was 4% or less.
There was an improvement of up to 4% from the existing scenario.</td></tr>
</table>

2.7.2.2 Acrolein

Table 46 presents the combined concentrations for 24-hour acrolein based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour acrolein combined concentrations for the existing and future build scenarios were below their respective MOE guidelines.*

Table 46: Summary of Existing and 2031 Future Build Acrolein

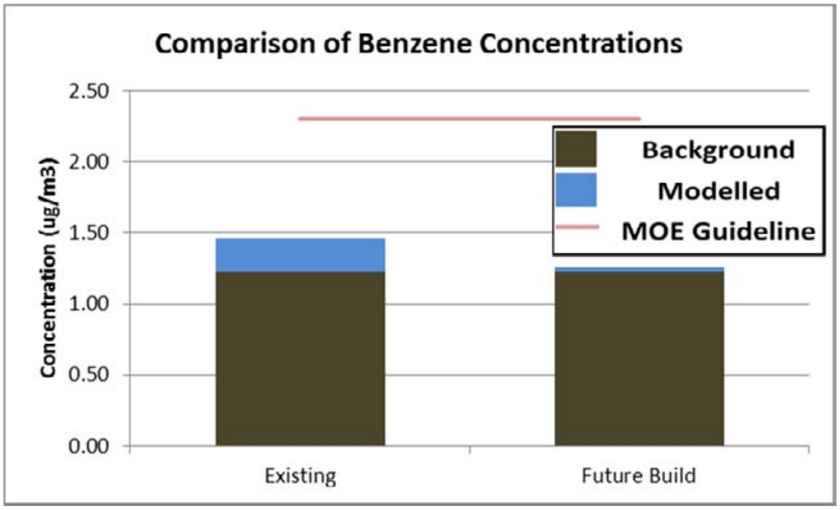
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="13">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>21%</td></tr>
<tr><td>90th Percentile</td><td>20%</td></tr>
<tr><td>Average</td><td>20%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>2%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>-8%</td></tr>
<tr><td>90th Percentile</td><td>-3%</td></tr>
<tr><td>Average</td><td>-1%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="3">Conclusions:
• The maximum acetaldehyde combined concentration was below the MOE guideline.
• The contribution from the roadway to the combined concentrations was 2% or less.
• There was an improvement of up to 8% from the existing scenario.</td></tr>
</table>

2.7.2.3 Benzene

Table 47 presents the combined concentrations for 24-hour benzene based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour benzene combined concentrations for the existing and future build scenarios were below their respective MOE guidelines.*

Table 47: Summary of Existing and 2031 Future Build Benzene

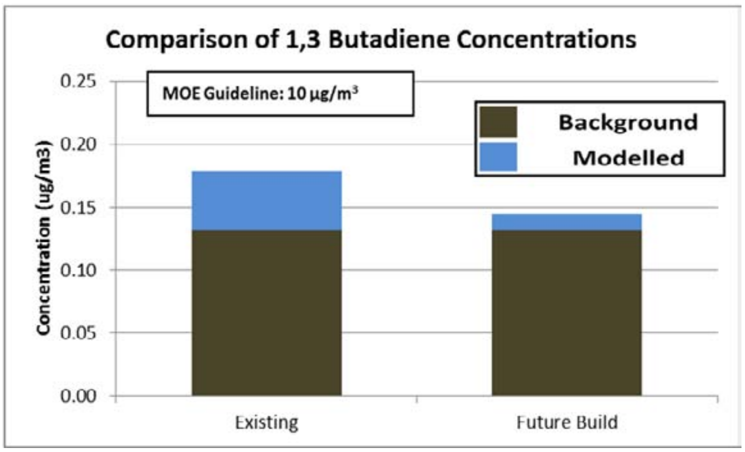
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="13">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>55%</td></tr>
<tr><td>90th Percentile</td><td>54%</td></tr>
<tr><td>Average</td><td>53%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>3%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>-14%</td></tr>
<tr><td>90th Percentile</td><td>-6%</td></tr>
<tr><td>Average</td><td>-3%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="3">Conclusions:
• The maximum benzene combined concentration was below the MOE guideline.
• The contribution from the roadway to the combined concentrations was <3%.
• There was an improvement of up to 14% from the existing scenario.</td></tr>
</table>

2.7.2.4 1,3-Butadiene

Table 48 presents the combined concentrations for 24-hour 1,3-butadiene based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour 1,3-butadiene combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 48: Summary of Existing and 2031 Future Build 1,3-Butadiene

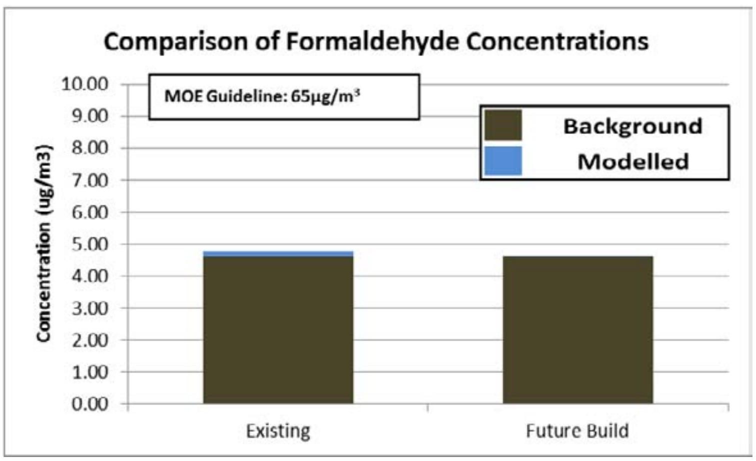
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>9%</td></tr>
<tr><td>90th Percentile</td><td>4%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>-19%</td></tr>
<tr><td>90th Percentile</td><td>-7%</td></tr>
<tr><td>Average</td><td>-3%</td></tr>
<tr><td colspan="3">Conclusions:
• The maximum 1,3-butadiene combined concentration was below the MOE guideline.
• The contribution from the roadway to the combined concentrations was 9% or less.
• There was an improvement of up to 19% from the existing scenario.</td></tr>
</table>

2.7.2.5 Formaldehyde

Table 49 presents the combined concentrations for 24-hour formaldehyde based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour formaldehyde combined concentrations for the existing and future build scenarios were below their respective MOE guidelines.*

Table 49: Summary of Existing and 2031 Future Build Formaldehyde

<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="14">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>7%</td></tr>
<tr><td>90th Percentile</td><td>7%</td></tr>
<tr><td>Average</td><td>7%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>-2%</td></tr>
<tr><td>90th Percentile</td><td>-1%</td></tr>
<tr><td>Average</td><td>0%</td></tr>
<tr><td colspan="3">Conclusions:
• The maximum formaldehyde combined concentration was below the MOE guideline.
• The contribution from the roadway to the combined concentrations was 1% or less.
• There was an improvement of up to 2% from the existing scenario.</td></tr>
</table>

2.7.3 Concentration Contour Plot

A maximum $PM_{2.5}$ roadway concentration contour plot is provided below for a worst-case section of Dundas Street in order to graphically display results. The plot also shows how contaminant concentration decreases as a function of distance from the roadway. The plot was constructed by modelling a fine Cartesian Grid of hypothetical receptors and determining the maximum roadway concentration at each receptor. It should be noted that from the modelling results the roadway contribution to the $PM_{2.5}$ combined concentration was small in comparison to the background and that the roadway contribution falls off quickly with downwind distance from the roadway, as shown in the contour plot. Typically, at distances of 300 to 500 m from the roadway, the combined concentration is almost all due to the background.

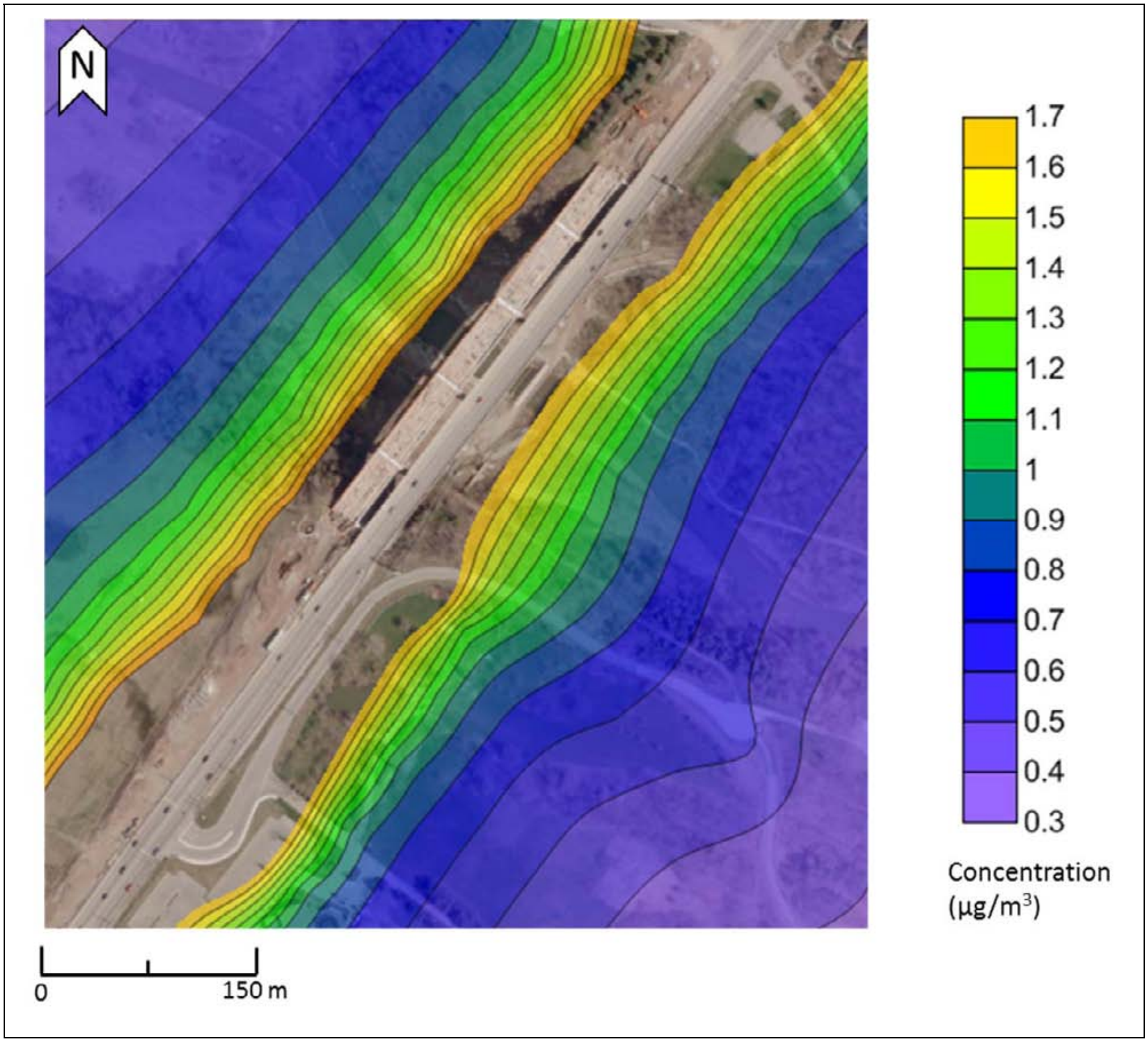
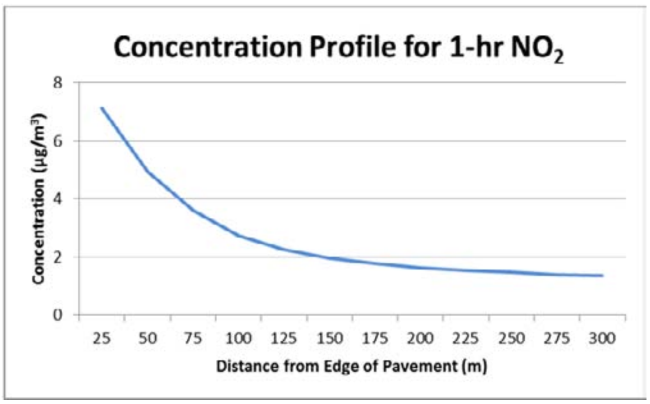
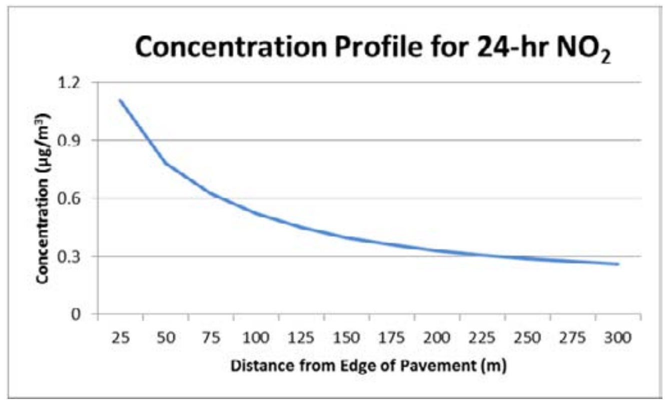
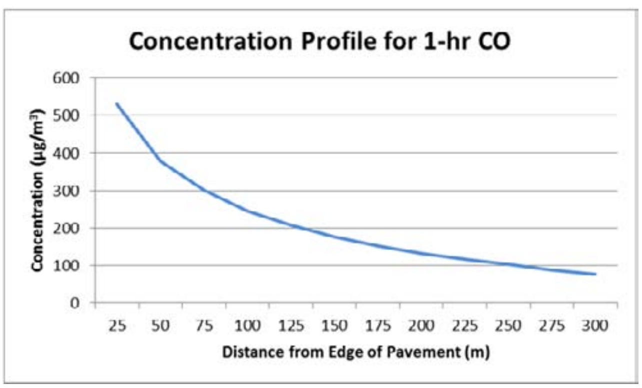
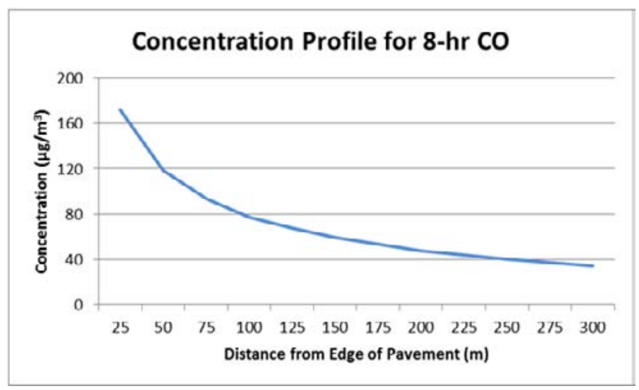
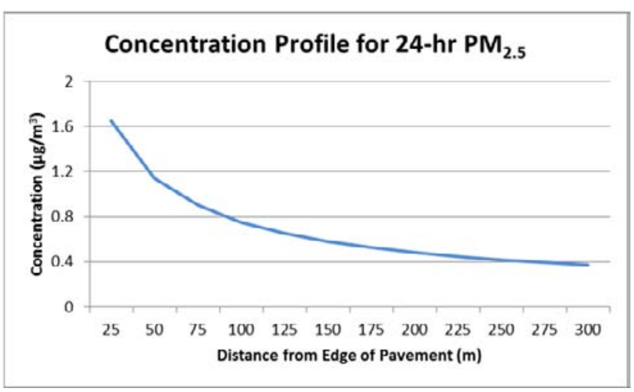
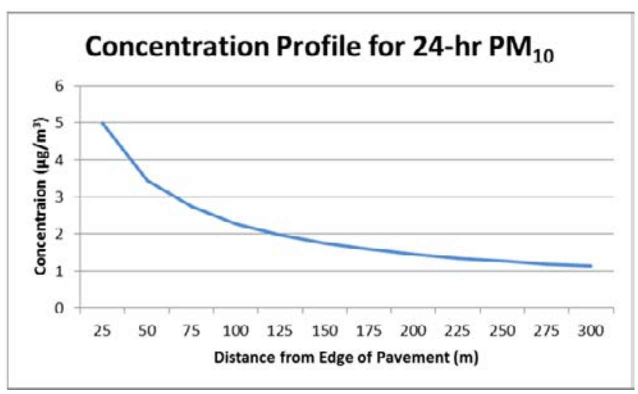


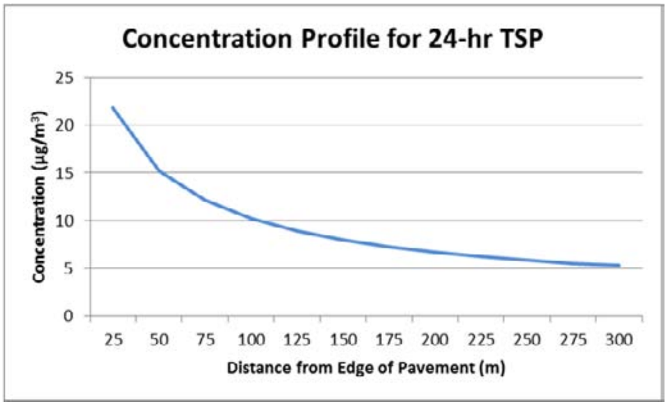
Figure 23: Concentration Contour Plot of Maximum $PM_{2.5}$ Concentrations

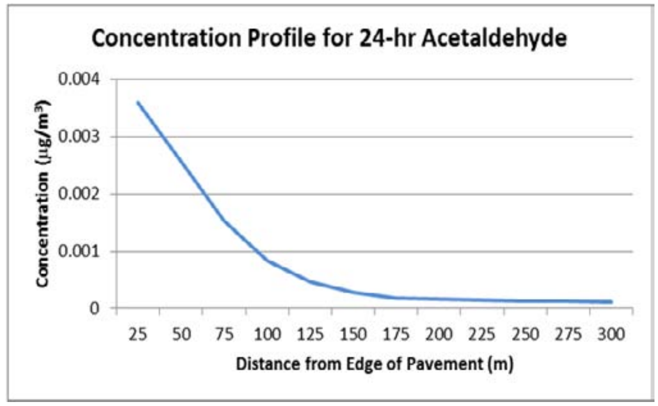
2.7.4 Concentration Profiles

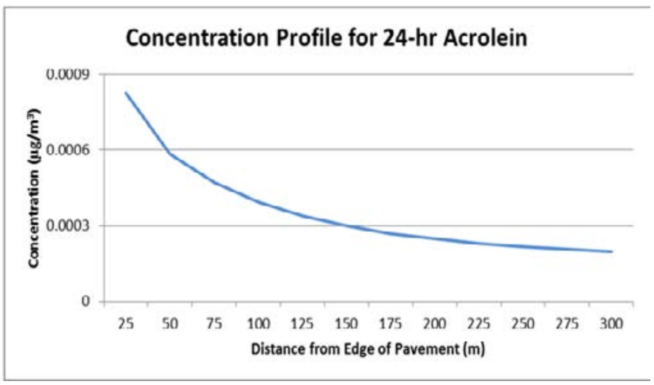
Presented below are concentration profile curves for each of the modelled contaminants for a worst-case section of Dundas Street for the Future Build scenario. These concentration profiles show how contaminant concentrations decrease as a function of distance from the roadway. The profiles were constructed by modelling a line of receptors spaced 25 m apart to a distance of 300 m from the roadway edge of pavement. These results show only the emissions from the roadway. At a distance of 300 m to 500 m from the roadway, contaminant levels are dominated by background concentrations.

Table 50: Concentration Profiles


Concentration Profile for 24-hr TSP
Concentration (µg/m³)
25
20
15
10
5
0
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Acetaldehyde
Concentration (µg/m³)
0.004
0.003
0.002
0.001
0
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Acrolein
Concentration (µg/m³)
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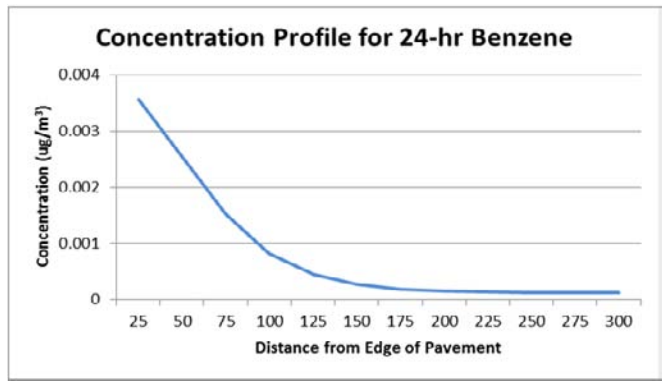
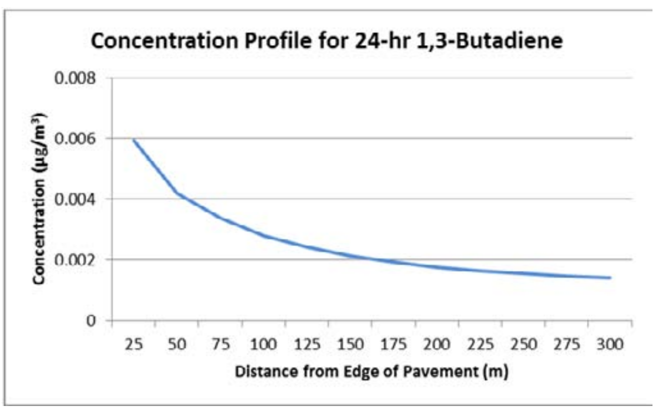
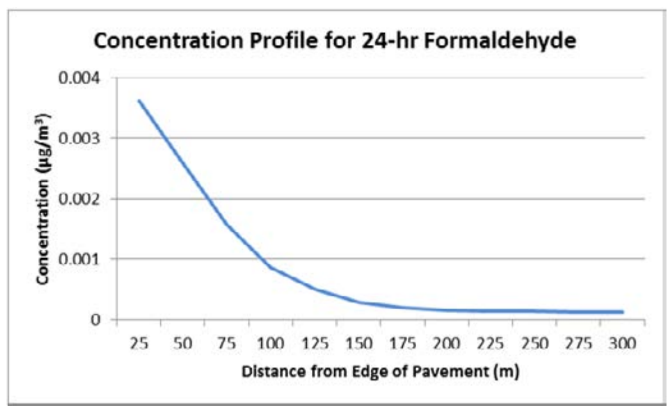
0.0006
0.0003
0
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Benzene
Concentration (µg/m³)
0.004
0.003
0.002
0.001
0
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement


Concentration Profile for 24-hr 1,3-Butadiene
Concentration (µg/m³)
0.008
0.006
0.004
0.002
0
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Formaldehyde
Concentration (µg/m³)
0.004
0.003
0.002
0.001
0
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)

2.8 Implications of Air Quality on Human Health

As noted in Section 2.7, the predicted maximum combined concentrations experienced at the worst-case sensitive receptor location along the corridor for all evaluated contaminants of concern were below their corresponding air quality guideline, with the exception of particulate matter (*i.e.*, $PM_{2.5}$, PM_{10}, and TSP). As such, for those predicted worst-case exposures that did not exceed the regulatory guideline, no potential health risks would be expected to even sensitive members of the population. As such, only the potential health risks related to particulate matter (PM) need be discussed further in this report.

PM consists of airborne particles in solid or liquid form, the size of ambient PM ranging from approximately 0.005 to 100 microns (µm) in aerodynamic diameter (WHO, 2005). PM is operationally separated into three groups: i) total suspended particulate (TSP); ii) inhalable coarse particles (PM_{10}); and, iii) fine or respirable particles ($PM_{2.5}$). It is important to recognize that TSP contains all particles smaller than 44 microns; PM_{10} contains all particles with a mean aerodynamic diameter of 10 microns or less; and $PM_{2.5}$ contains particles equal to or smaller than 2.5 microns as well as ultrafine PM of less than 0.1 micron.

When evaluating the potential health implications arising from exceedances of the various regulatory guidelines pertaining to PM, the most relevant guideline is for the fine particulate matter size fraction (*i.e.*, $PM_{2.5}$). Fine particulate matter (*i.e.*, particulates smaller than 2.5 microns in size) largely originates from combustion processes. Particle size is a very important factor in determining the inhalability and eventual deposition of particulate matter within the respiratory tract (Health Canada, 1999). Particles between 2 and 3 µm or smaller are able to reach the alveoli in the distal parts of the lung, and therefore, have been termed respirable (Health Canada, 1999). Those particles that penetrate the lowest reaches of the lungs typically have the greatest potential for health impacts to the individual.

Epidemiological studies have indicated a positive association between particulate matter and health outcomes such as daily mortality, impaired lung function, adverse respiratory symptoms and medication use, respiratory and cardiovascular hospitalizations, frequency of reported chronic respiratory disease and restricted activity days (Environment Canada, 2000).

Time-series epidemiological studies estimate that a 10 $\mu g/m^3$ increase in mean 24-hour $PM_{2.5}$ concentration increases the relative risk for daily cardiovascular mortality by approximately 0.4% to 1.0%. Despite theoretical statistical risks ascribed to all individuals, this elevated risk from exposure is not equally distributed within a population. At present-day levels, $PM_{2.5}$ likely poses an acute threat principally to susceptible people, even if seemingly healthy, such as the elderly and those with (unrecognized) existing coronary artery or structural heart disease. Research has indicated that a 10 $\mu g/m^3$ increase during the preceding day contributes on average to the premature death of approximately one susceptible person per day in a region of 5 million people (based on annual US death rates in 2005). However, when one extrapolates this to the small impact area that may actually be exposed to these concentrations along a transportation corridor, it would be difficult to detect any increase in premature death from a statistical point-of-view.

The primary health concern with respect to particulate matter is related to chronic exposures to elevated concentrations. When focussing on $PM_{2.5}$, the regulatory benchmark (*i.e.*, Canada Wide Standard, or CWS) is 30 $\mu g/m^3$ over a 24-hour averaging time. In this case, the air quality benchmark is a risk management objective intended to provide protection for human health effects for the vast majority of the normal population. It is not intended to be considered a level at which no health impacts could occur. The CWS benchmark is calculated based on the 98th percentile of ambient measurements annually, averaged over the three consecutive years. As such, the intention is to identify those circumstances where concentrations would be consistently exceeding the established benchmark, resulting in significant health impacts on individuals with the exposure area.

In the case of the current assessment, background concentrations of $PM_{2.5}$ (*i.e.*, in absence of contribution from the corridor) exceed the CWS approximately 4.8 days in a year (*i.e.*, 24 days over a five year period). These would be considered "bad air days" where regional air quality is poor, and health departments send out advisories to avoid heavy exercise outdoors, particularly if you are an individual with pre-existing health concerns. On these days, there is definitely the potential for health concerns for susceptible individuals. However, the results of the current assessment indicate that the proposed future build scenario would result in only one additional day that would exceed the regulatory benchmark, when compared to the existing conditions.

While worst-case exposures are important for evaluating the potential health impacts, and research has demonstrated any increase in ambient $PM_{2.5}$ concentrations has been shown to be statistically linked to an increase in adverse health outcomes in an overall population, the frequency of the occurrence of these elevated concentrations is also an important piece of the puzzle. While the maximum day concentration greatly exceeds the regulatory benchmark, both the 90th percentile and average days show significantly lower concentrations. Therefore, while those days that approach and exceed the risk management guideline could result in acute respiratory issues for sensitive individuals, given the typical ambient concentrations are significantly lower; the potential for chronic health concerns related to the proposed project would be low. Furthermore, the 98th percentile $PM_{2.5}$ combined concentration averaged over a 3 year period for the future build scenario was estimated to be 29.0 $\mu g/m^3$, which did not exceed the CWS benchmark of 30 $\mu g/m^3$.

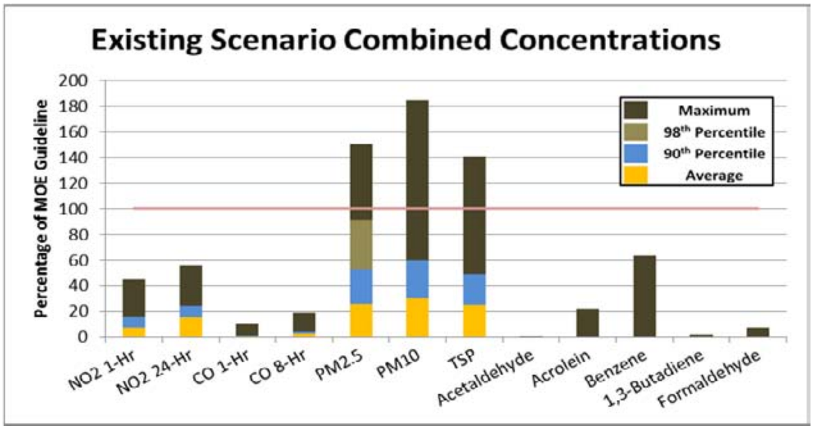
3.0 Conclusions and Recommendations

The potential air quality impacts of the proposed project have been assessed and are summarized in **Table 51.** The following conclusions and recommendations are a result of this assessment.

- *The maximum combined concentrations for the existing and 2031 future build scenarios were all below their respective MOE guidelines or CWS, with the exception of PM_{10} and TSP.*
- *Frequency Analysis determined that the project exceeded the PM_{10} and TSP guidelines 4 and 6 additional days respectively over the 5 year period. This equates to <1% of the time.*
- *The average percentage change of maximum combined concentrations from existing scenario to future build scenario for all contaminants was -4%. This represents an improvement in the overall pollutant concentrations.*
- *The potential for chronic health concerns would be low.*
- *Mitigation measures are not warranted, due to the fact that only 4 and 6 additional days above the guideline for PM_{10} and TSP respectively are predicted over a 5 year period.*

Table 51: Summary of Existing and 2031 Future Build Results

5 Year Statistical Summary

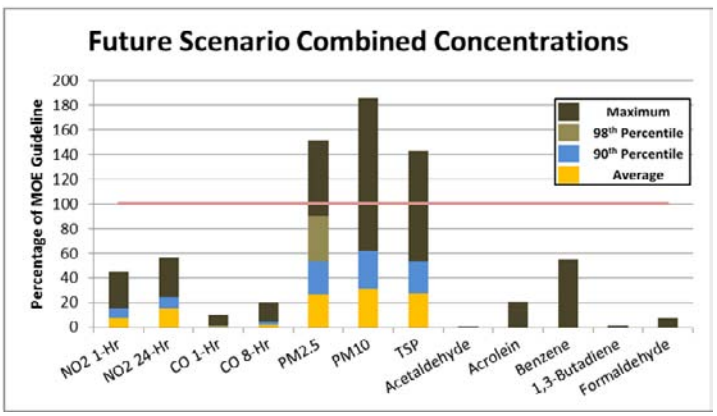


Note: The $PM_{2.5}$ background concentration is in compliance with the CWS. The highest 3-year rolling average of the yearly 98th percentile concentration was calculated to be 28.43 µg/m^3 (2005-2007) or 95% of the standard.

% of Guideline

Existing Scenario:

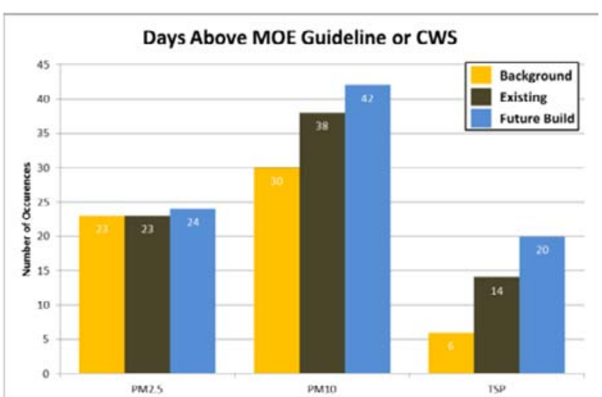
NO_2 (1-hr)	45%
NO_2 (24-hr)	56%
CO (1-hr)	10%
CO (8-hr)	19%
$PM_{2.5}$	95%
PM_{10}	185%
TSP	140%
Acetaldehyde	<1%
Acrolein	22%
Benzene	64%
1,3-Butadiene	2%
Formaldehyde	7%



Note: The $PM_{2.5}$ background concentration is in compliance with the CWS. The highest 3-year rolling average of the yearly 98th percentile concentration was calculated to be 29.0 µg/m^3 (2005-2007) or 97% of the standard.

Future Build Scenario:

NO_2 (1-hr)	45%
NO_2 (24-hr)	56%
CO (1-hr)	10%
CO (8-hr)	19%
$PM_{2.5}$	97%
PM_{10}	185%
TSP	143%
Acetaldehyde	<1%
Acrolein	21%
Benzene	55%
1,3-Butadiene	1%
Formaldehyde	7%



Additional Days Above Guideline Due to Project:

$PM_{2.5}$	1
PM_{10}	4
TSP	6

4.0 References

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Appendix A

Individual Sensitive Receptor Results

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for 2-sided printing purposes

5 Year Statistical Summary for All Modelled Sensitive Receptors

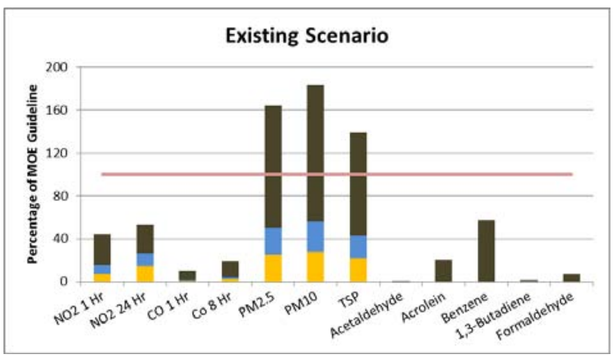
Legend:

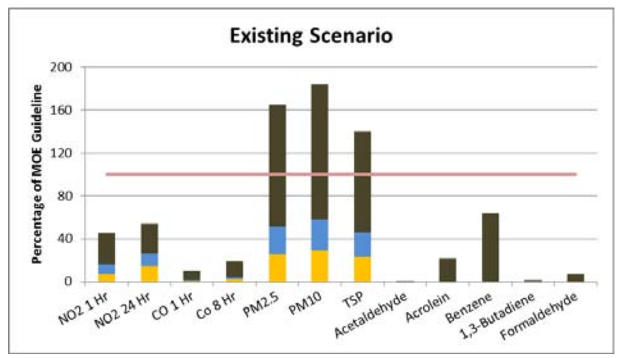
- Maximum
- 90th Percentile
- Average

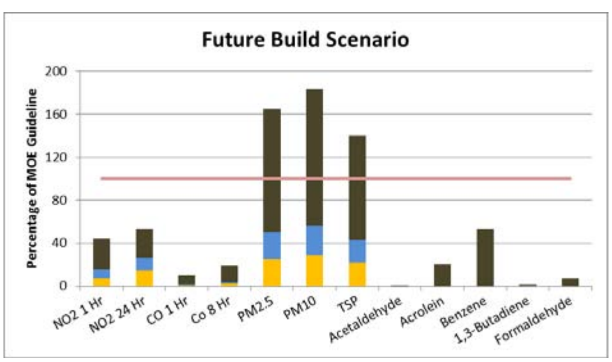
R1	R2

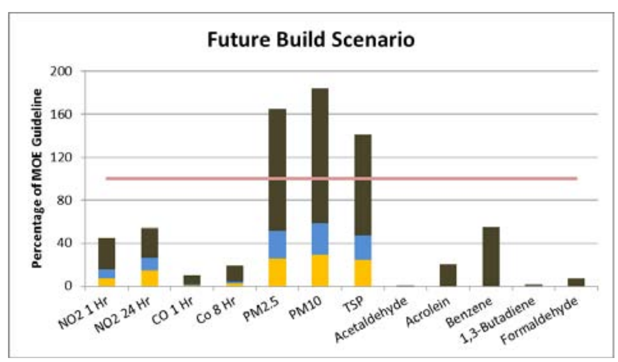
R1

R2









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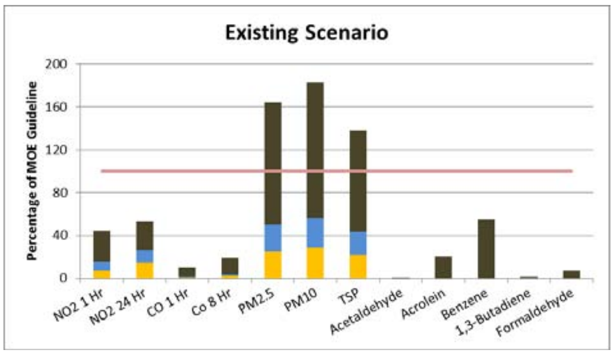
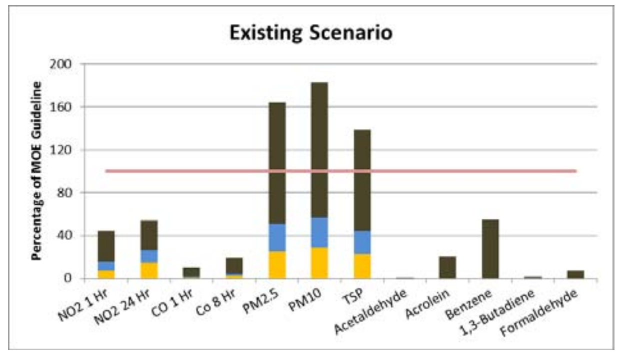
<tr><td>
</td><td>
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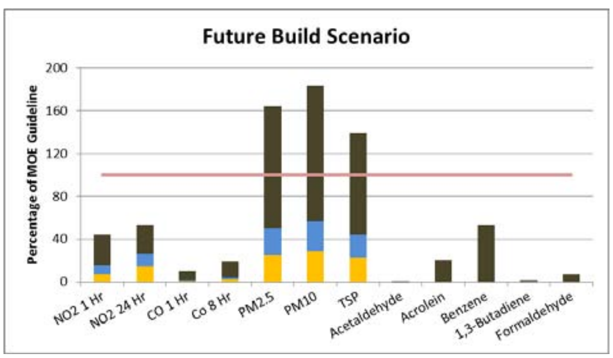
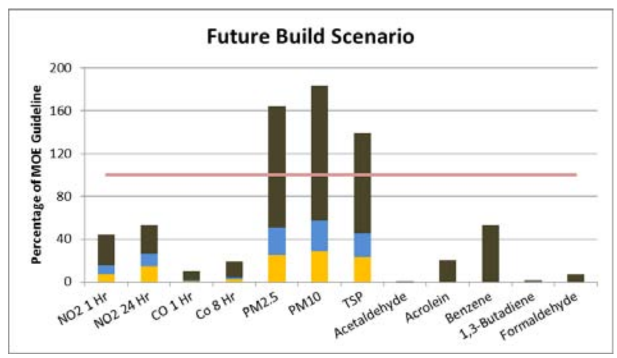
<tr><td>
</td><td>
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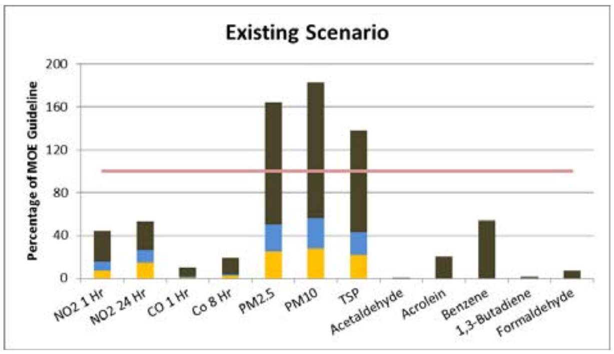
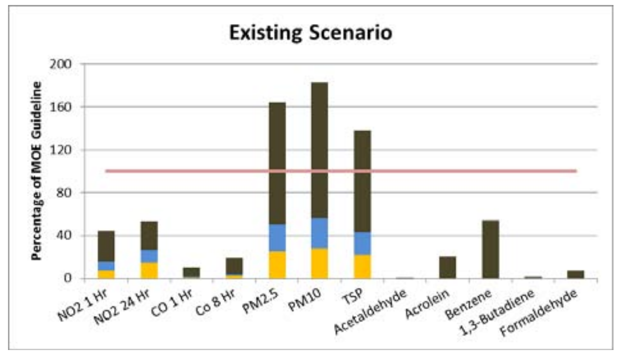
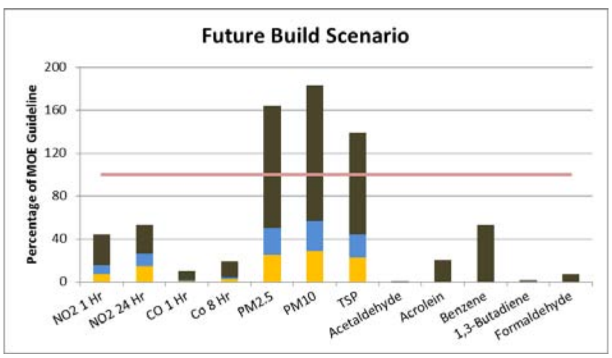
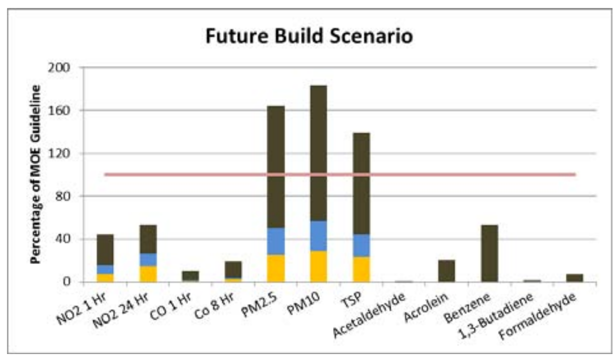
R5	R6
R5 R62	R6
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

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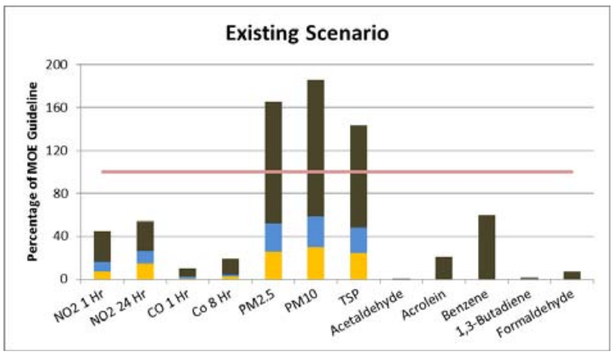
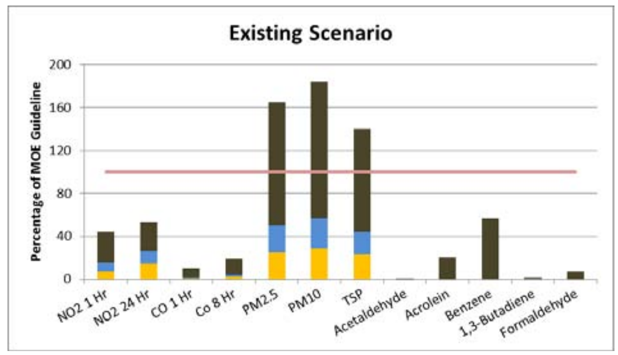
<tr><td>
</td><td>
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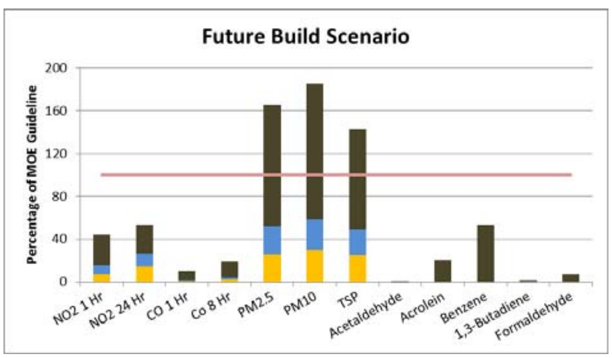
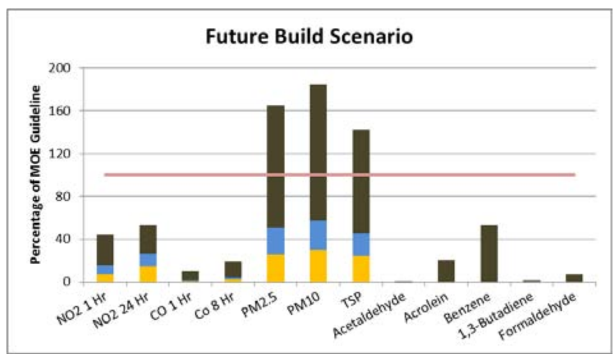
<tr><td>
</td><td>
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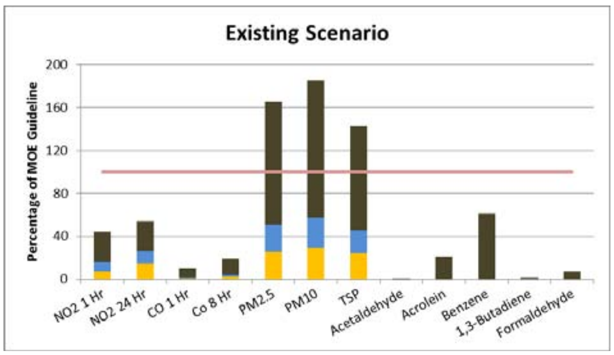
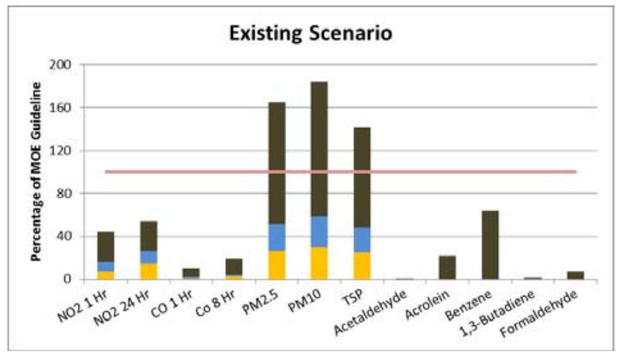
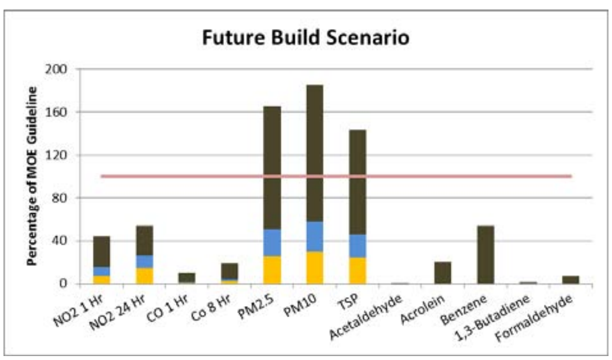
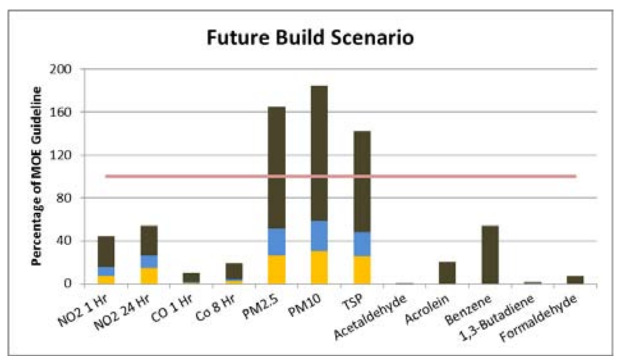
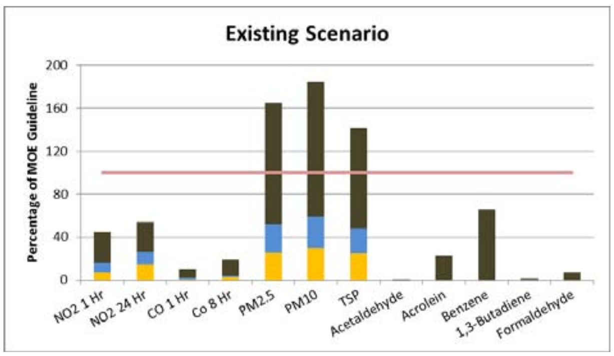
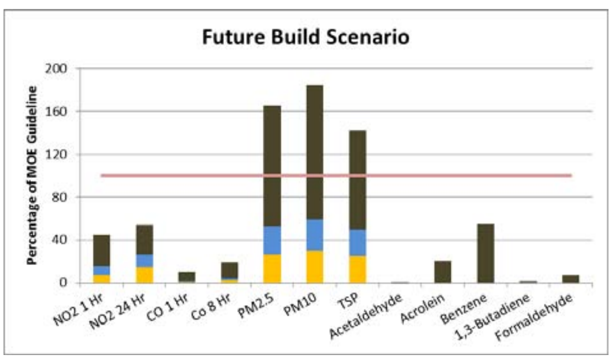
R9	R10
R9	R10
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

R11

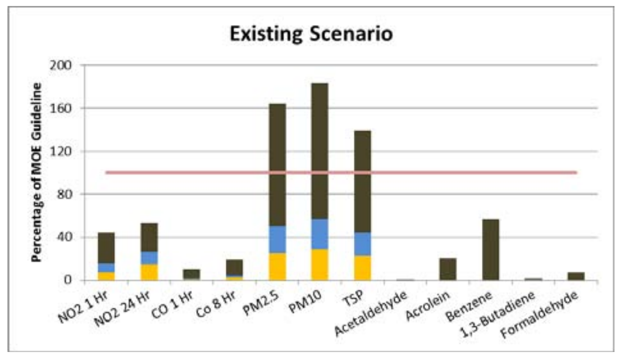

R61
R11

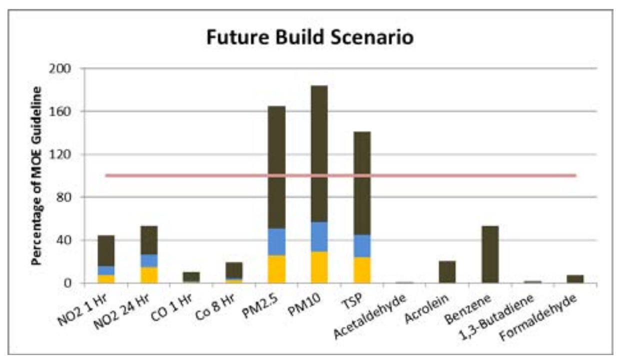

Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

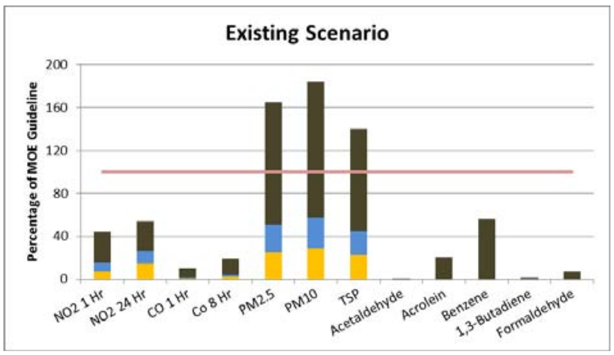
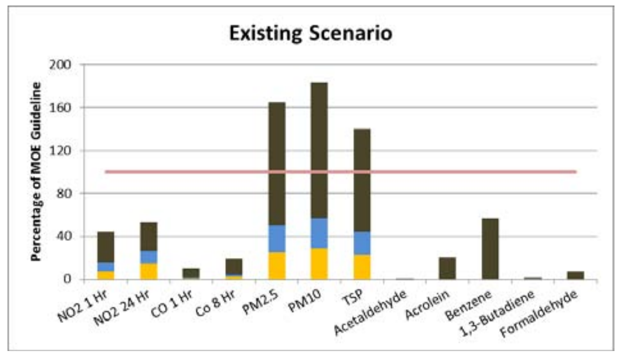
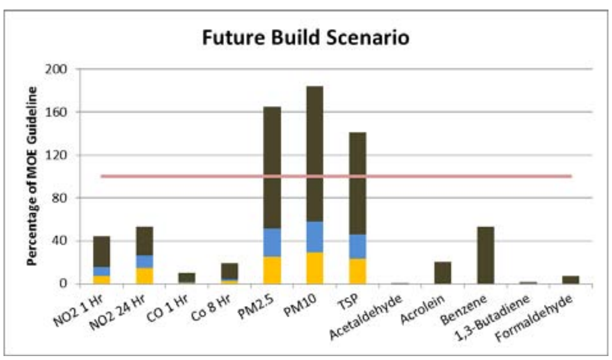
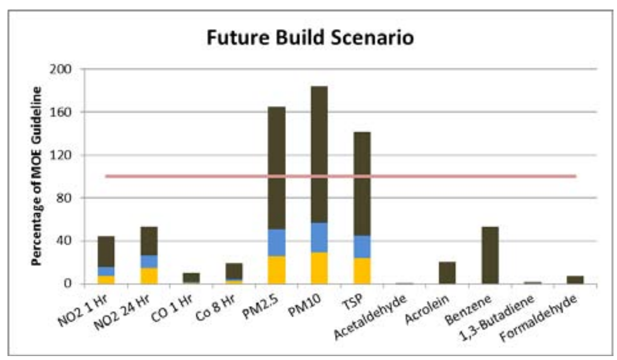

Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R12


R12


Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R13	R14
R13 R14	
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

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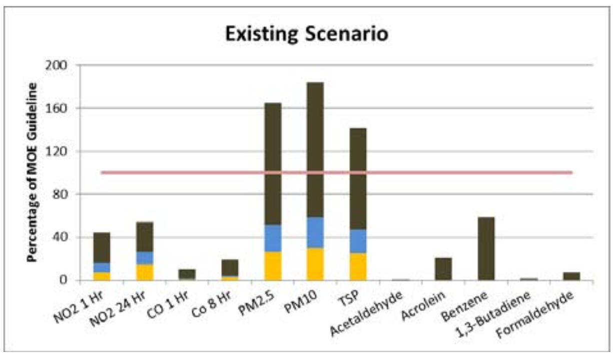
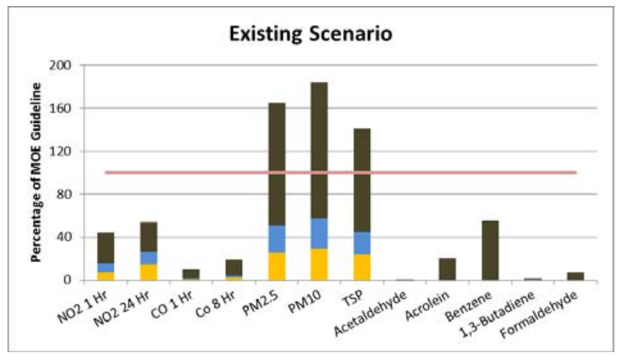
<tr><td>
</td><td>
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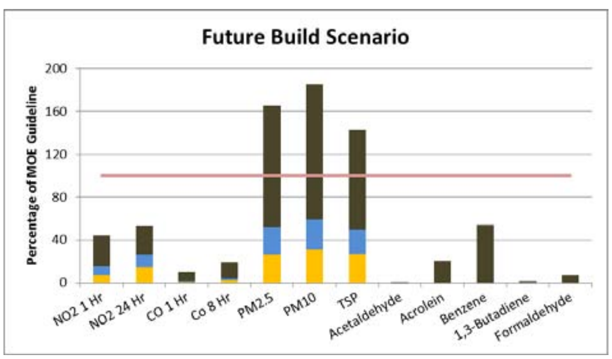
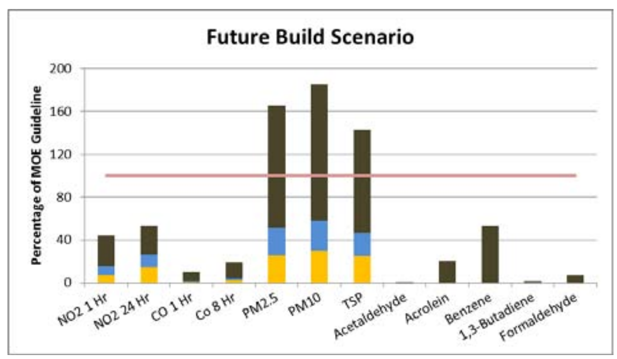
<tr><td>
</td><td>
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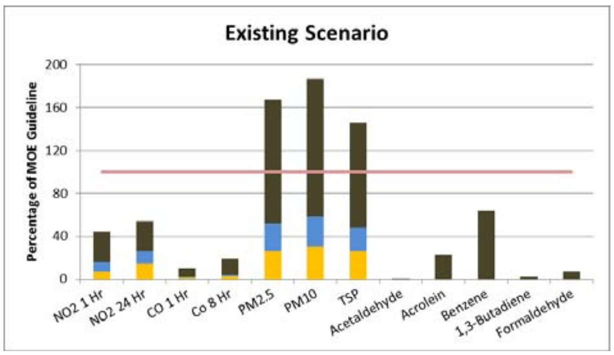
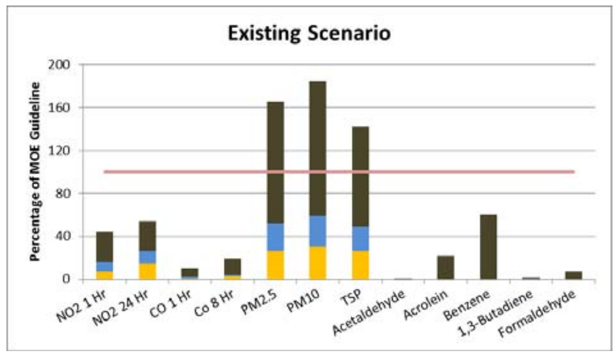
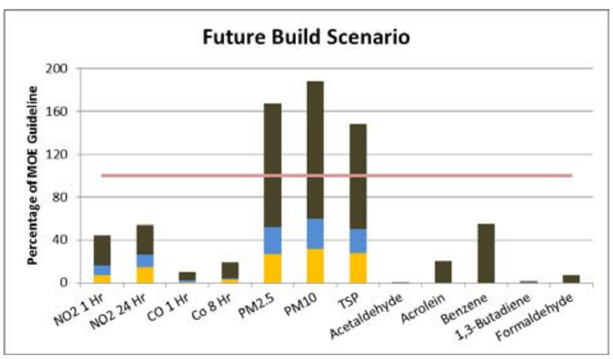
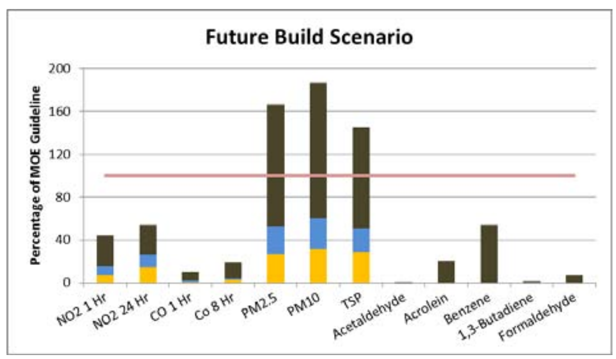
R17	R18


R18
R17


Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

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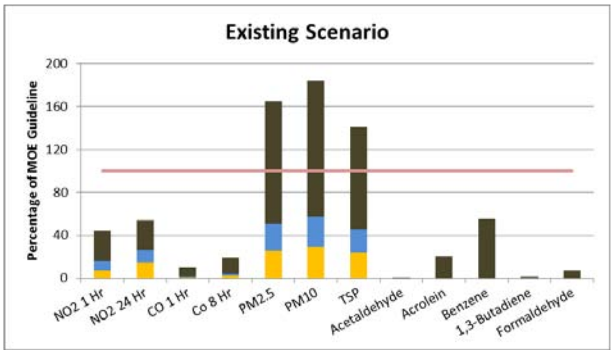
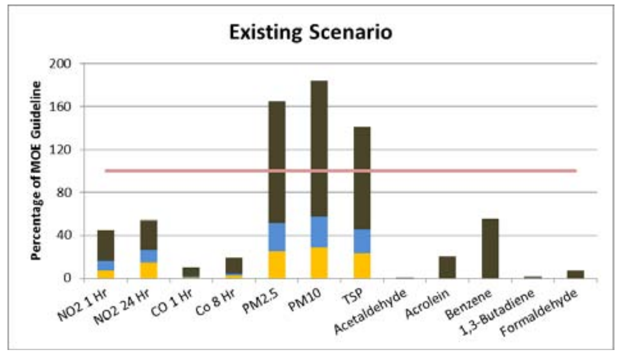
<tr><td>
</td><td>
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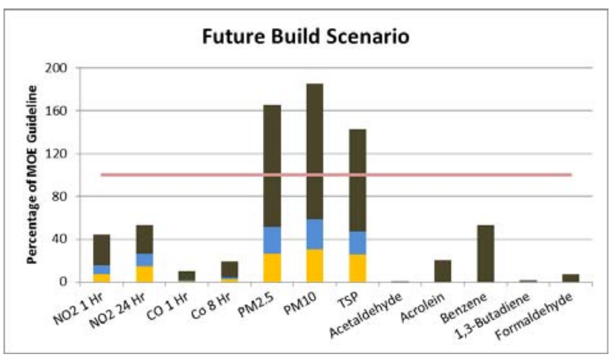
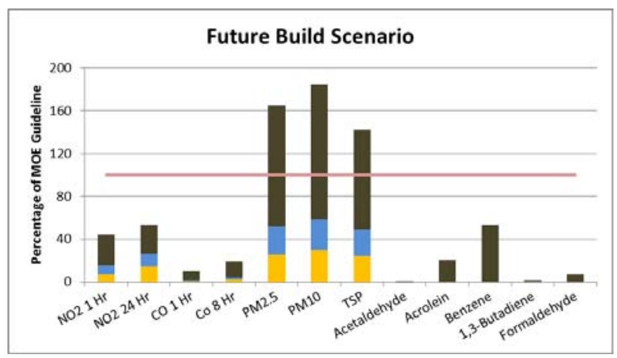
<tr><td>
</td><td>
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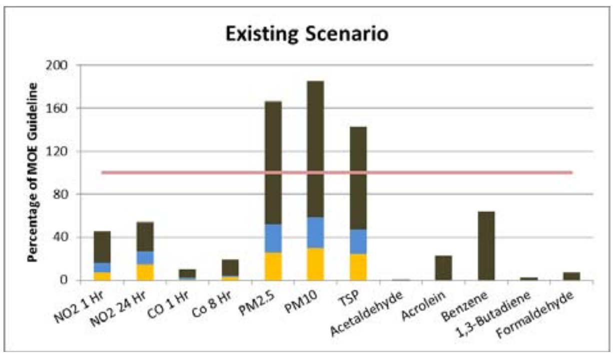
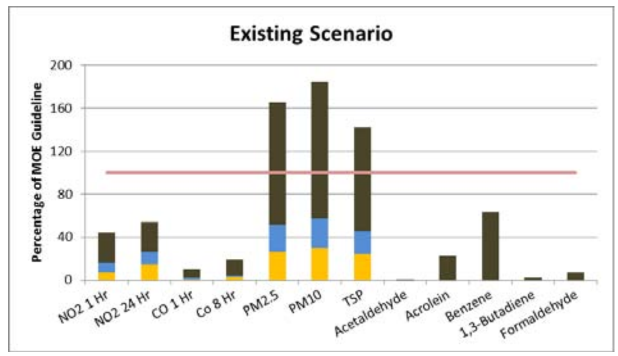
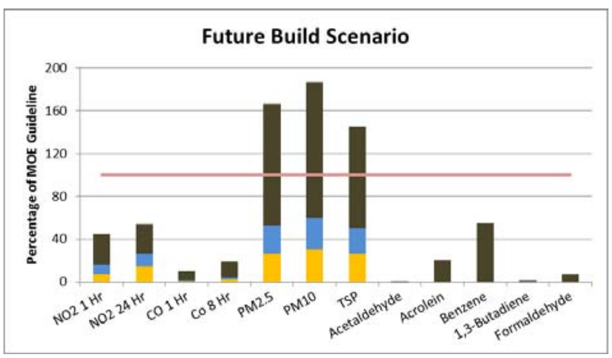
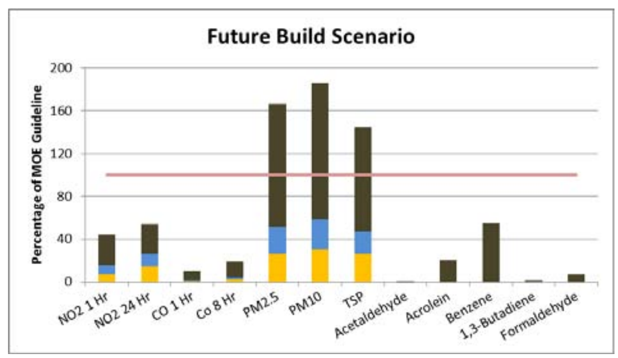
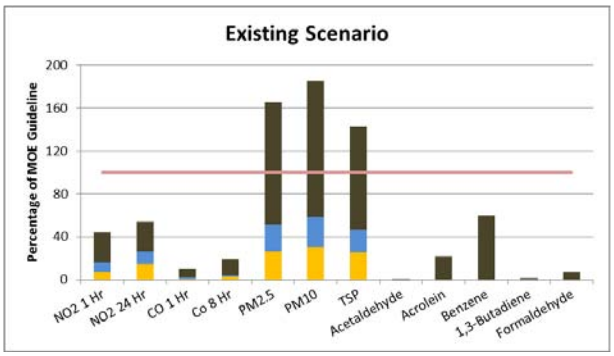
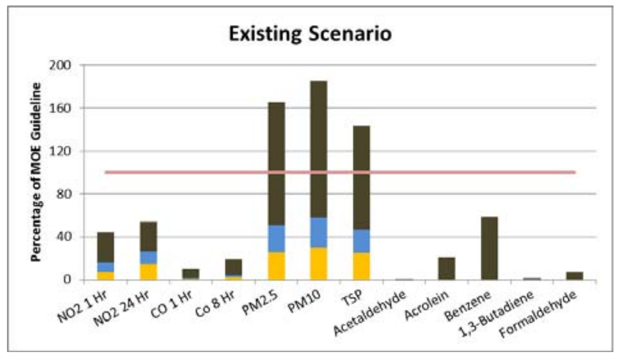
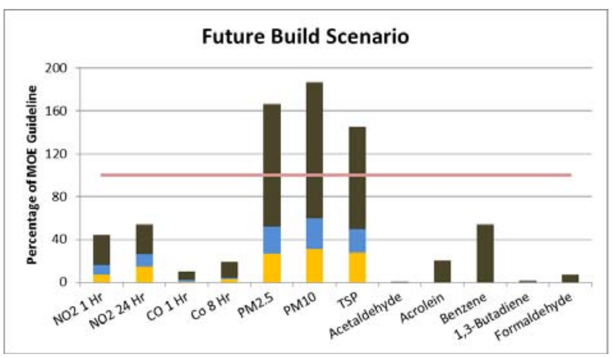
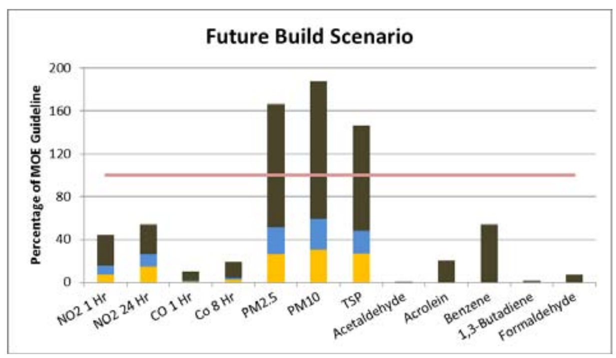
R21	R22
R21	R23 R22
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

R23	R24
R23 R22	R26 R25 R24
Existing Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

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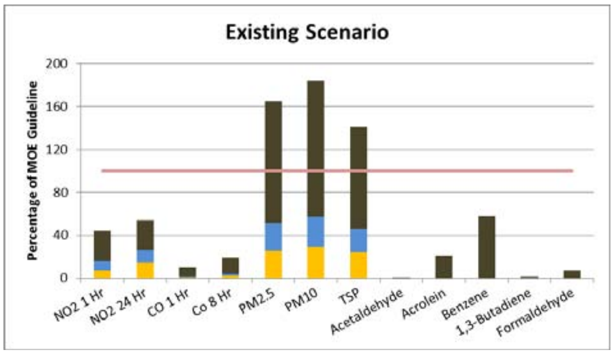
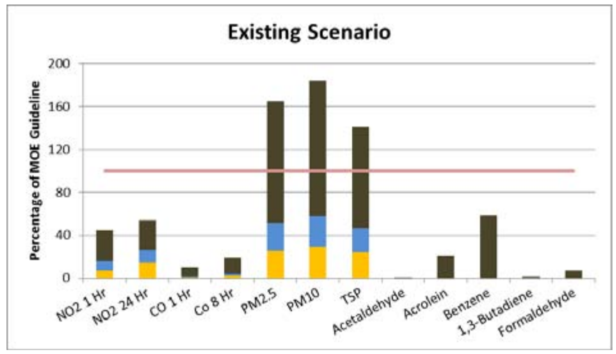
<tr><td>
</td><td>
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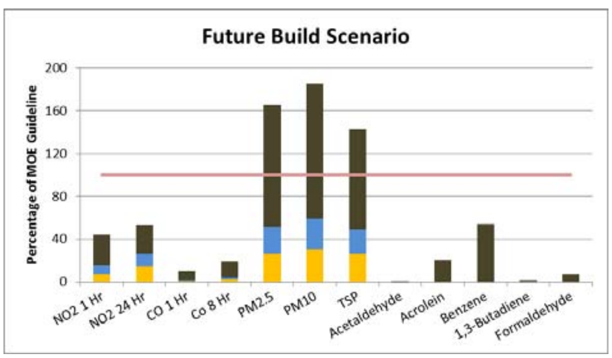
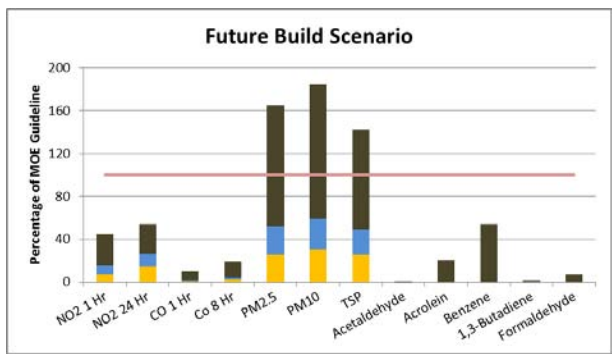
<tr><td>
</td><td>
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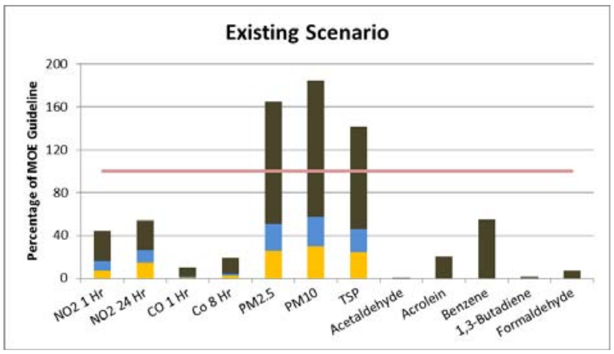
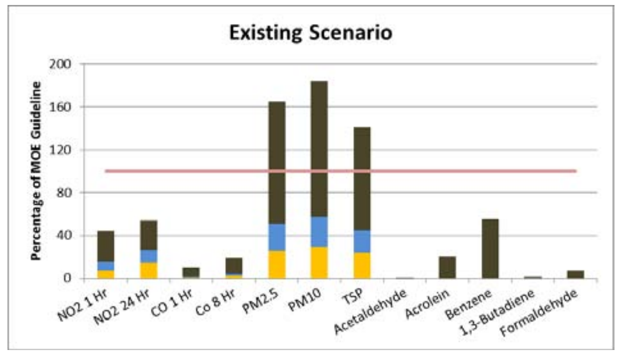
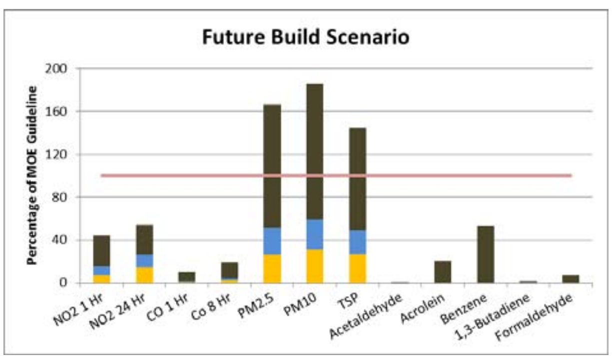
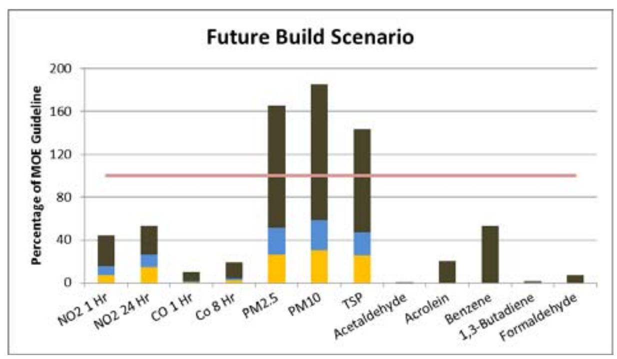
R27	R28
	
	
	

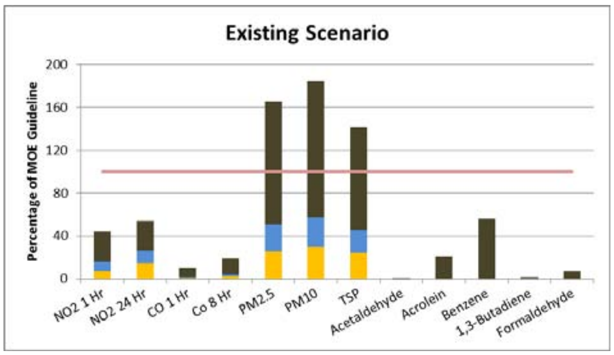
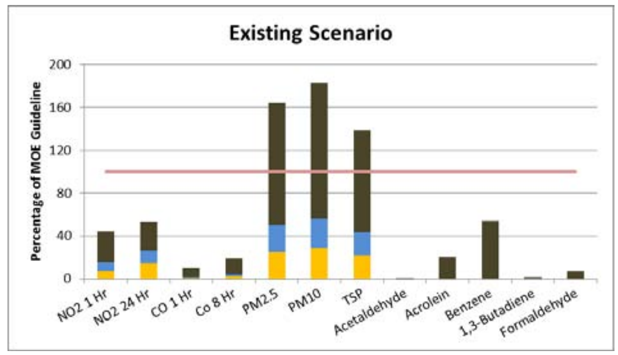
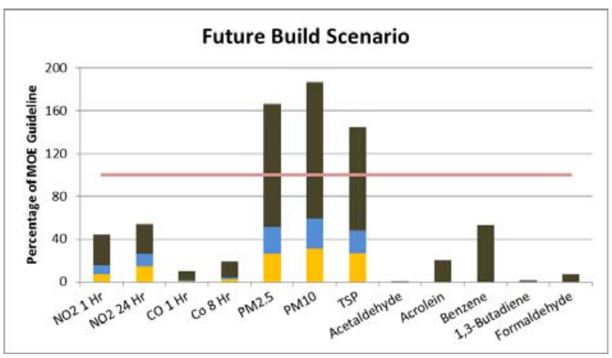
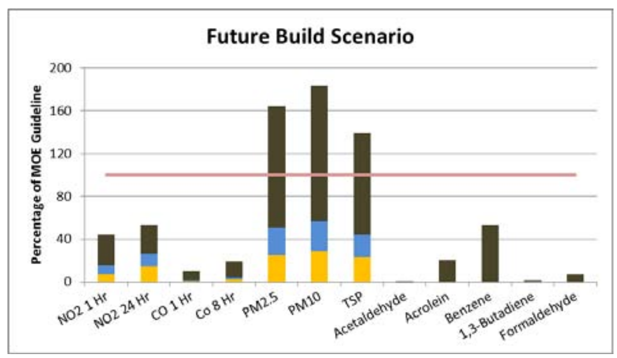
R28
R27

Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

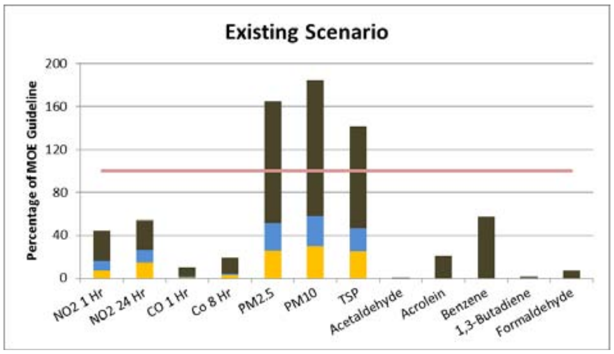
Future Build Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

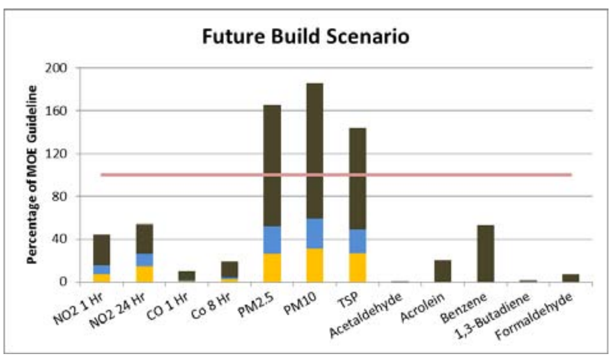
Future Build Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R29	R30
R29	R30
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

R31

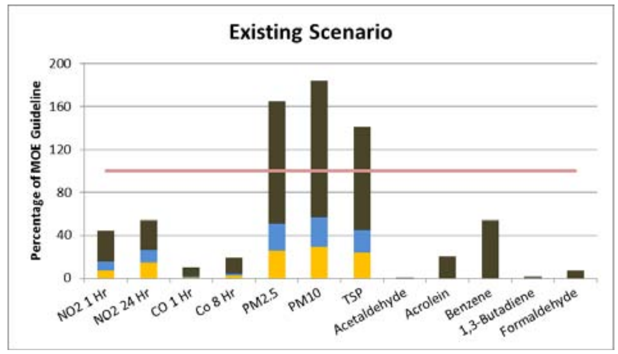

R31

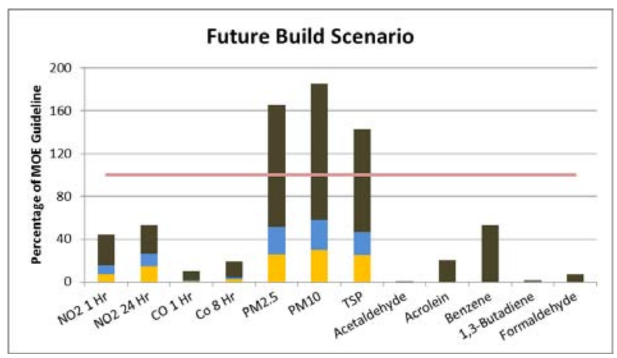

Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

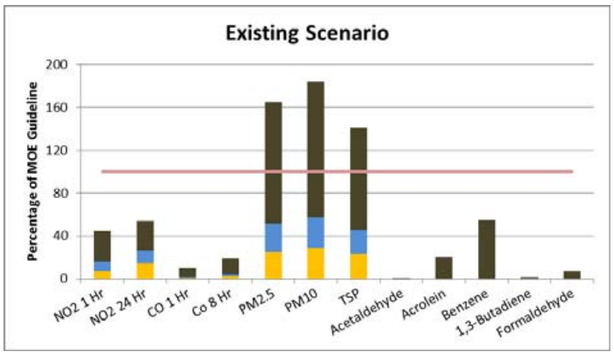
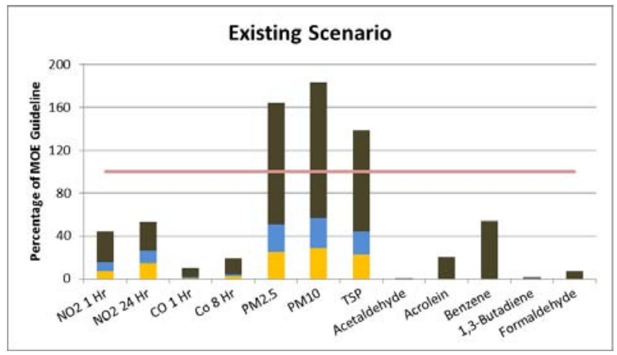
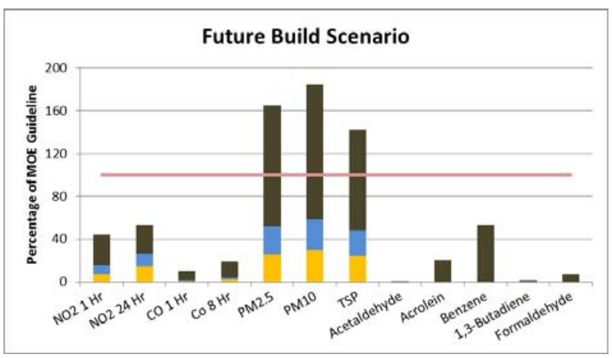
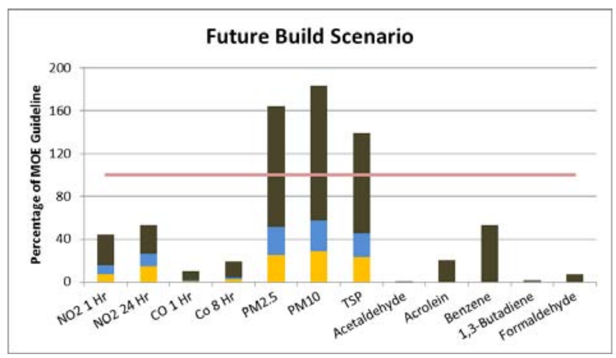

Future Build Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

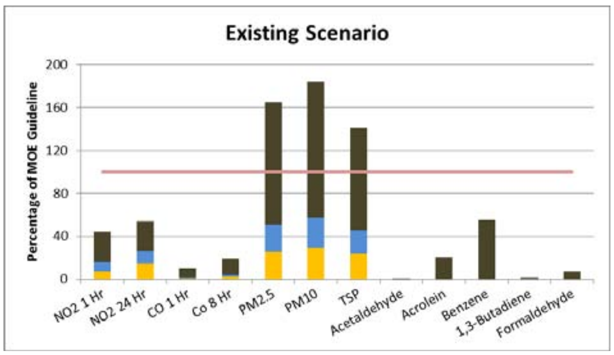
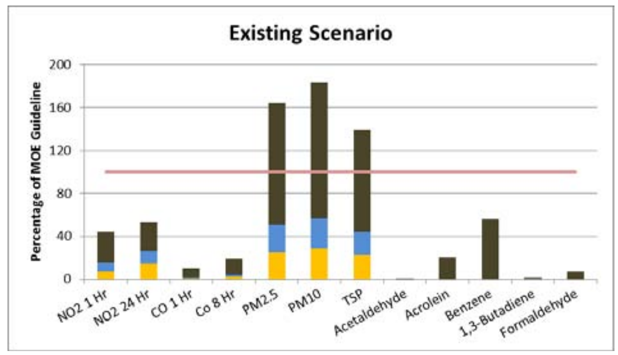
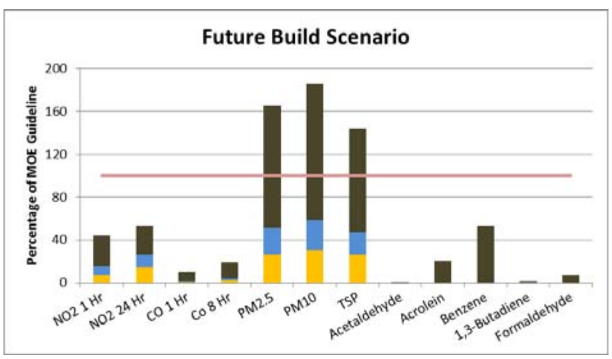
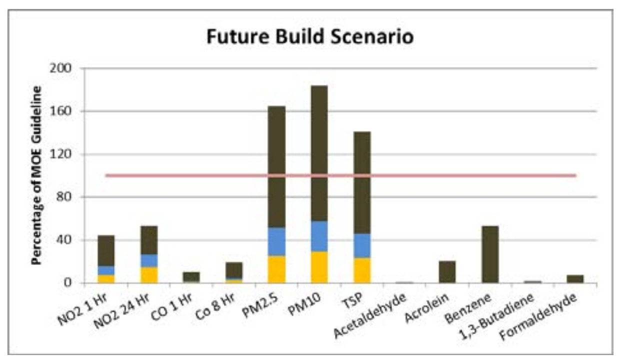
R32

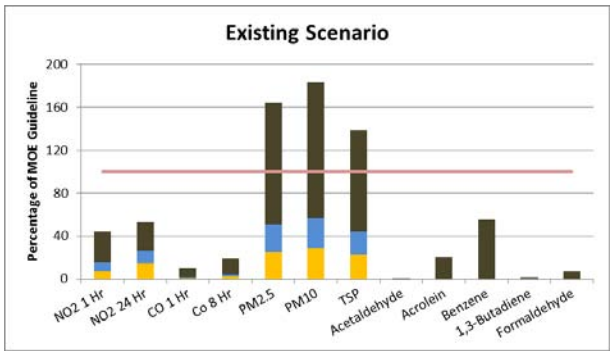
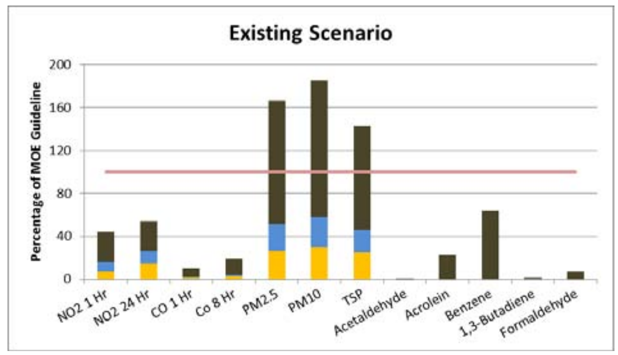
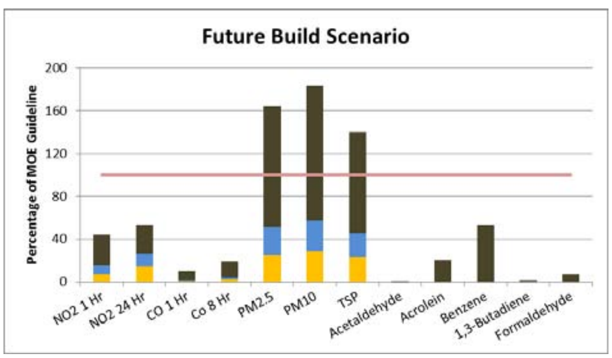
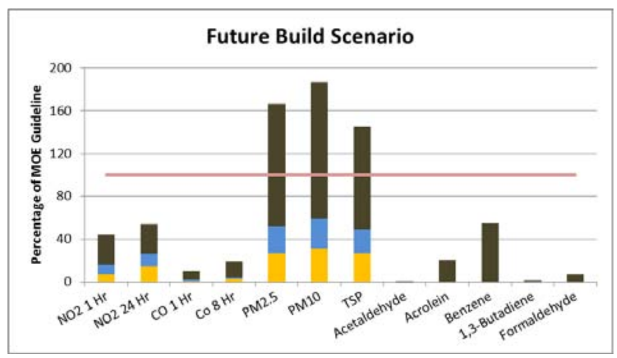

R32

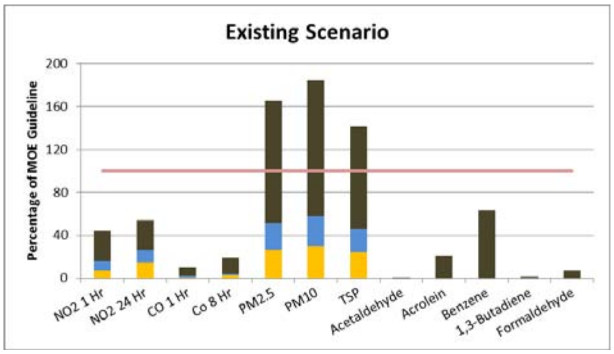
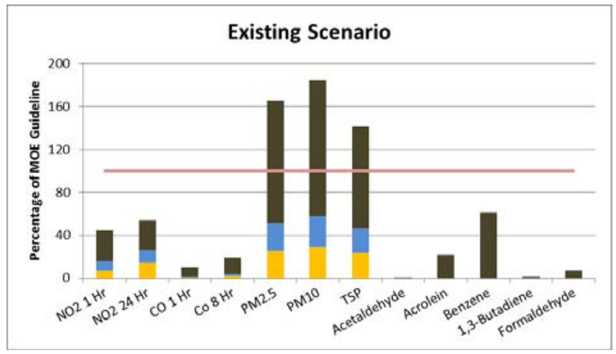
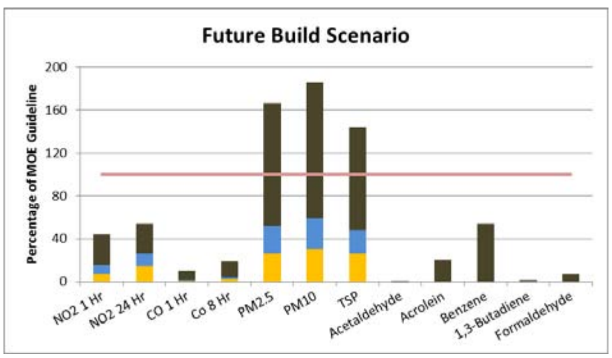
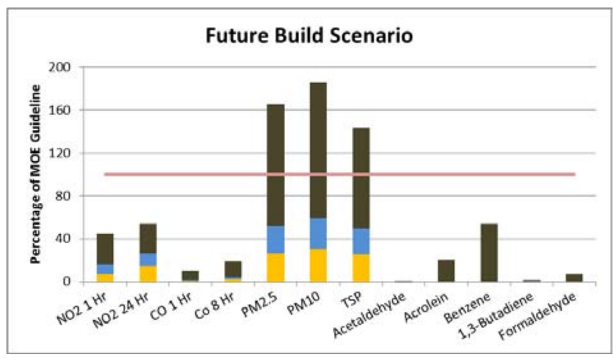

Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R33	R34
R33	R34
Existing Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

R35	R36
R36 R35	
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

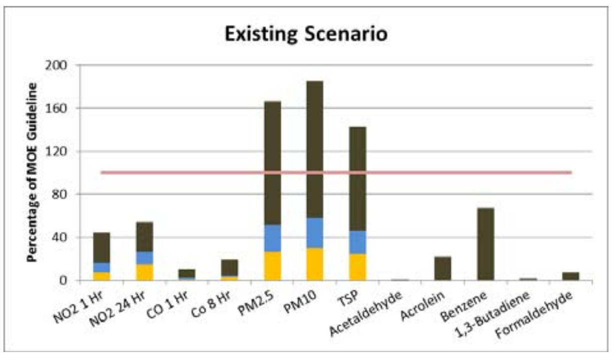
R37	R38
R38 R37	
Existing Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 200 160 120 80 40 0 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

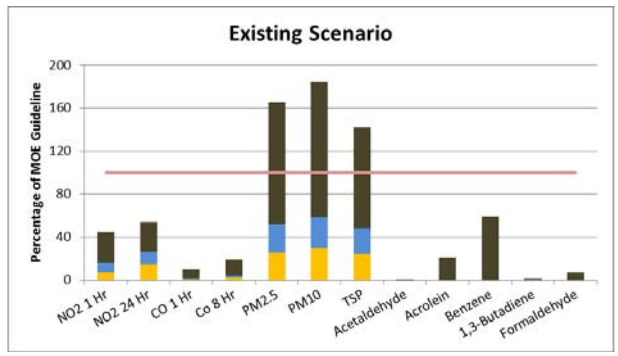
R39	R40
R40 R39 R38	
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

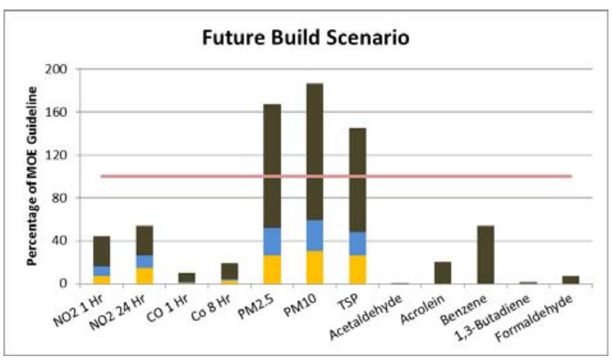
R41	R42


R41


R42
R43


Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
0
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80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
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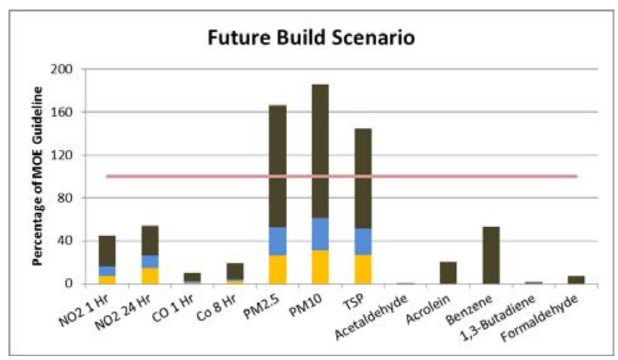
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
0
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80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
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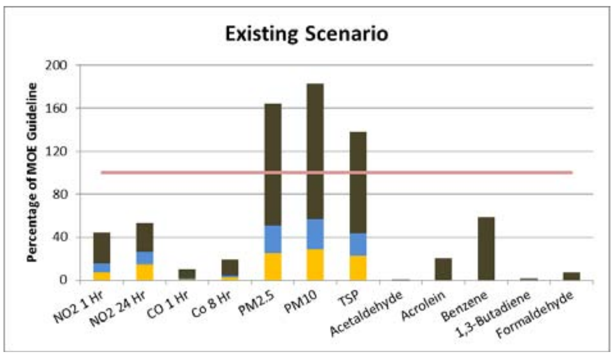
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R43


R42
R43


Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
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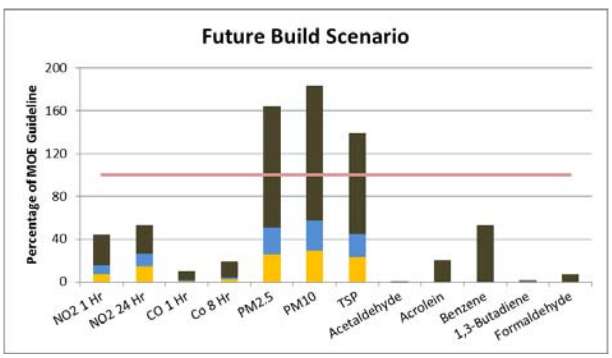
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
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120
80
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0
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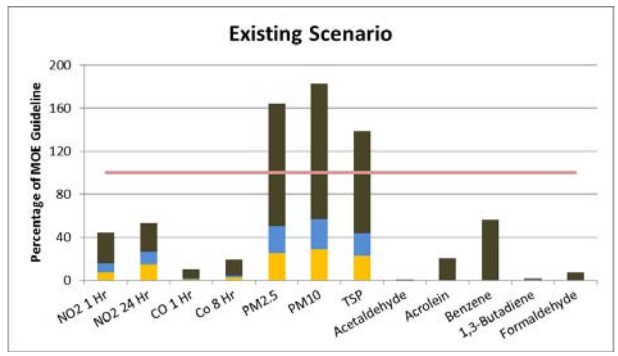
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R44


R45
R44


Existing Scenario
Percentage of MOE Guideline
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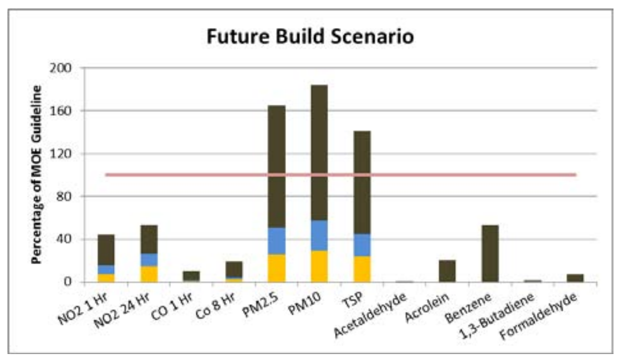
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

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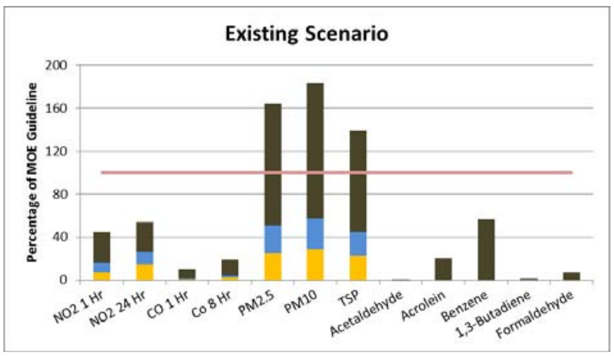

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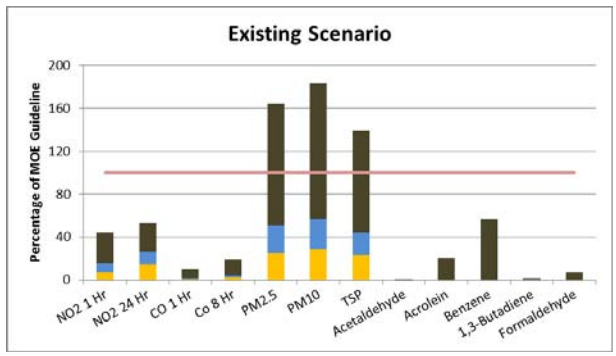

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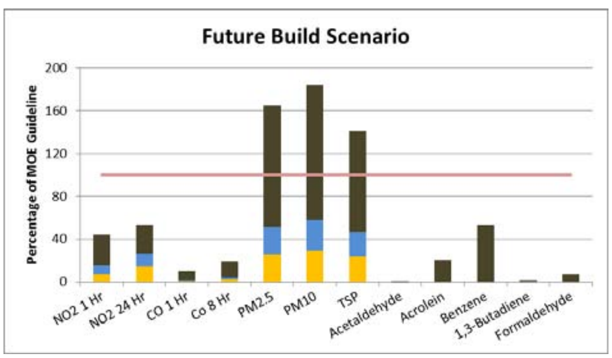

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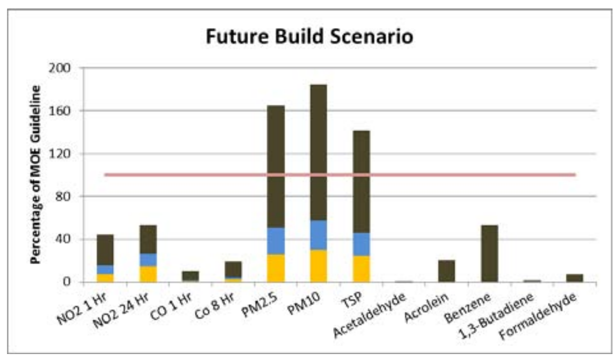

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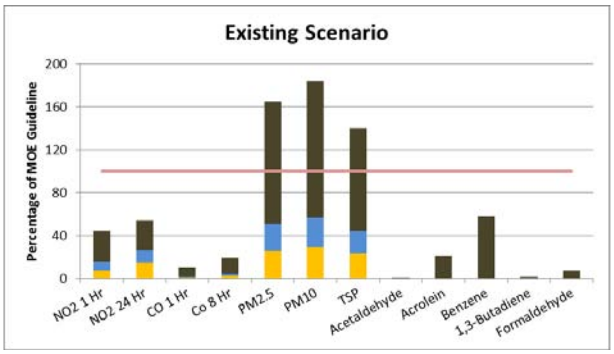
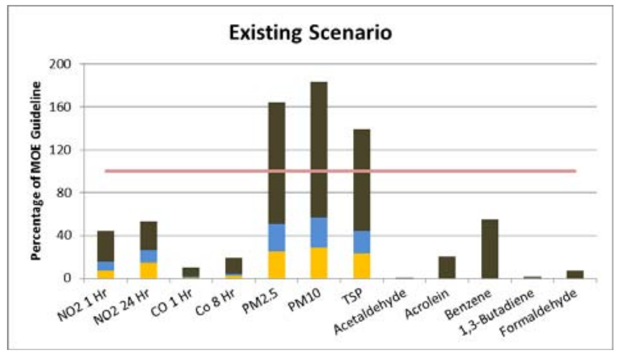
R47	R48


R47


R49
R48


Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
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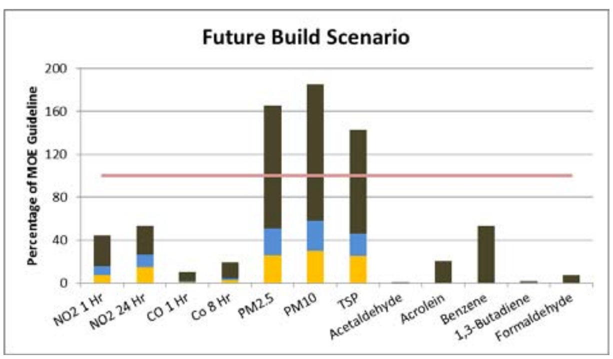
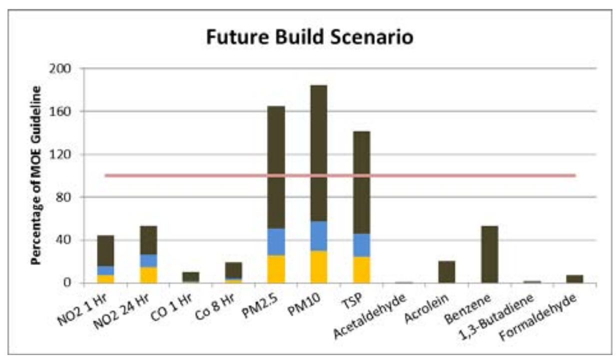
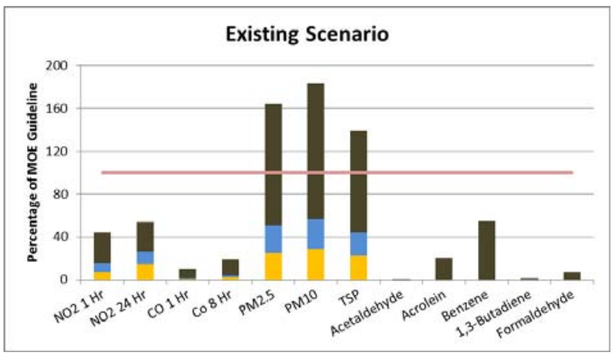
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R49	R50


R50
R49


Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
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NO2 24 Hr
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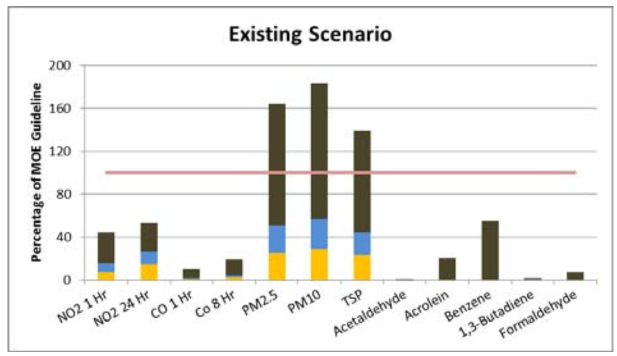
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Existing Scenario
Percentage of MOE Guideline
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80
40
0
NO2 1 Hr
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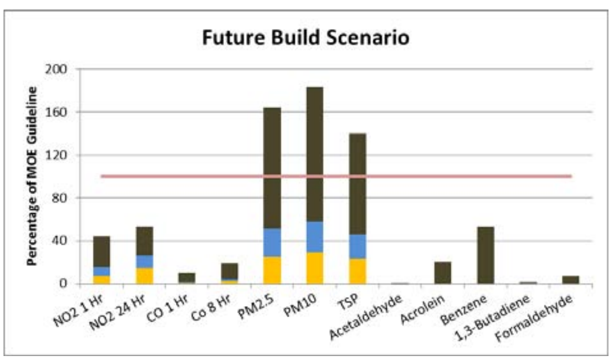
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
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160
120
80
40
0
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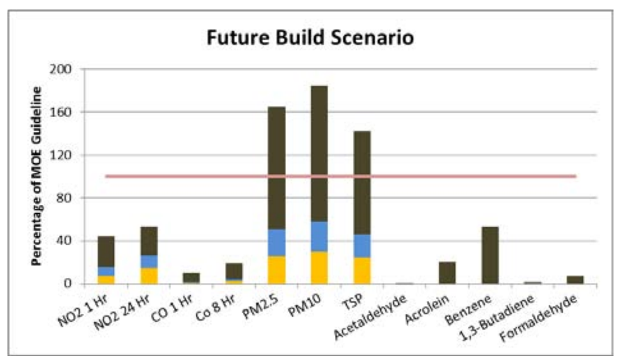
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
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120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
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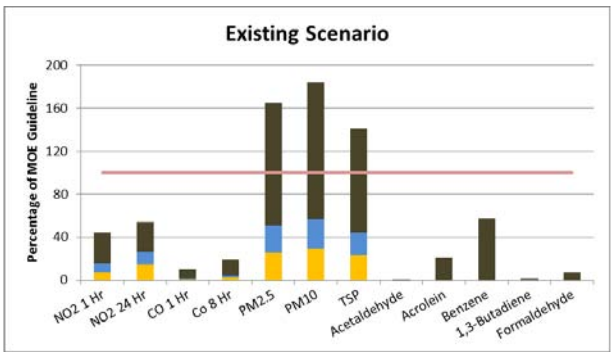
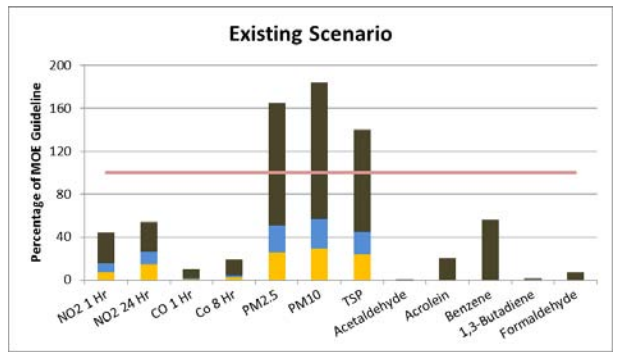
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

R51	R52


R52
R51


Existing Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Existing Scenario
Percentage of MOE Guideline
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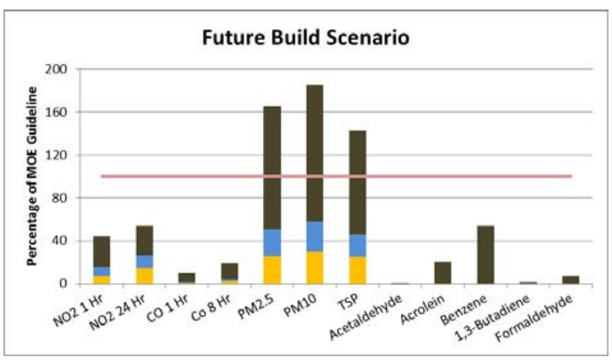
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
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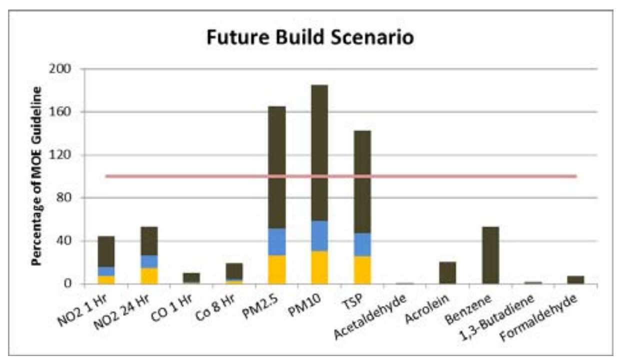
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde


Future Build Scenario
Percentage of MOE Guideline
200
160
120
80
40
0
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
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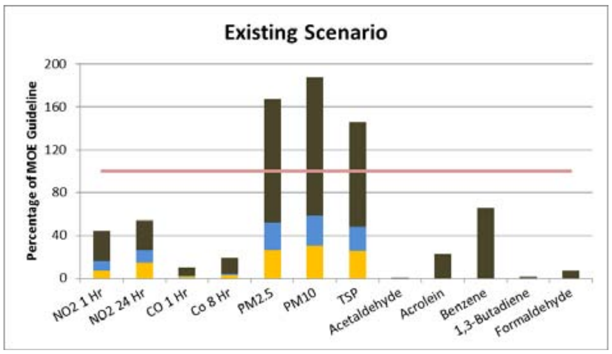
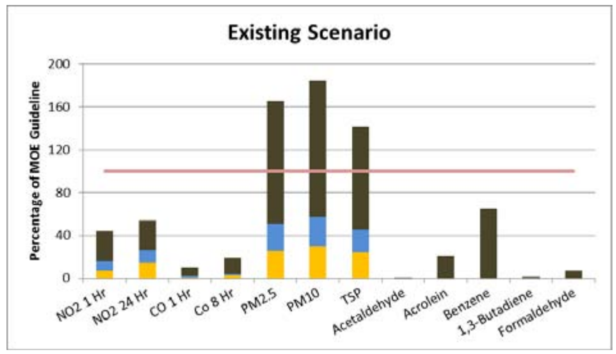
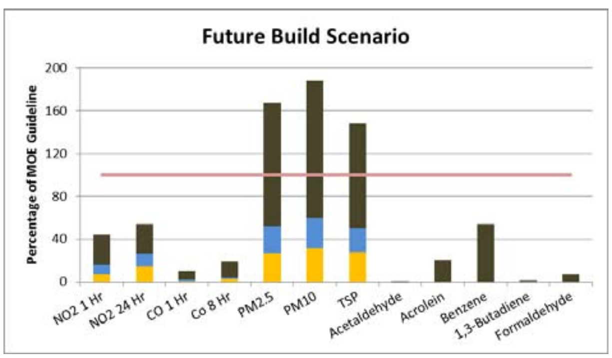
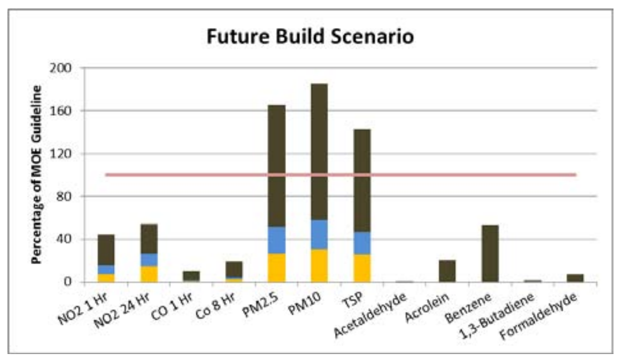
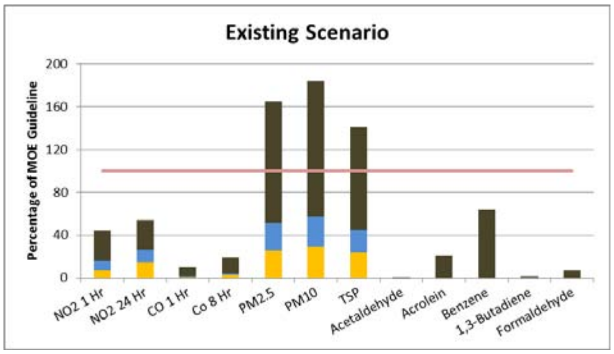
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde

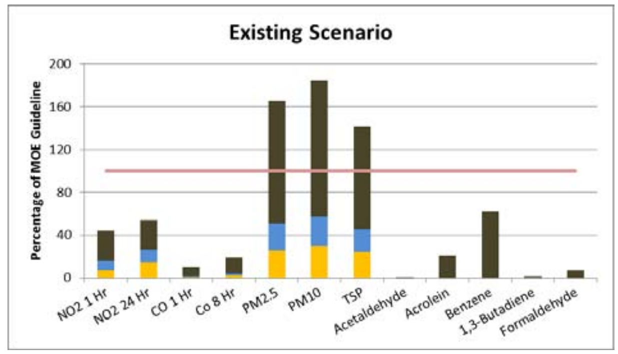
R53	R54
 	
 	
 	

R55	R56

R56
R55



Existing Scenario
Percentage of MOE Guideline
0
40
80
120
160
200
NO2 1 Hr
NO2 24 Hr
CO 1 Hr
Co 8 Hr
PM2.5
PM10
TSP
Acetaldehyde
Acrolein
Benzene
1,3-Butadiene
Formaldehyde



Existing Scenario
Percentage of MOE Guideline
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NO2 1 Hr
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Co 8 Hr
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TSP
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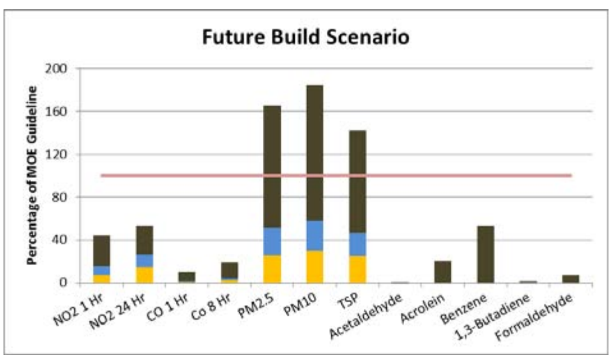
Acrolein
Benzene
1,3-Butadiene
Formaldehyde



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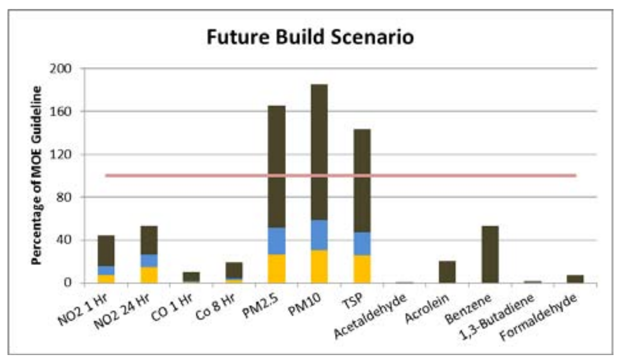

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Benzene
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Formaldehyde

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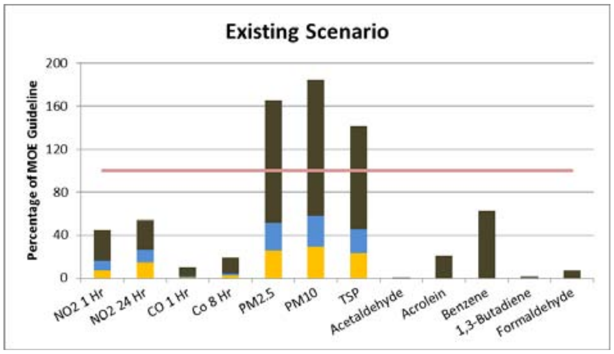
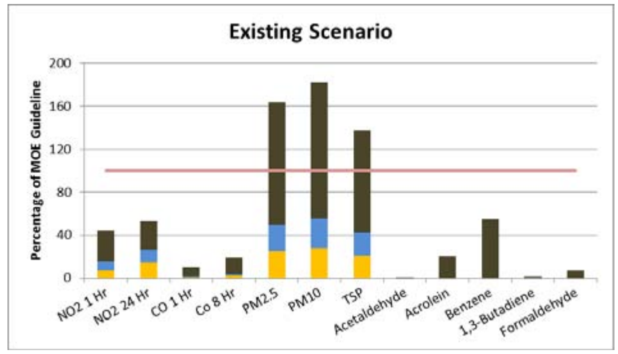
<tr><td>
</td><td>
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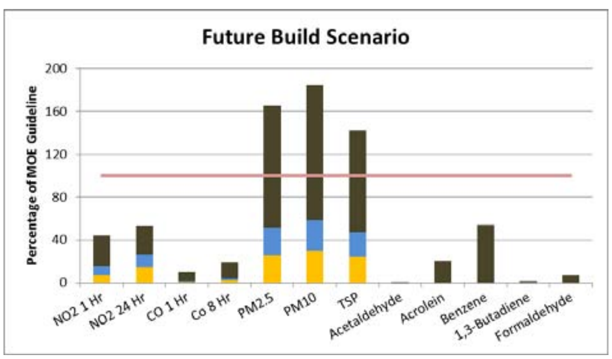
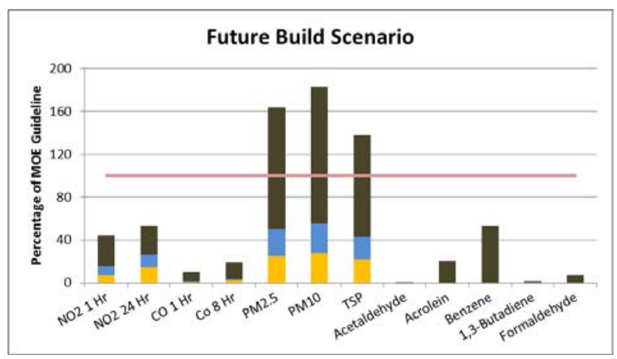
<tr><td>
</td><td>
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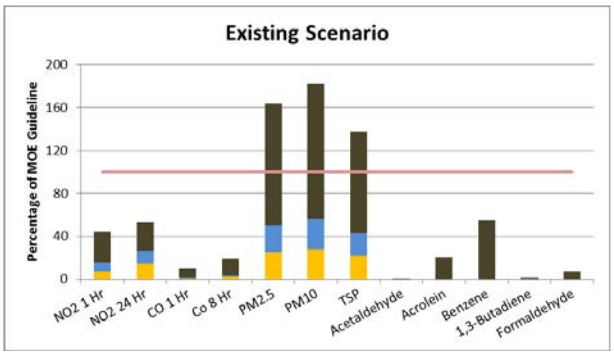

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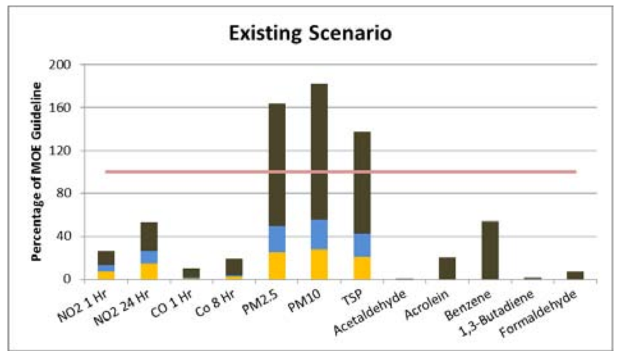

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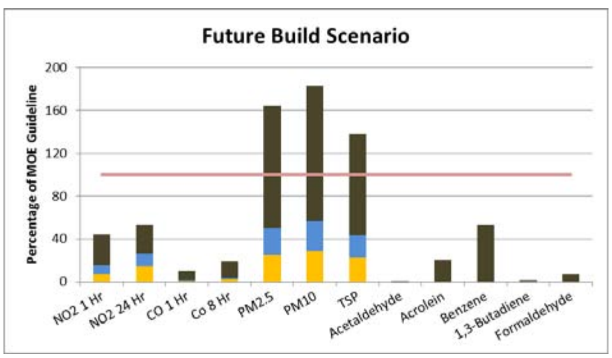

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Co 8 Hr
PM2.5
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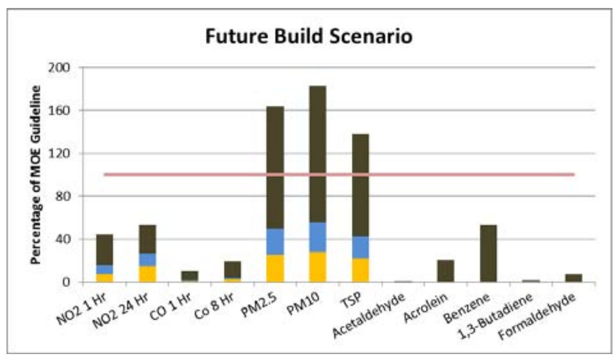

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CO 1 Hr
Co 8 Hr
PM2.5
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Benzene
1,3-Butadiene
Formaldehyde

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R61
R11


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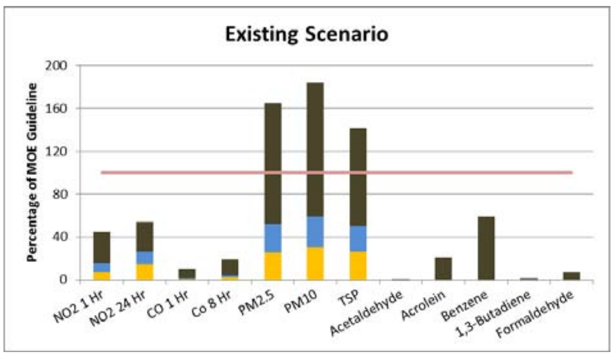
R62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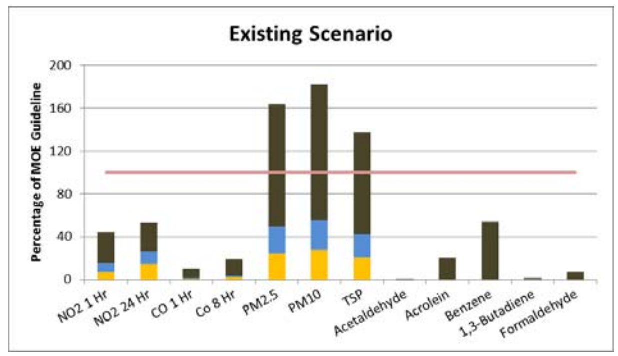
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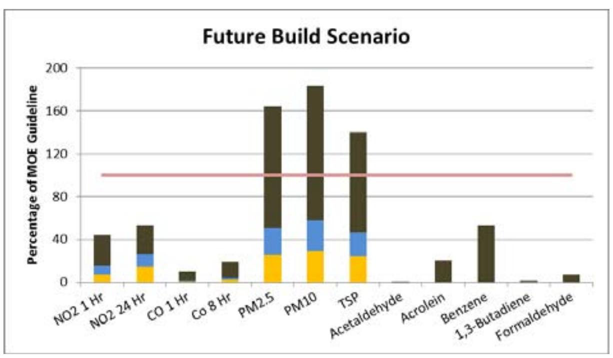
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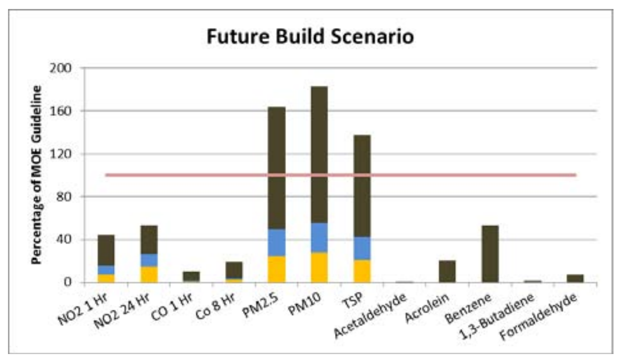
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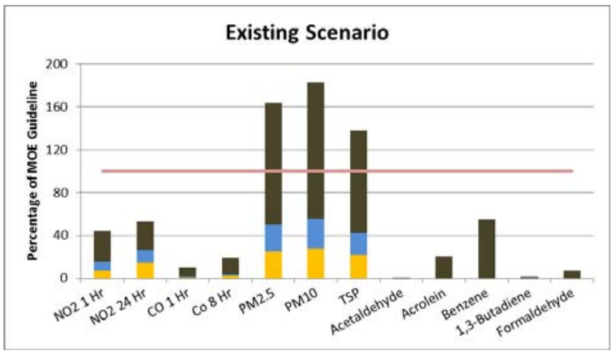
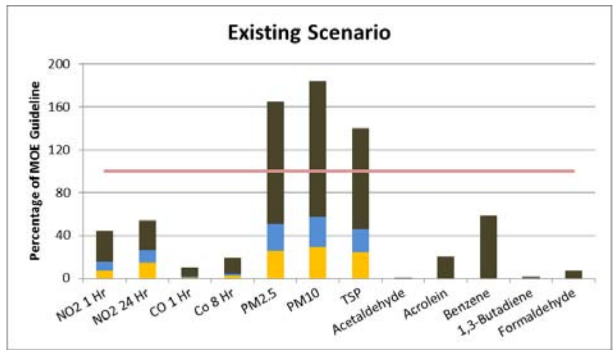
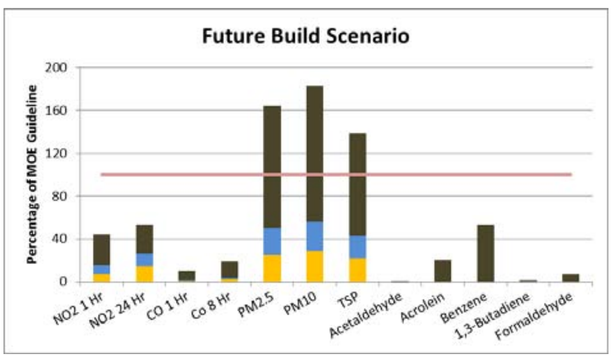
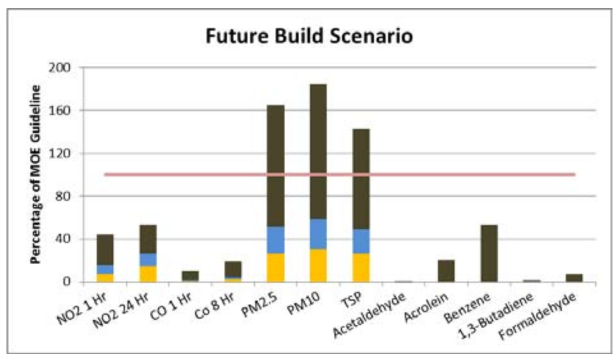
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

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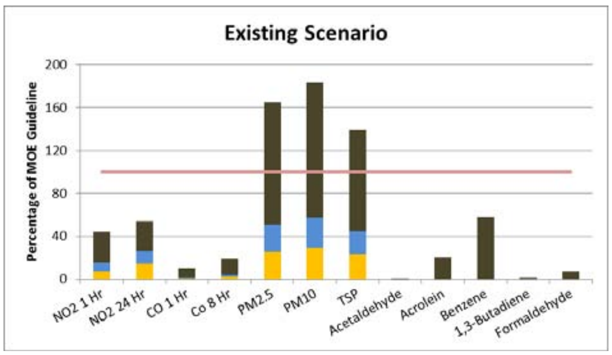

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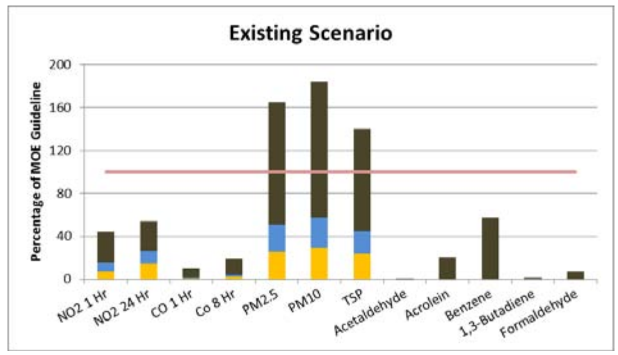

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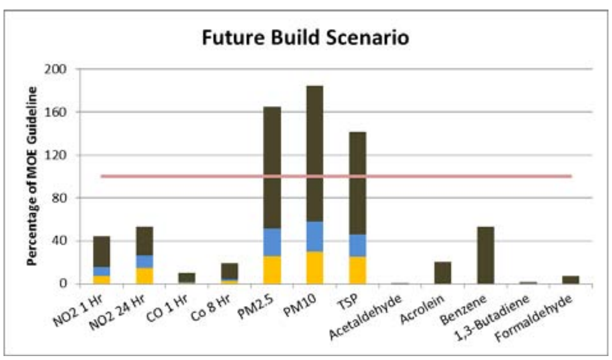

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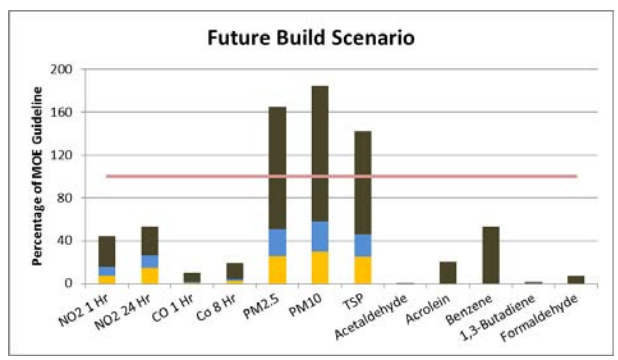

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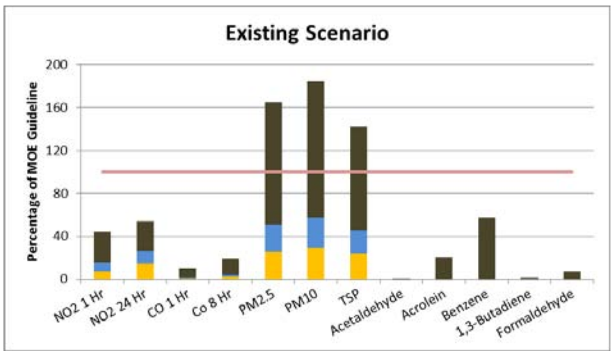
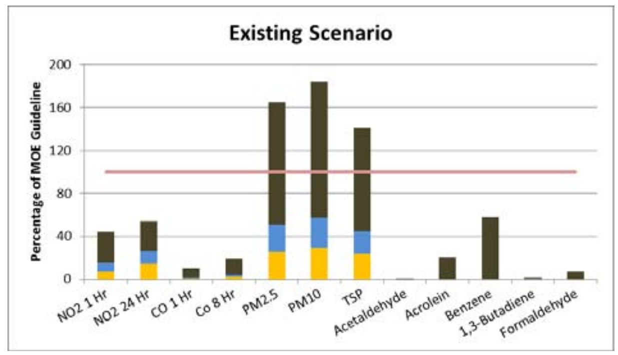
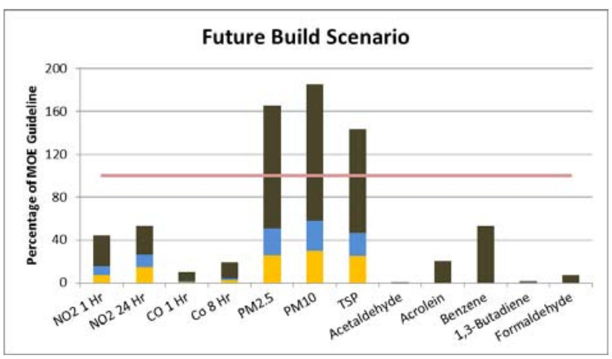
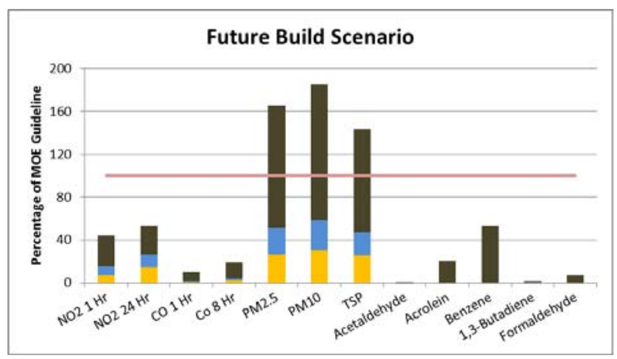
Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Existing Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde
Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde	Future Build Scenario Percentage of MOE Guideline 0 40 80 120 160 200 NO2 1 Hr NO2 24 Hr CO 1 Hr Co 8 Hr PM2.5 PM10 TSP Acetaldehyde Acrolein Benzene 1,3-Butadiene Formaldehyde

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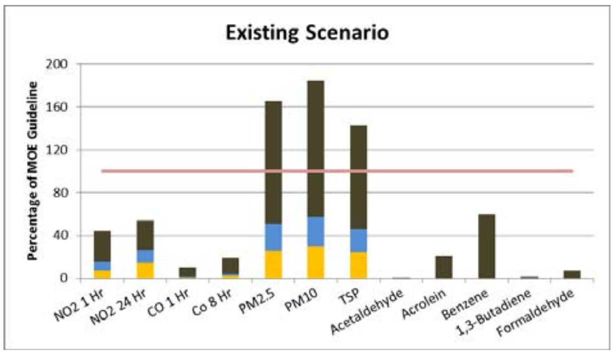
R69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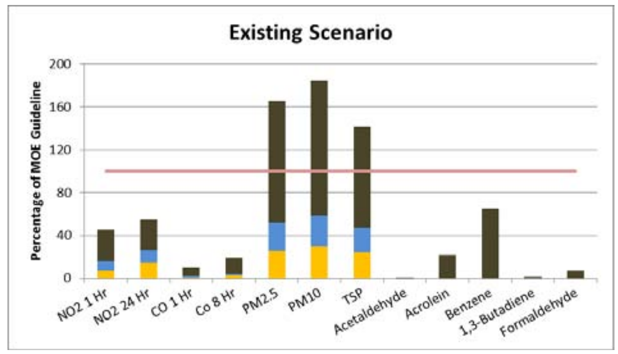
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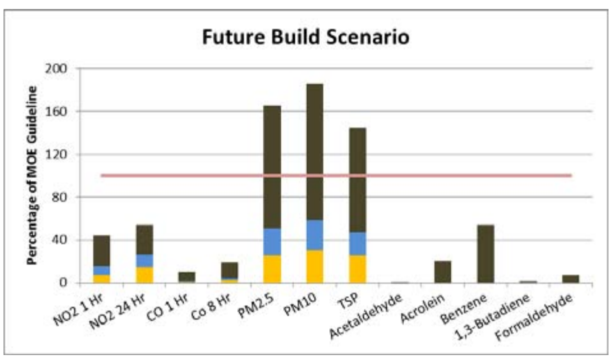
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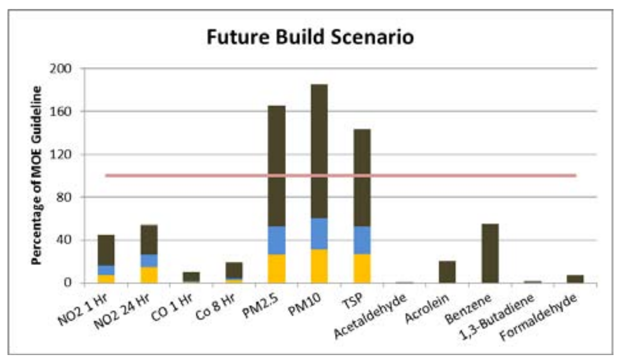
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Air Quality Assessment
Dundas Street Corridor Improvements Class Environmental Assessment
Brant Street to Bronte Road
City of Burlington / Town of Oakville

Novus Reference No.: **11-0023** Version No**. Final** **February 27th, 2014**

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Glenn Ferguson, Ph.D., QPRA (Intrinsik Environmental Sciences)

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e-mail info@novusenv.com **tel** 226.706.8080 **fax** 226.706.8081

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1.0 Introduction

1.1 Background

As part of a tiered improvement approach to Dundas Street from Brant Street to Bronte Road, High Occupancy Vehicle (HOV) transit lanes are being considered in each direction with the plan to ultimately convert the lanes to dedicated Bus Rapid Transit (BRT) lanes as transit ridership increases (**Figure 1**). This section of road will be widened from 2 lanes in each direction to 3 lanes in each direction, with the exterior lanes being used solely for high occupancy vehicles, and transit vehicles. Recognizing that completing the widening of Dundas Street through Oakville and Burlington will take a number of years, and after meeting with residents, local municipalities, transit authorities and others, further consideration was given to a phased implementation approach for providing incremental transportation improvements. By incorporating the HOV lanes that can be used by both buses and qualified vehicles including carpools, the Region would be able to promote transit usage while optimizing the use of the widened road. As the demand for public transit grows to a threshold level, the HOV lanes can be readily converted to dedicated BRT lanes.

Given the above, Halton Region has divided the original study limits from Trafalgar Road to Brant Street into three sections and is carrying out three co-ordinated, but separate Class Environmental Assessment Studies. These studies will be carried out in the following order and will build on earlier work the Project Team has already completed:

Section 1: Bronte Road (Regional Road 25) to Proudfoot Trail - Town of Oakville

Section 2: Neyagawa Boulevard (Regional Road 4) to Oak Park Boulevard - Town of Oakville

Section 3: Brant Street (Regional Road 18) to Bronte Road (Regional Road 25) - City of Burlington / Town of Oakville

The purpose of this report is to document the air quality assessment carried out for the Environmental Assessment Study for the proposed improvements on Dundas Street between Brant Street and Bronte Road in the City of Burlington and Town of Oakville. This section of the roadway runs approximately 8.2 km through the City of Burlington and the Town of Oakville.

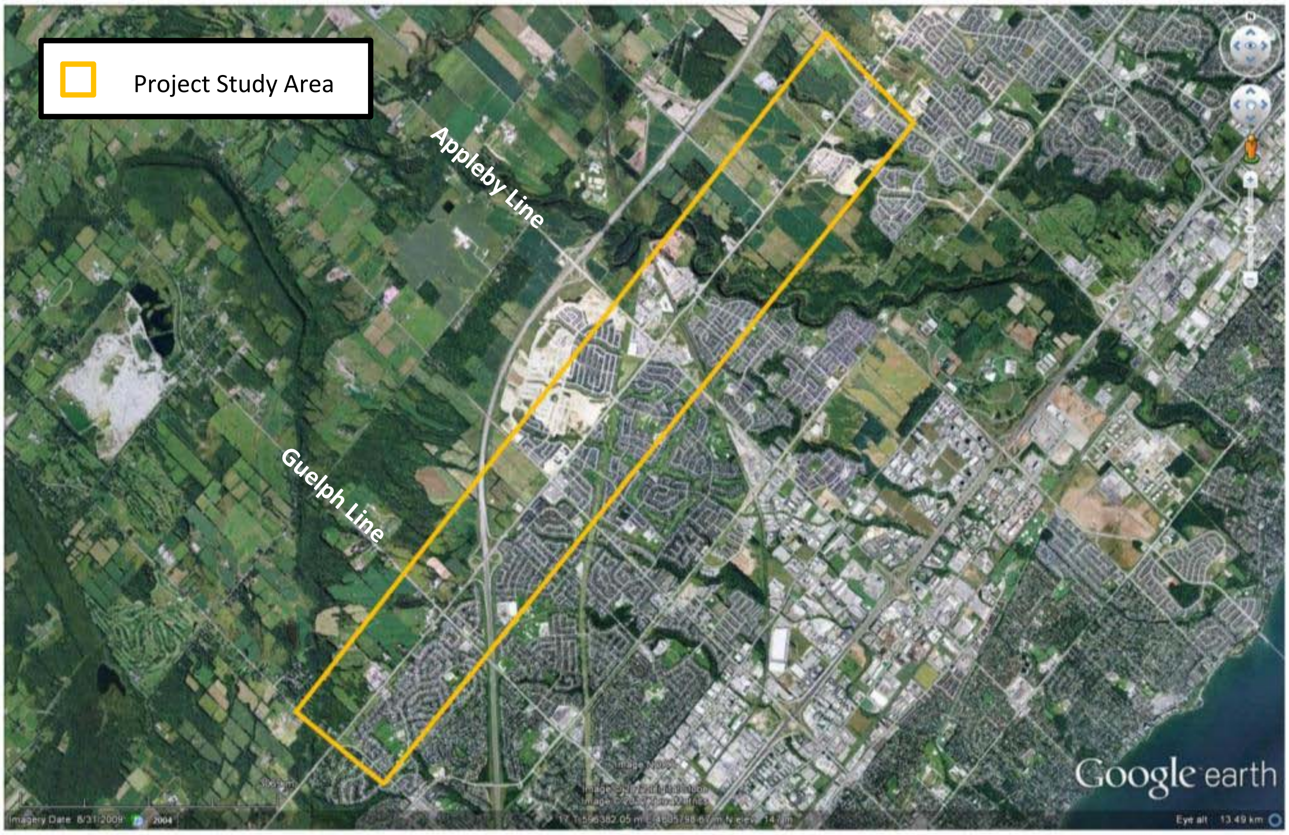


Figure 1: Study Area of Local Air Quality Assessment (Image from Google Earth)

1.2 Halton Region's Air Quality Initiatives

Halton Region understands the importance of air quality and its linkage to public health. With expected growth over the next 25 years, increased stresses on local air quality are anticipated as new vehicles, homes and workplaces are introduced to the community. In response to this expected growth, Halton Region has developed an air quality program that is directed at community emissions. This program includes:

- Air monitoring, including a Region owned air monitoring station in Milton;
- Airshed modelling;
- Policy development directed at the planning and development processes; and
- Health promotion directed at air quality and climate change as they relate to the built environment.

Halton Region's overall air quality initiatives include partnership with communities and corporations. Projects and programs include areas such as renewable energies, protection of natural areas, transportation and planning.

In terms of air quality issues related to roadway and vehicles, Halton Region believed that consideration of the potential for air quality impacts was crucial to formulating a comprehensive and effective

Transportation Master Plan. The current Transportation Master Plan – The Road to Change 2031 included an air quality strategy to limit the impacts of mobile emissions. The key recommendations of the strategy include the following:

- Promote use of transit and Transportation Demand Management (TDM) measures (i.e., carpooling to reduce vehicle kilometres travelled and minimize road traffic congestion);
- Increase fuel efficiency in regional fleet management (e.g., alternative fuels, hybrid engines);
- Implement street sweeping and flushing near construction and industrial activities to minimize dirt trackout and subsequent suspension in the atmosphere;
- Maintain posted driving speeds (e.g., 50 - 80 km/h) to reduce tailpipe emissions, where possible;
- Promote on-street and off-street bicycle and walking trail networks, especially where public transit services are spatially or temporally inadequate;
- Develop design and roadway maintenance guidelines that improve air quality, such as wider paved shoulders and appropriate street and shoulder flushing to reduce dust emissions;
- Increase tree planting across the Region as an effective means of removing airborne contaminants;
- Develop a corporate model, to lead by example, in the reduction of vehicle travel/emissions and the reduction of air quality impacts from transportation sources; and
- Develop an education campaign to promote air quality. Programmes such as commuter challenges, tree planting events and walk/cycle days to work have successfully been implemented in other municipalities.

1.3 Study Objectives

Novus Environmental Inc. (Novus) was retained by MRC to conduct an air quality assessment for the proposed improvements on Dundas Street between Brant Street and Bronte Road; HOV/transit curb lanes in the interim (2021) and ultimately dedicated BRT lanes by 2031.

The objectives of this study are as follows:

- to predict the concentrations of selected contaminants resulting from road traffic on the road for the existing and future build scenarios;
- to predict the combined effect of road traffic and ambient background concentrations at representative worst-case receptors; and
- to use these predictions to assess the potential impacts of the project to applicable guidelines.

2.0 Local Air Quality Assessment

This study looks at the potential impacts of increased vehicular traffic due to the addition of an HOV/transit lane on both sides of Dundas Street. Potential impacts are assessed by predicting contaminant concentrations at sensitive land-uses adjacent to the road for the existing and future build scenarios. The contaminants chosen for this study are those commonly associated with motor vehicle emissions. Local meteorology, vehicle fleet distribution and characteristics, road type and traffic signals were all used in this assessment.

2.1 Contaminants of Interest from Motor Vehicles

The contaminants of interest from motor vehicles have largely been determined by scientists and engineers with United States and Canadian government agencies such as the U.S. Environmental Protection Agency (EPA), Ontario Ministry of Environment (MOE), Environment Canada (EC), Health Canada (HC), and the Ministry of Transportation Ontario (MTO). These contaminants are emitted due to fuel combustion, brake wear, tire wear, the breakdown of dust on the roadway, fuel leaks, evaporation and permeation, and refuelling leaks and spills and are illustrated below. Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions resulting from travel on a roadway. Instead, these emissions contribute to the overall background levels of the applicable contaminants.

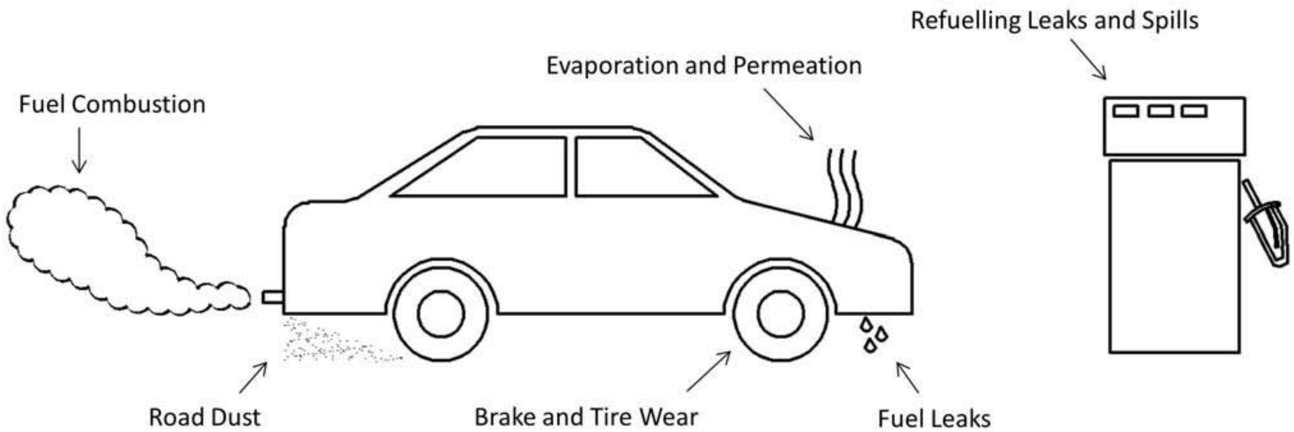


Figure 2: Motor Vehicle Emission Sources

The contaminants of interest from motor vehicles are categorized as Criteria Air Contaminants (CACs) and Volatile Organic Compounds (VOCs). The contaminants emitted during fuel combustion include all of the CACs and VOCs, and the contaminants emitted from brake wear, tire wear, and breakdown of road dust include the particulates. A summary of these contaminants is provided in **Table 1**.

Table 1: Contaminants of Interest

Criteria Air Contaminants (CACs)		Volatile Organic Compounds (VOCs)	
Name	**Symbol**	**Name**	**Symbol**
Nitrogen Dioxide	NO_2	Acetaldehyde	HCHO
Carbon Monoxide	CO	Acrolein	C_3H_4O
Fine Particulate Matter (<2.5 microns in diameter)	$PM_{2.5}$	Benzene	C_6H_6
Coarse Particulate Matter (<10 microns in diameter)	PM_{10}	1,3-Butadiene	C_4H_6
Total Suspended Particulate Matter (<44 microns in diameter)	TSP	Formaldehyde	CCHO

2.2 Applicable Guidelines

In order to assess the impact of the project, the predicted effects at sensitive receptors were compared to guidelines established by the government agencies and organizations. Relevant agencies and organizations in Canada and their applicable contaminant guidelines are:

- MOE Ambient Air Quality Criteria (AAQC)
- Health Canada/Environment Canada National Ambient Air Quality Objectives (NAAQOs)
- Canadian Council of Ministers of the Environment (CCME) Canada Wide Standards (CWSs)

Within the guidelines, the threshold value for each contaminant and its applicable averaging period was used to assess the maximum predicted effect at sensitive receptors derived from computer simulations. The applicable averaging periods for the contaminants of interest are based on 1, 8 and 24-hour acute (short-term) exposures. The threshold values and averaging periods used in this assessment are presented in **Table 2** below. It should be noted that the CWS for $PM_{2.5}$ is not based on the maximum threshold value. Instead, it is based on the average annual 98^{th} percentile value, averaged over 3 consecutive years.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value (µg/m^3)	Source
NO_2	1	400	AAQC
	24	200	AAQC
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	30*	AAQC (CWS)
PM_{10}	24	50	Interim AAQC
TSP	24	120	AAQC
Acetaldehyde	24	500	AAQC
Acrolein	1	4.5	MOE Environmental Registry
	24	0.4	MOE Environmental Registry
Benzene	24	2.3	MOE Environmental Registry
1,3-Butadiene	24	10	MOE Environmental Registry
Formaldehyde	24	65	AAQC

* The CWS is based on the average annual 98th percentile concentration, averaged over three consecutive years.

2.3 Background (Ambient) Conditions

2.3.1 Overview

Background (ambient) conditions are contaminant concentrations that are exclusive of emissions from the existing or proposed project infrastructure. These emissions are typically the result of trans-boundary (macro-scale), regional (meso-scale), and local (micro-scale) emission sources and result due to both primary and secondary formation. Primary contaminants are emitted directly by the source and secondary contaminants are formed by complex chemical reactions in the atmosphere. Secondary pollution is generally formed over great distances in the presence of sunlight and heat and most noticeably results in the formation of fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3), also considered smog.

In Ontario, a significant amount of smog originates from emission sources in the United States and is the major contributor during smog events, usually occurring in the summer season (MOE, 2005). During smog episodes, the U.S. contribution to $PM_{2.5}$ can be as much as 90 percent near the southwest U.S. border and approximately 50 percent in the Greater Toronto Area (GTA). The effect of U.S. air pollution on Ontario on a high $PM_{2.5}$ day and on an average $PM_{2.5}$ spring/summer day is illustrated in **Figure 3**.

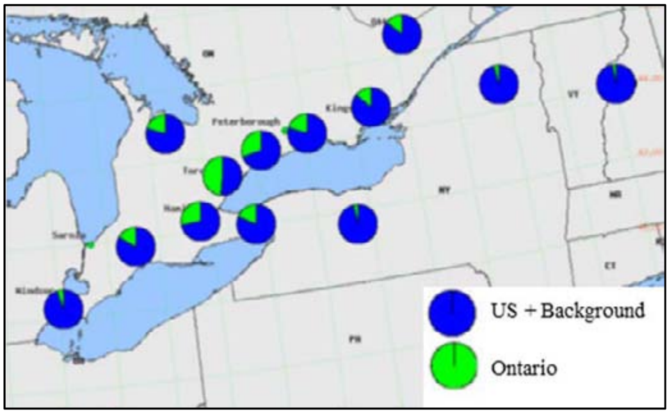
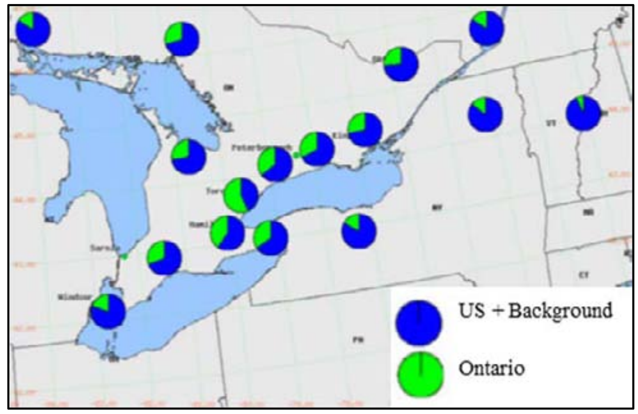
High PM$_{2.5}$ Days	Average PM$_{2.5}$ of Spring/Summer Season
	

Figure 3: Effect of Trans-boundary Air Pollution (MOE, 2005)

Air pollution is strongly influenced by weather systems (i.e., meteorology) that typically move out of central Canada into the mid-west of the U.S. then eastward to the Atlantic coast. This weather system generally produces winds with a southerly component that travel over major emission sources in the U.S. and result in the transport of pollution into Ontario. This phenomenon is demonstrated in the following figure and is based on a computer model run from the Weather Research and Forecasting (WRF) Model.

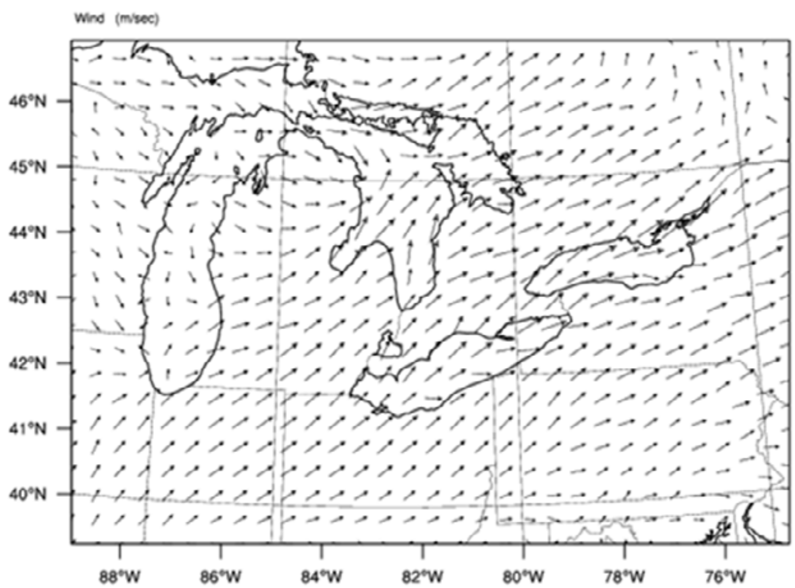


Figure 4: Typical Weather System during a Smog Episode

As discussed above, understanding the composition of background air pollution and its influences is important in determining the potential impacts of a project, considering that the majority of the combined concentrations are typically due to existing elevated ambient background levels. In this assessment, background conditions were characterized utilizing existing ambient monitoring data from MOE and

NAPS (National Air Pollution Surveillance) Network stations and added to the modelled predictions in order to conservatively estimate the combined concentration.

2.3.2 Selection of Relevant Ambient Monitoring Stations

A review of MOE and NAPS monitoring stations in Ontario was undertaken in order to select the monitoring stations that are in relevant proximity to the study area and that would be representative of background contaminant concentrations in the study area. Five MOE and five NAPS monitoring stations were determined to be representative of background conditions in the study area. The representative MOE stations were Burlington, Oakville, Mississauga, Brampton and Toronto West. The representative NAPS stations were Kitchener, Toronto West, Brampton, Egbert and Windsor. Their locations relevant to the study area (highlighted blue) are shown in **Figure 5** and station information can be found in **Table 3.** Note that the Winsor station is not shown, due to its distance from the study area.

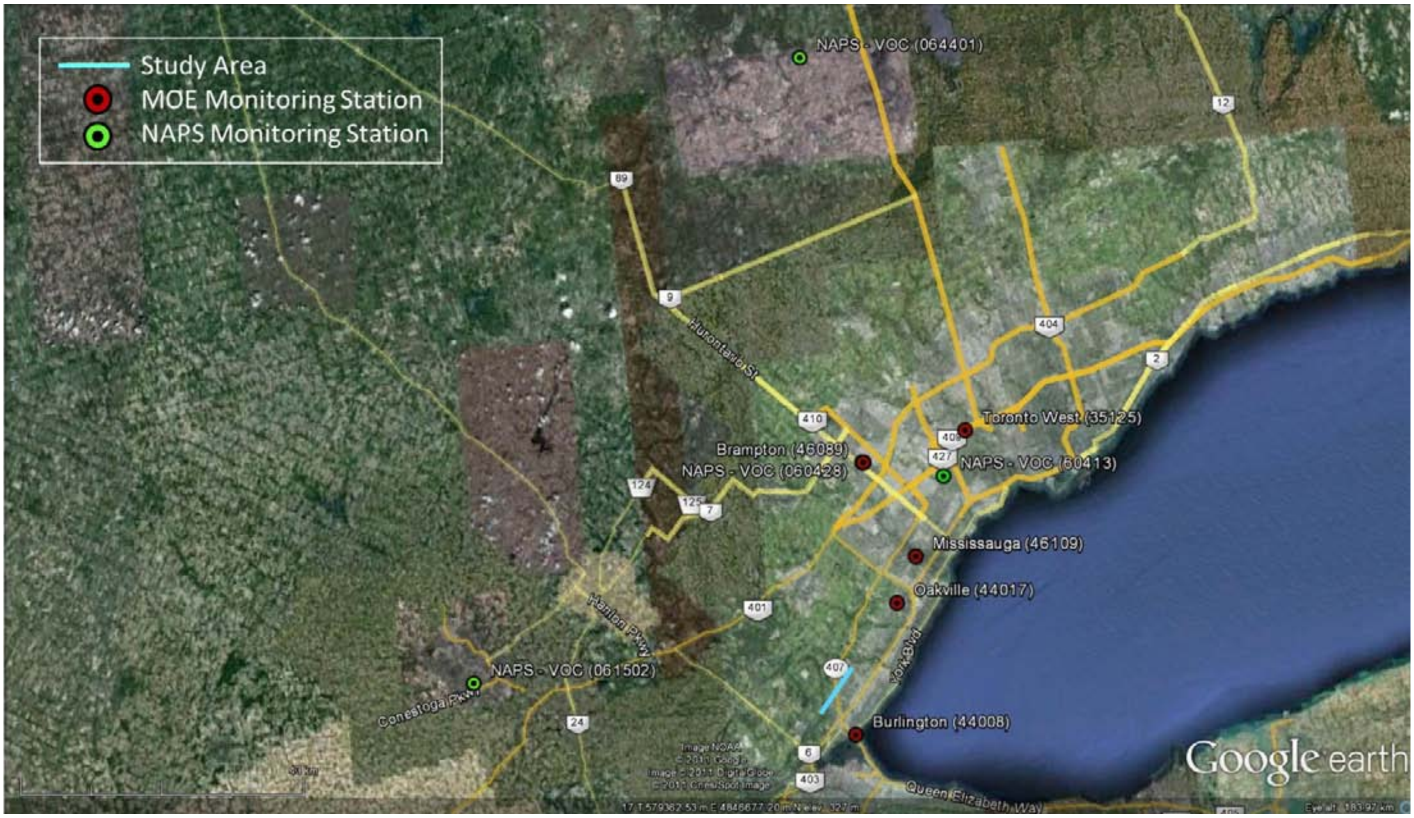


Figure 5: Relevant MOE and NAPS Monitoring Stations

Table 3: Relevant MOE and NAPS Monitoring Station Information

City/Town	Station ID	Location	Operator	Contaminants
Burlington	44008	North Shore Blvd. E./Lakeshore Rd.	MOE	$PM_{2.5}$ | NO_2
Oakville	44017	Eighth Line/Glenashton Dr.	MOE	$PM_{2.5}$ | NO_2
Mississauga	46109	3359 Mississauga Rd. N.	MOE	$PM_{2.5}$ | NO_2
Brampton	46089	525 Main St. N	MOE	$PM_{2.5}$ | NO_2
Toronto West	35125	125 Resources Rd.	MOE	CO
Kitchener	61502	West Ave. & Homewood	NAPS	Benzene | 1,3-Butadiene
Toronto West	60413	Elmcrest Rd.	NAPS	Benzene | 1,3-Butadiene
Brampton	60428	525 Main St. N	NAPS	Benzene | 1,3-Butadiene
Egbert	64401	Simcoe RR56/Murphy Rd.	NAPS	Formaldehyde | Acetaldehyde
Windsor	60211	College Ave./Prince Rd.	NAPS	Formaldehyde | Acetaldehyde |Acrolein

Since the study area is surrounded by many monitoring stations, a comparison of several stations was performed for the available data on a contaminant basis, to determine the worst-case representative background concentration (see **Section 2.3.3**). Selecting the worst-case concentration would result in conservative combined concentrations. Recently in Ontario, formaldehyde and acetaldehyde are only measured at the Egbert and Windsor stations and acrolein is measured only at Windsor. It is likely that acrolein concentrations from Windsor result in conservative background concentrations in this study area due to the large amount of industrial activity in the Windsor area.

2.3.3 Selection of Worst-Case Monitoring Station

Year 2005 to 2009 hourly ambient monitoring data, the most recent 5 years publically available, from the selected stations were statistically summarized for average, 90th percentile (90 percent of the dataset are less than or equal to the 90th percentile value), and maximum concentration for the desired averaging period, 1-hour, 8-hour or 24-hour. Average concentrations represent a typical background scenario, 90th percentile concentrations represent a typical worst-case background scenario, and maximum concentrations represent a worst-case background scenario. It should be noted that the 2005 to 2009 monitoring data was selected to coincide with 2005 to 2009 meteorological data for consistency in the dispersion modelling.

For the CACs, the station with the highest five year maximum value for each contaminant and averaging period was selected to represent background concentrations in the study area. From a review of the VOC dataset, it was determined that due to the lack of hourly and daily background monitoring data, 90th percentile background concentrations for each VOC in the 5 year dataset would be calculated and used to determine the combined concentration. The station with the highest five year 90th percentile value for each VOC was selected to represent background concentrations in the study area. This method was suggested by the MOE.

Table 4: Comparison of Background NO_2

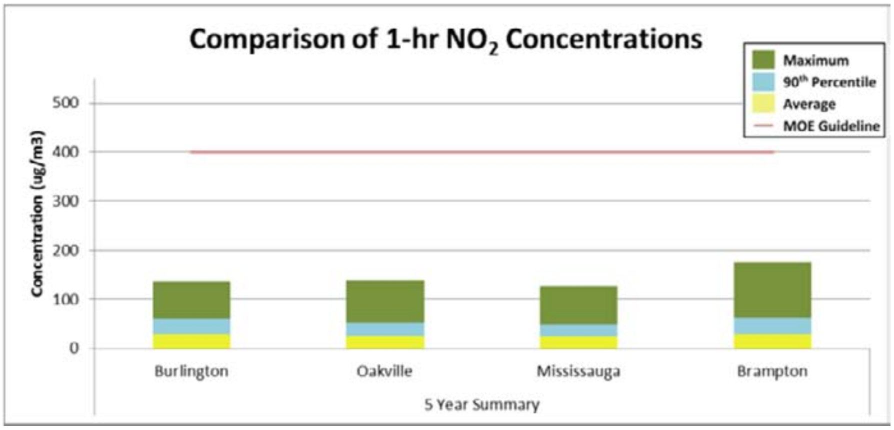
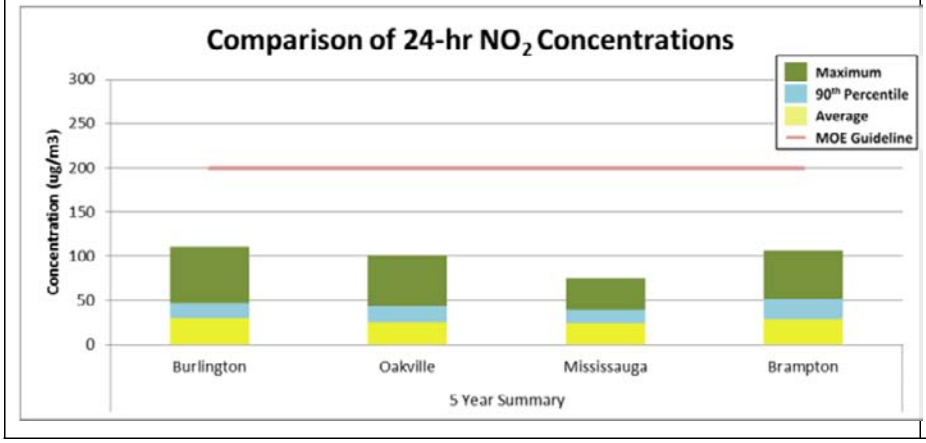
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Brampton Station on a 1-hour basis.
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Burlington Station on a 24-hour basis.

Table 5: Comparison of Background CO

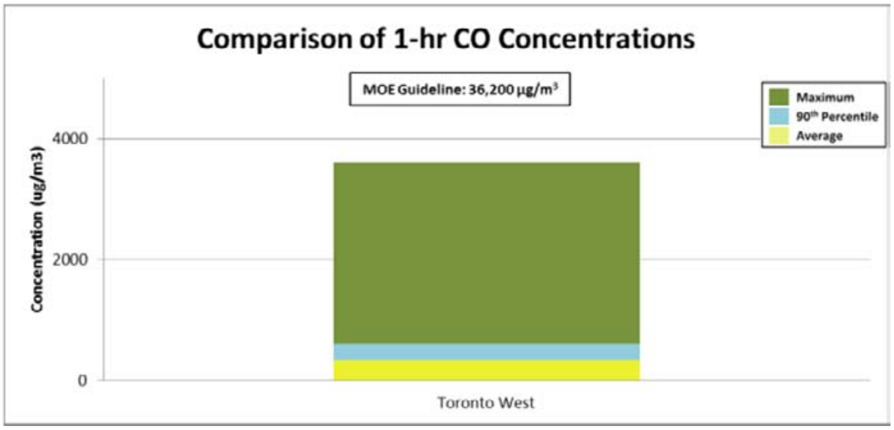
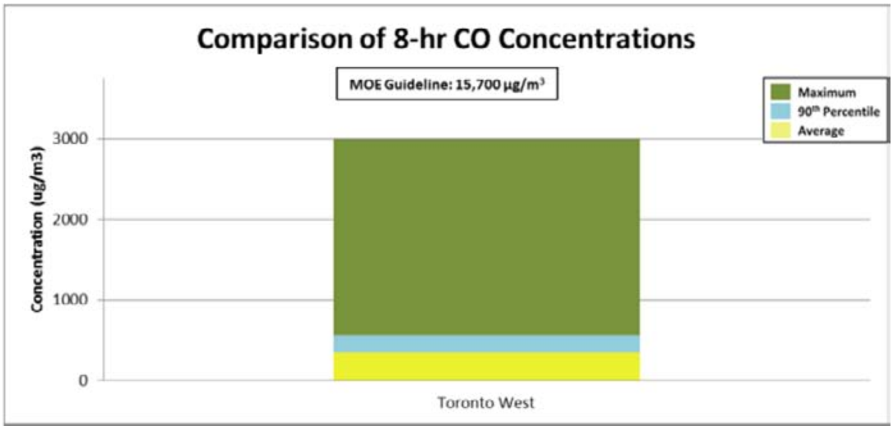
Statistical Analysis	Selection of Station
	**Conclusion:** Toronto West is the only representative station for the study area with ambient monitoring data for CO.
	**Conclusion:** Toronto West is the only representative station for the study area with ambient monitoring data for CO.

Table 6: Comparison of Background $PM_{2.5}$

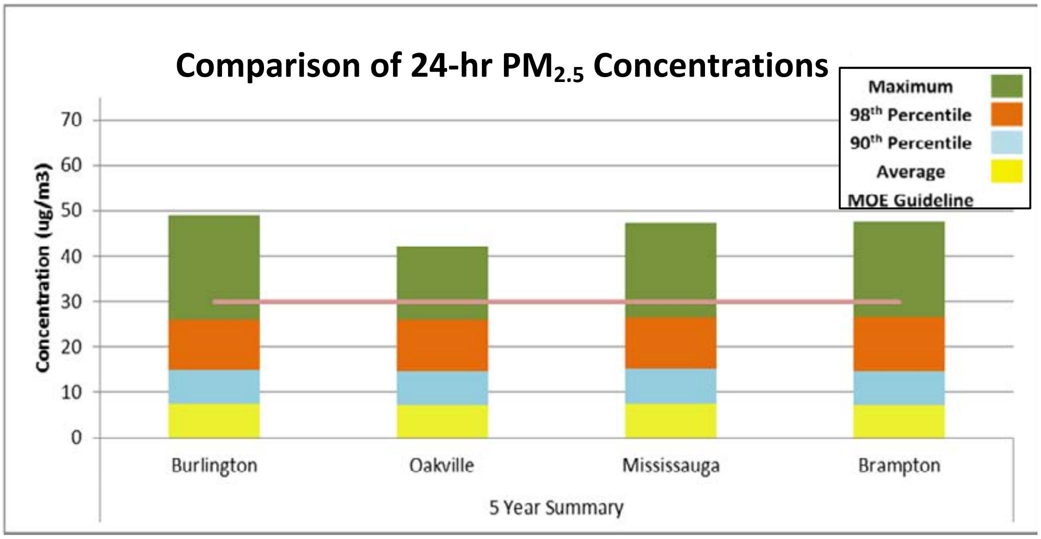
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration was measured at the Burlington Station on a 24-hour basis.

Table 7: Comparison of Background PM_{10}

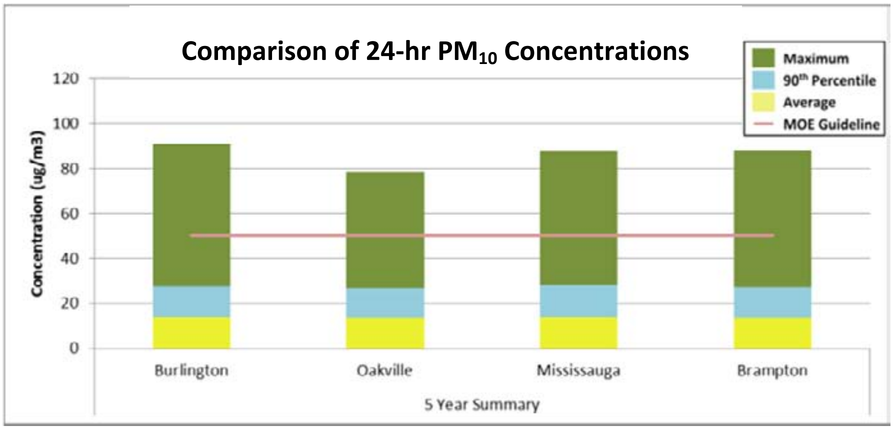
Statistical Analysis	Selection of Station
 **<u>Note</u>:** PM_{10} is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54. Lall et al. (2004)	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration would occur at the Burlington Station on a 24-hour basis.

Table 8: Comparison of Background TSP

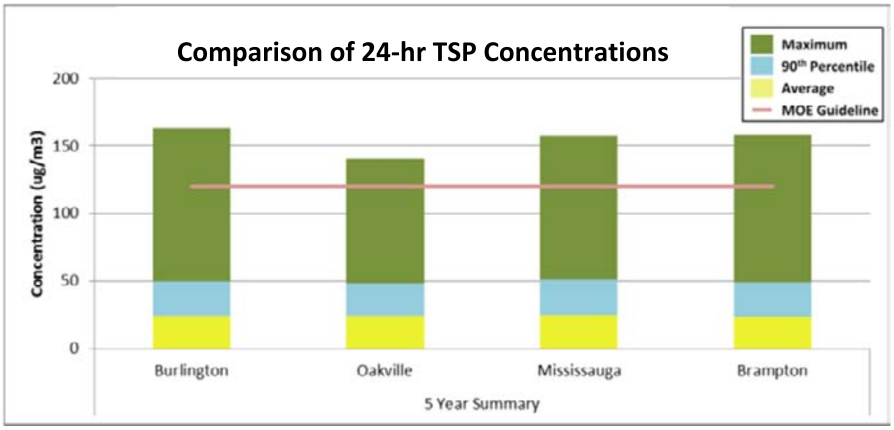
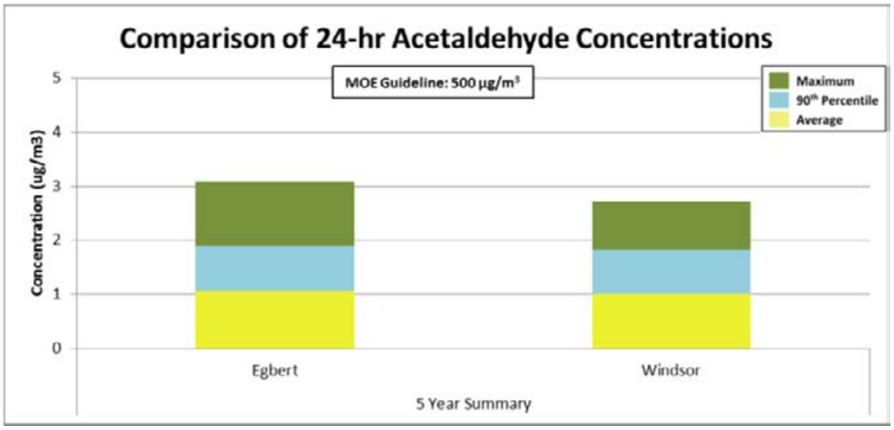
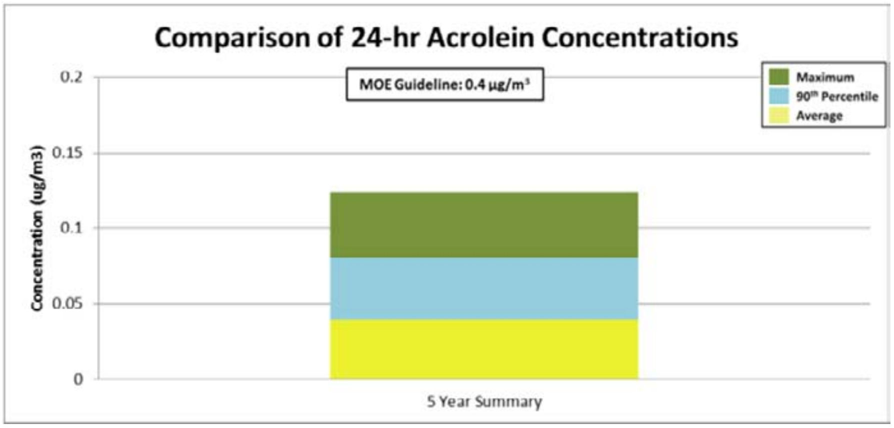
Statistical Analysis	Selection of Station
 **<u>Note</u>:** TSP is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}$/TSP ratio of 0.3. Lall et al. (2004)	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the maximum background concentration would occur at the Burlington Station on a 24-hour basis.

Table 9: Comparison of Background Acetaldehyde

<table>
<tr><th>Statistical Analysis</th><th>Selection of Station</th></tr>
<tr><td>
</td><td>Conclusion:

A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Egbert Station.</td></tr>
</table>

Table 10: Comparison of Background Acrolein

<table>
<tr><th>Statistical Analysis</th><th>Selection of Station</th></tr>
<tr><td>
</td><td>Conclusion:

Windsor is the only station at which ambient monitoring data for acrolein is collected in Ontario.</td></tr>
</table>

Table 11: Comparison of Background Benzene

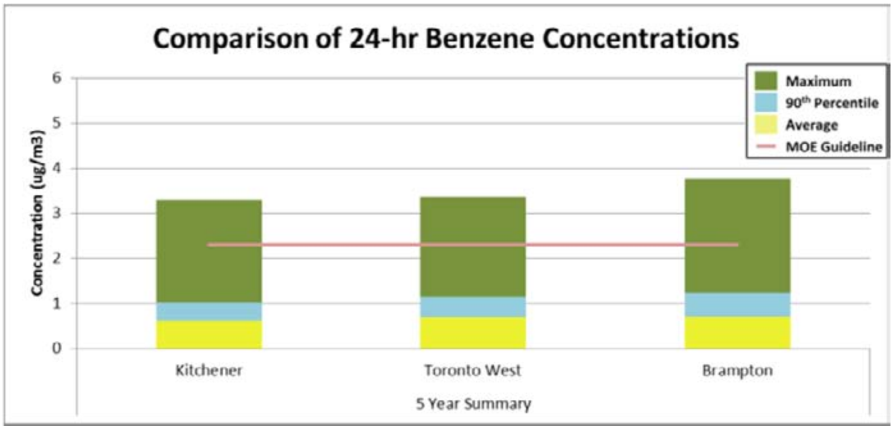
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Brampton Station.

Table 12: Comparison of Background 1,3-Butadiene

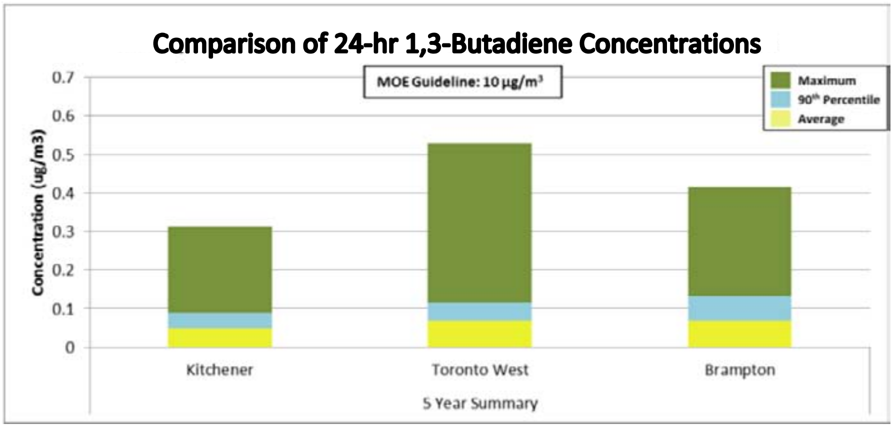
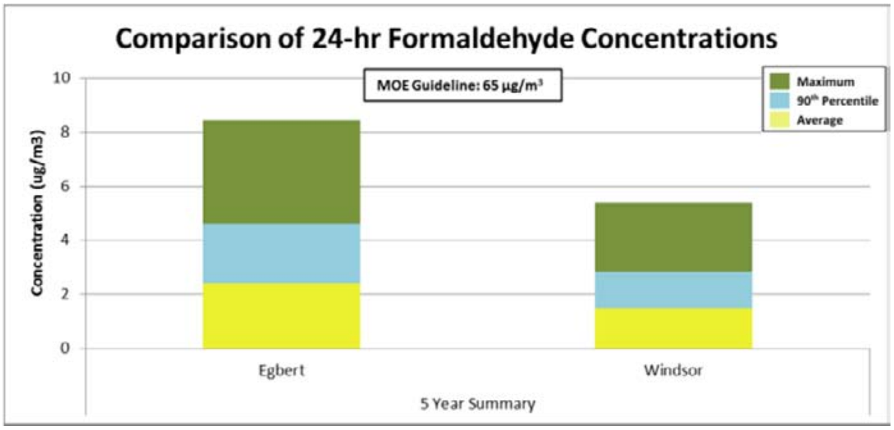
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Brampton Station.

Table 13: Comparison of Background Formaldehyde

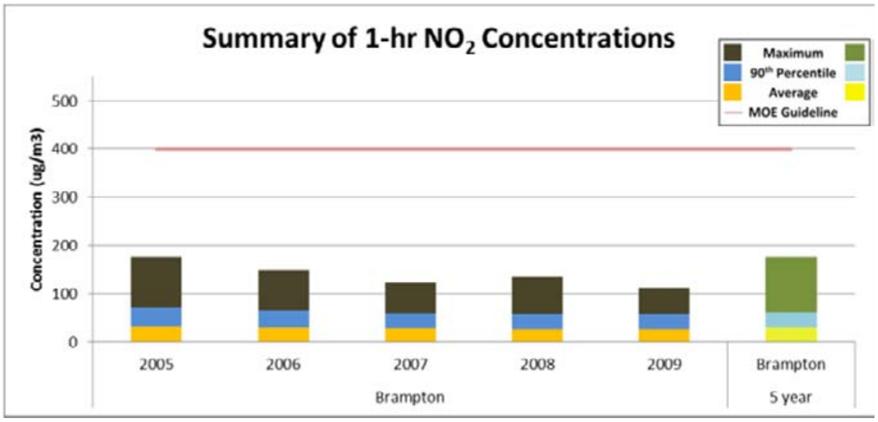
Statistical Analysis	Selection of Station
	**Conclusion:** A review of five years of ambient monitoring data from nearby stations indicated that the highest 90th percentile background concentration was measured at the Egbert Station.

2.3.4 Detailed Analysis of Selected Worst-Case Monitoring Stations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants is presented below. Each site was summarized on a yearly basis and for the five year period. Where measurements exceeded the guideline, frequency analysis was performed.

Table 14: Summary of Background NO_2

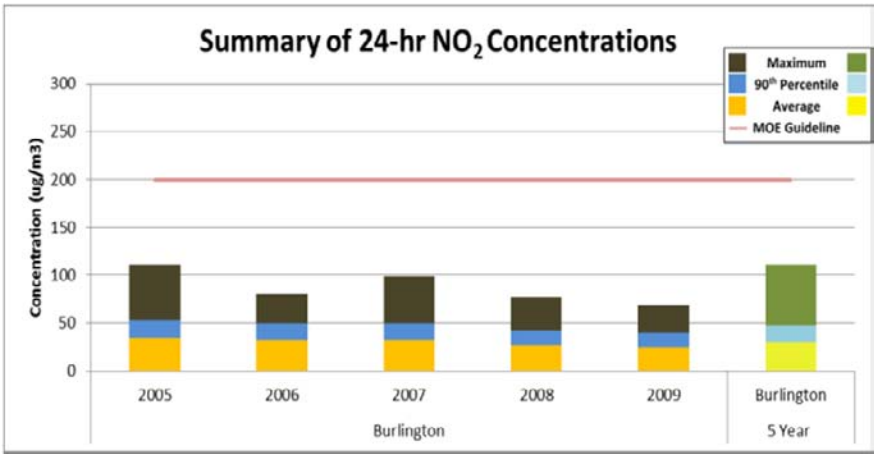
Statistical Analysis / Five Year Summary



Statistic	% of MOE Guideline
Maximum	44%
90th Percentile	15%
Average	7%

Conclusion:

A review of five years of ambient monitoring data from the Brampton Station indicated that background concentrations are well below the MOE Guideline on a 1-hour basis.



Statistic	% of MOE Guideline
Maximum	55%
90th Percentile	24%
Average	15%

Conclusion:

A review of five years of ambient monitoring data from the Brampton Station indicated that background concentrations are well below the MOE Guideline on a 24-hour basis.

Table 15: Summary of Background CO

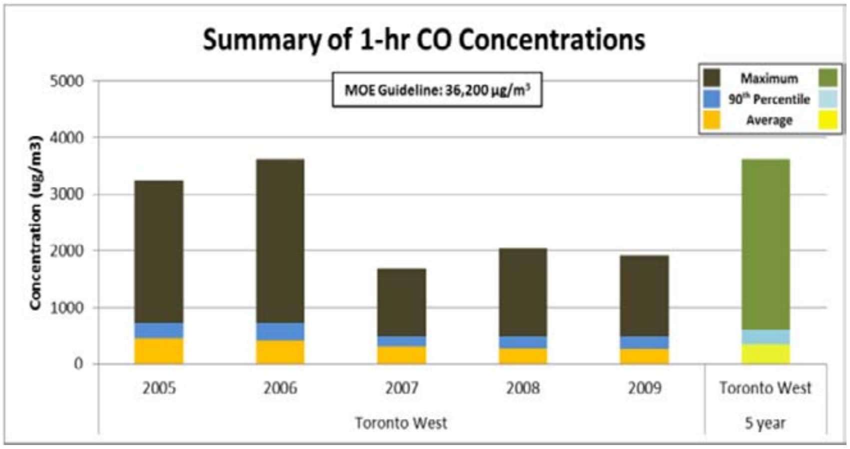
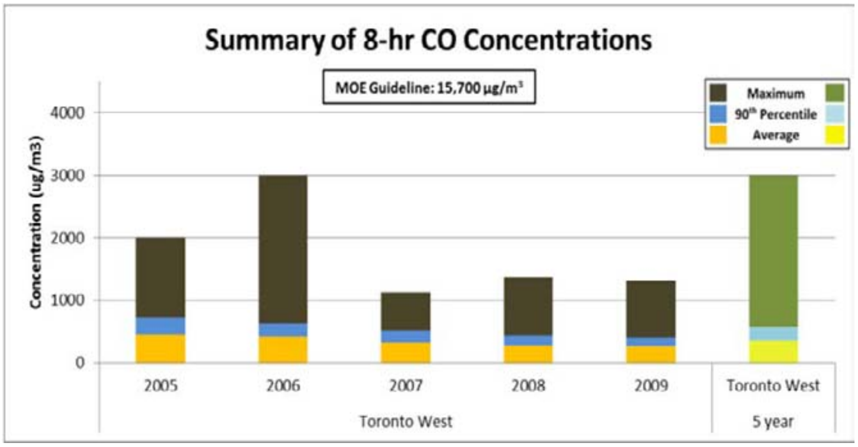
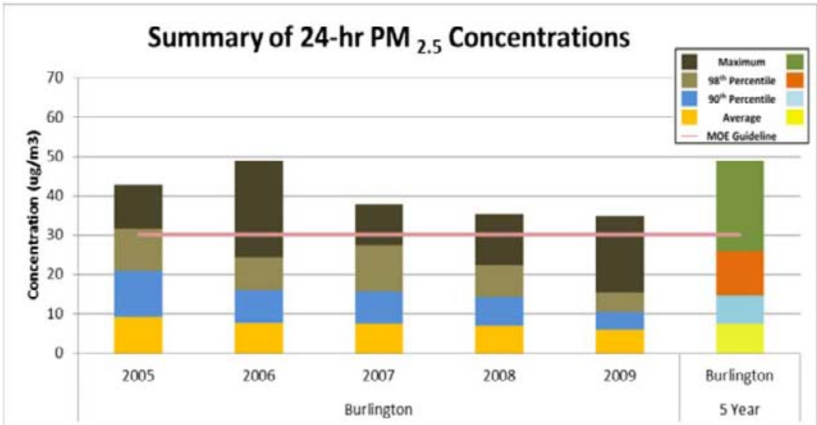
<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">
</td><td>Statistic</td><td>% of MOE Guideline</td></tr>
<tr><td>Maximum</td><td>10%</td></tr>
<tr><td>90th Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the MOE guideline on a 1-hour basis.</td></tr>
<tr><td rowspan="5">
</td><td>Statistic</td><td>% of MOE Guideline</td></tr>
<tr><td>Maximum</td><td>19%</td></tr>
<tr><td>90th Percentile</td><td>4%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the MOE guideline on an 8-hour basis.</td></tr>
</table>

Table 16: Summary of Background $PM_{2.5}$

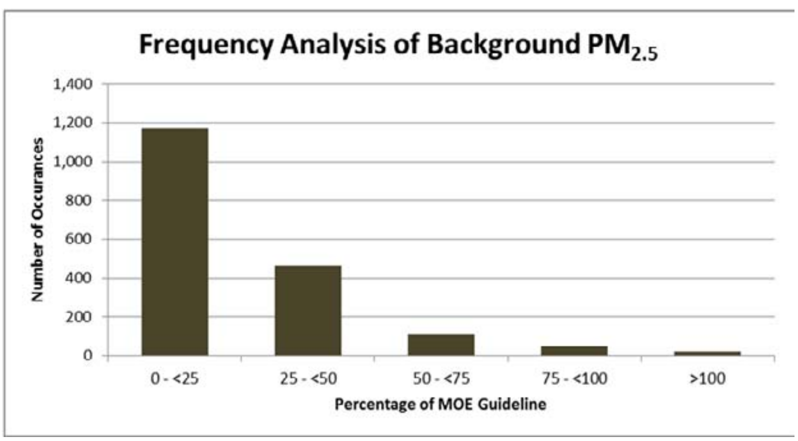
Statistical Analysis	Five Year Summary



Statistic	% of MOE Guideline
Maximum	163%
98th Percentile	87%
90th Percentile	49%
Average	24%

Conclusion:

A review of five years of ambient monitoring data from the Burlington Station indicated that the maximum background concentration exceeded the CWS on a 24-hour basis. However, the guideline for $PM_{2.5}$ is based on the 98^{th} percentile value averaged over three consecutive years. Therefore, the highest 3 year average of 27.81 µg/m^3 was below the guideline. However, frequency analysis was still conducted in order to show the number of days the background exceeded the guideline (see below).

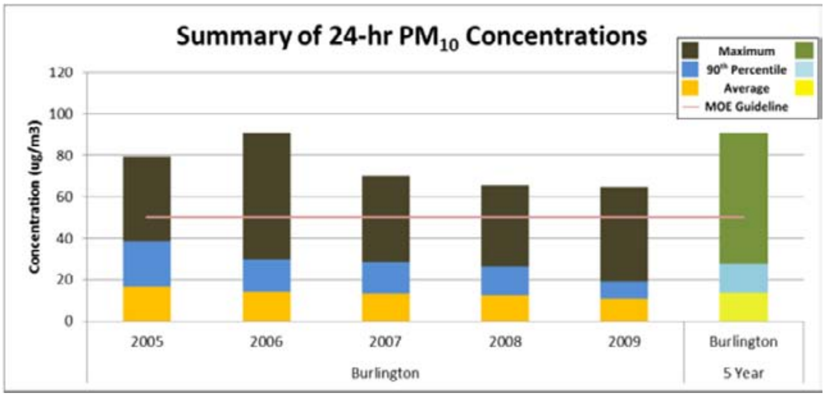


Number of Days Measured	Number of Days Exceeding MOE Guideline
1,818	23

Conclusion:

Frequency analysis determined that 24-hour concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the guideline 23 days over the 5 year period, with 11 days occurring in 2005. This means that the background concentration exceeded the guideline 1% of the time over the 5 year period.

Table 17: Summary of Background PM_{10}

<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">

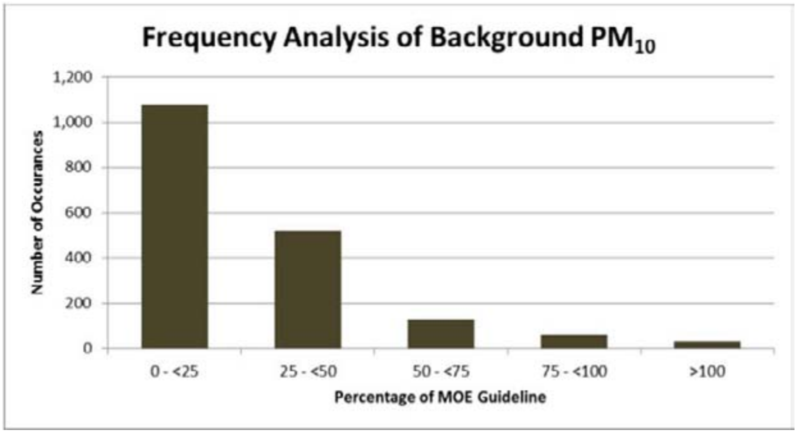
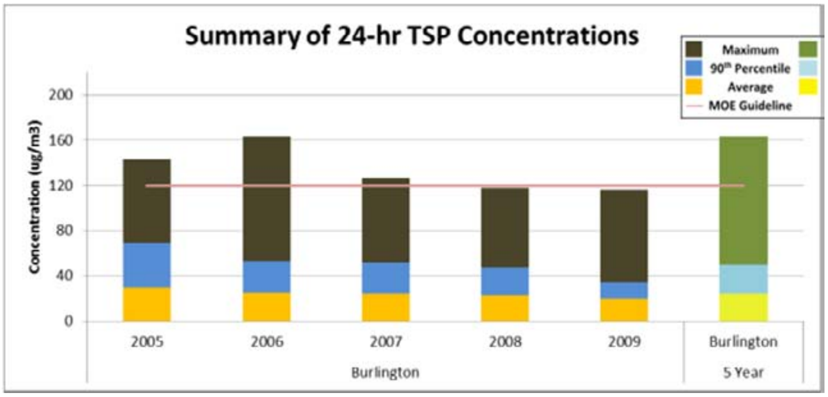
Note: PM_{10} is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54. Lall et al. (2004)</td><th>Statistic</th><th>% of MOE Guideline</th></tr>
<tr><td>Maximum</td><td>182%</td></tr>
<tr><td>90th Percentile</td><td>55%</td></tr>
<tr><td>Average</td><td>27%</td></tr>
<tr><td colspan="2">Conclusion:
A review of five years of PM_{10} data calculated from $PM_{2.5}$ ambient monitoring data from the Burlington Station indicated that the estimated maximum background concentration exceeded the MOE guideline on a 24-hour basis. Therefore, frequency analysis was conducted to determine the number of days the estimated background exceeded the MOE guideline (see below).</td></tr>
<tr><td rowspan="3">
</td><th>Number of Days Measured</th><th>Number of Days Exceeding MOE Guideline</th></tr>
<tr><td>1,818</td><td>30</td></tr>
<tr><td colspan="2">Conclusion:
Frequency analysis determined that 24-hour concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the MOE guideline 30 days over the 5 year period, with 16 days occurring in 2005. This means that the background concentration exceeded the MOE guideline 2% of the time over the 5 year period.</td></tr>
</table>

Table 18: Summary of Background TSP

Statistical Analysis



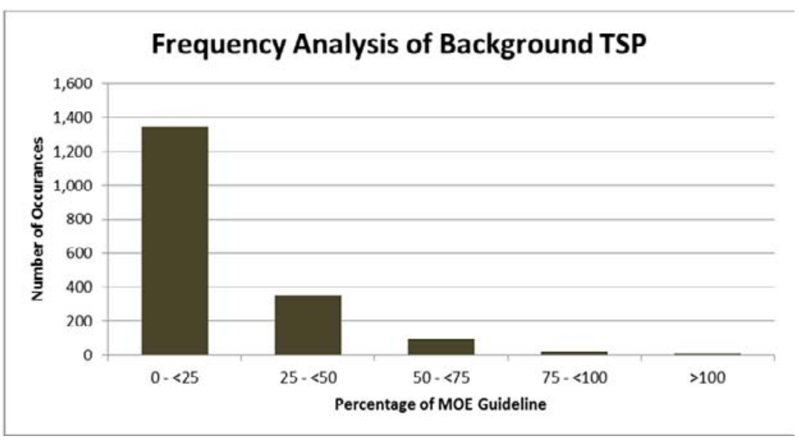
<u>Note</u>: TSP is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}$/TSP ratio of 0.3. Lall et al. (2004)

Five Year Summary

Statistic	% of MOE Guideline
Maximum	136%
90th Percentile	41%
Average	20%

Conclusion:

A review of five years of TSP data calculated from $PM_{2.5}$ ambient monitoring data from the Burlington Station indicated that the estimated maximum background concentration exceeded the MOE guideline on a 24-hour basis. Therefore, frequency analysis was conducted to determine the number of days the estimated background exceeded the guideline (see below).



Number of Days Measured	Number of Days Exceeding MOE Guideline
1,818	6

Conclusion:

Frequency analysis determined that 24-hourconcentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the MOE guideline 6 days over the 5 year period, with 3 days occurring in 2005. This means that the background concentration exceeded the MOE guideline <1% of the time over the 5 year period.

Table 19: Summary of Background Acetaldehyde

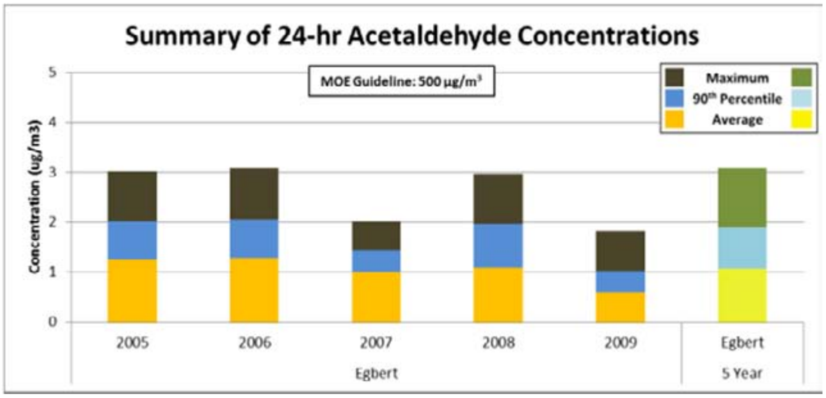
Statistical Analysis	Five Year Summary	
	**Statistic**	**% of MOE Guideline**
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Conclusion: A review of five years of ambient monitoring data from the Egbert Station indicated that the maximum background concentration was well below the MOE guideline.	

Table 20: Summary of Background Acrolein

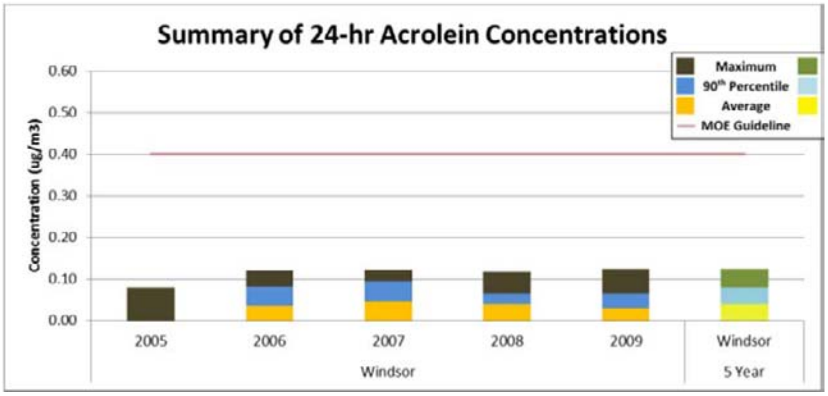
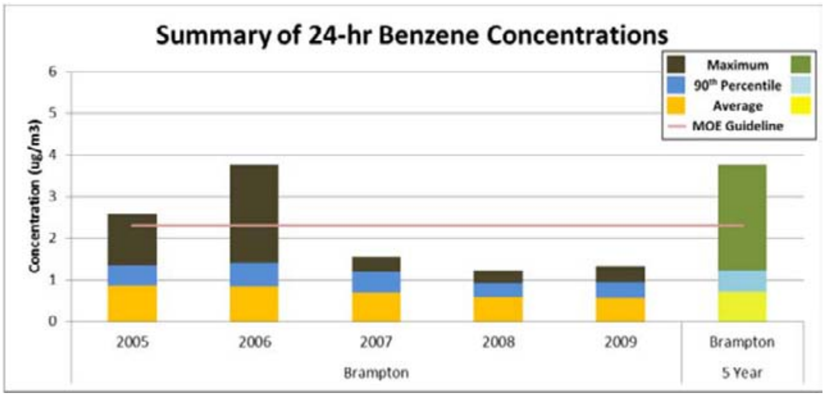
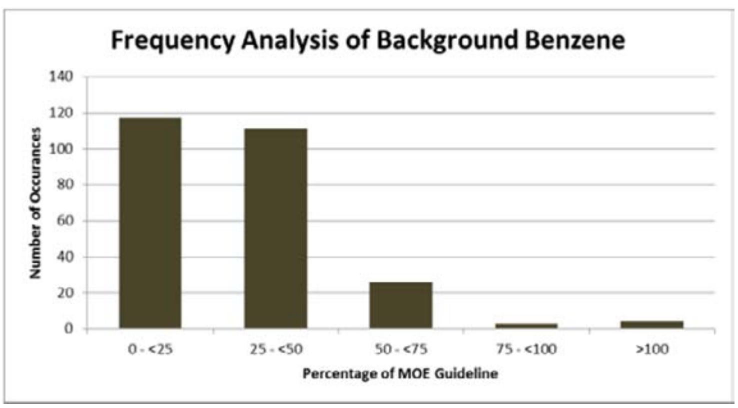
Statistical Analysis	Five Year Summary	
	**Statistic**	**% of MOE Guideline**
	Maximum	31%
	90th Percentile	20%
	Average	10%
	Conclusion: A review of five years of ambient monitoring data from the Windsor Station indicated that the maximum background concentration was well below the MOE guideline.	

Table 21: Summary of Background Benzene

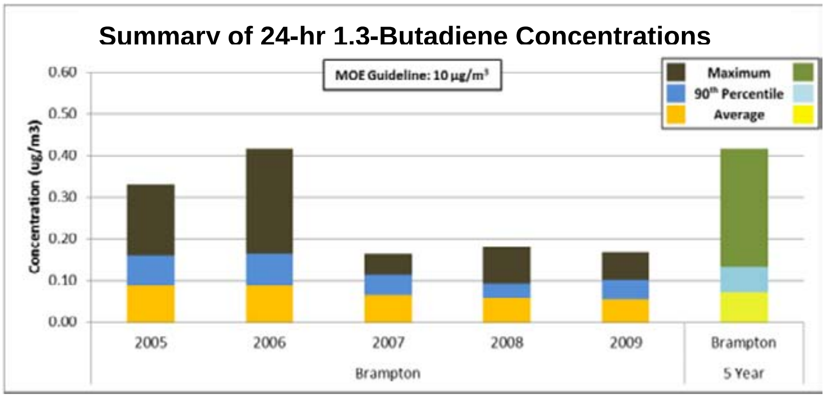
<table>
<tr><th>Statistical Analysis</th><th colspan="2">Five Year Summary</th></tr>
<tr><td rowspan="5">
</td><td>Statistic</td><td>% of MOE Guideline</td></tr>
<tr><td>Maximum</td><td>164%</td></tr>
<tr><td>90th Percentile</td><td>53%</td></tr>
<tr><td>Average</td><td>31%</td></tr>
<tr><td colspan="2">Conclusion:

A review of five years of ambient monitoring data from the Brampton Station indicated that the maximum background concentration exceeded the MOE guideline. Therefore, frequency analysis was conducted to determine the number of days the background exceeded the guideline (see below).</td></tr>
<tr><td rowspan="3">
</td><td>Number of Days Measured</td><td>Number of Days Exceeding MOE Guideline</td></tr>
<tr><td>261</td><td>4</td></tr>
<tr><td colspan="2">Conclusion:

Frequency analysis determined that concentrations exceeded the MOE guideline on an infrequent basis. Measured concentrations exceeded the guideline 4 days over the 5 year period, with 3 days occurring in 2005. This means that the background concentration exceeded the MOE guideline 2% of the time over the 5 year period.</td></tr>
</table>

Table 22: Summary of Background 1,3-Butadiene

Statistical Analysis	Five Year Summary



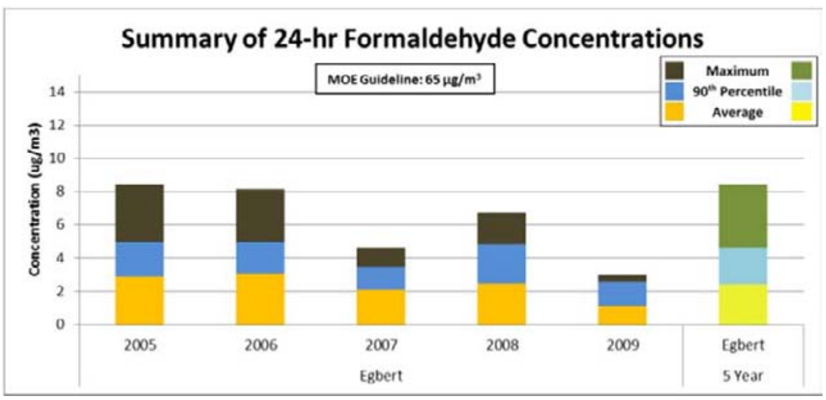
Statistic	% of MOE Guideline
Maximum	4%
90th Percentile	1%
Average	<1%

Conclusion:

A review of five years of ambient monitoring data from the Brampton Station indicated that the maximum background concentration was well below the MOE guideline.

Table 23: Summary of Background Formaldehyde

Statistical Analysis	Five Year Summary



Statistic	% of MOE Guideline
Maximum	13%
90th Percentile	7%
Average	4%

Conclusion:

A review of five years of ambient monitoring data from the Egbert Station indicated that the maximum background concentration was well below the MOE guideline.

2.3.5 Summary of Background Conditions

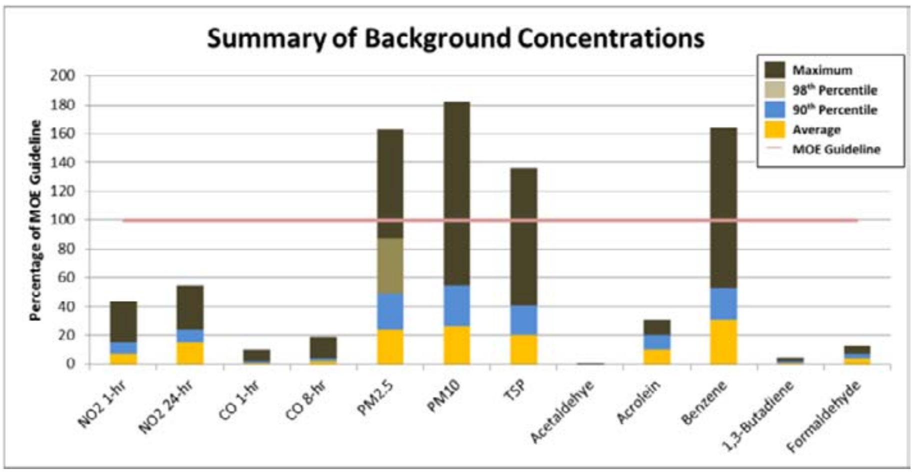
Based on a review of a Year 2005 to 2009 ambient monitoring dataset, all contaminants were below their respective MOE criteria with the exception of PM_{10}, TSP, and benzene. Benzene concentrations were based on actual measurements while PM_{10} and TSP concentrations were calculated based on their relationship to $PM_{2.5}$. It should be noted that even though the maximum concentration of $PM_{2.5}$ exceeded the CWS, the guideline for $PM_{2.5}$ is based on an average annual 98th percentile concentration, averaged over 3 consecutive years. Therefore, it was determined that the maximum rolling 98th percentile average was 27.81 μg/m^3, which is less than the guideline.

From a review of the VOC dataset, it was determined that due to the lack of hourly and daily background monitoring data, 90th percentile background concentrations for each VOC in the 5 year dataset would be calculated and used to determine the combined concentration. However, the summary of ambient monitoring data presented in this section provides the statistics for all available data. This method was suggested by the MOE.

A summary of the background concentrations as a percentage of their respective MOE guidelines or CWS is presented in **Table 24**. Also presented is the number of days that the monitoring data was above the MOE guideline or CWS.

Table 24: Statistical Summary of Background Concentrations

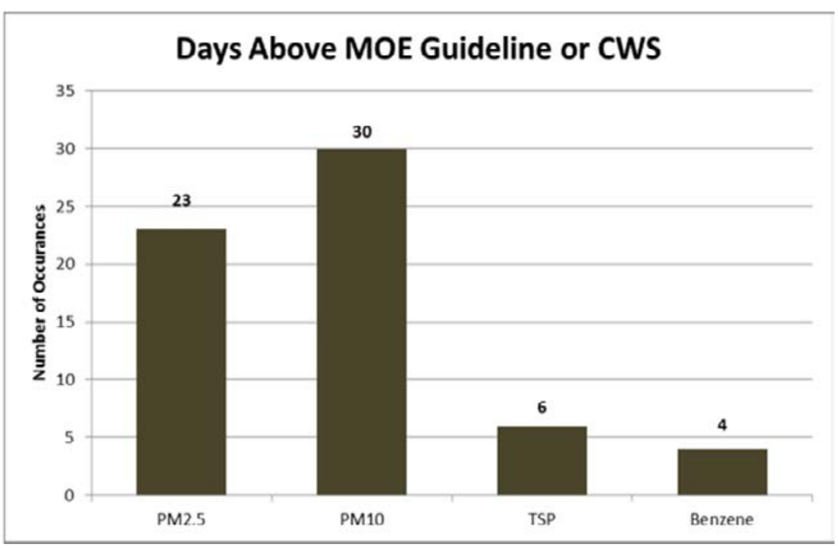
5 Year Statistical Summary	% of Guideline



Background:

NO_2 (1-hr)	44%
NO_2 (24-hr)	55%
CO (1-hr)	10%
CO (8-hr)	19%
$PM_{2.5}$	93%
PM_{10}	182%
TSP	136%
Acetaldehyde	<1%
Acrolein	31%
Benzene	164%
1,3-Butadiene	4%
Formaldehyde	13%

<u>Note:</u> The $PM_{2.5}$ background concentration is in compliance with the CWS. The highest 3-year rolling average of the yearly 98th percentile concentration was calculated to be 27.81 µg/m3 (2005-2007) or 93% of the standard.



Days Above Guideline:

$PM_{2.5}$	23
PM_{10}	30
TSP	6
Benzene	4

*Note that $PM_{2.5}$ is compared against the CWS three year maximum average 98th percentile.

2.4 Location of Sensitive Receptors Within The Study Area

Land uses which are defined as sensitive receptors for evaluating potential air quality effects are:

- Health care facilities;
- Senior citizens' residences or long-term care facilities;
- Child care facilities;
- Educational facilities;
- Places of worship; and
- Residential dwellings.

Forty-four sensitive receptors were selected to represent worst-case impacts surrounding the project area. These sensitive receptors are summarized in **Table 25** and their locations on mapping are identified in **Figure 6** through **Figure 14**. In addition to the sensitive receptors locations, the mapping also shows the existing scenario (i.e., aerial photograph) and the future build scenario in pink. Detailed figures showing each sensitive receptor's precise location in relation to the roadway are presented in **Appendix A**. Distances in **Table 25** are measured from the Dundas Street edge of pavement to the closest façade of the sensitive receptor. Sensitive receptors adjacent to intersections are also measured from the Dundas Street edge of pavement and not from the side roads.

Table 25: Representative Worst-Case Sensitive Receptors

Receptor Number	Land-Use	Distance From Dundas Street at Six Lanes (m)
R1	Residential	50
R2	Residential	25
R3	Residential	65
R4	Residential	27
R5	Residential	55
R6	Place of Worship	70
R7	Place of Worship	6
R8	Residential	24
R9	Residential	60
R10	Residential	55
R11	Residential	16
R12	Residential	55
R13	Residential	35
R14	Residential	53
R15	Residential	26
R16	Child Care Facility	23
R17	Residential	17
R18	Residential	12
R19	Residential	18
R20	Residential	15
R21	Residential	12
R22	Residential	22
R23	Residential	13
R24	Residential	46
R25	Residential	40
R26	Residential	54
R27	Residential	14
R28	Residential	22
R29	Residential	16
R30	Residential	108
R31	Residential	15
R32	Residential	22
R33	Residential	17
R34	Residential	45
R35	Residential	15
R36	Residential	48
R37	Place of Worship	55
R38	Place of Worship	16
R39	Residential	22
R40	Residential	16
R41	Residential	35

Receptor Number	Land-Use	Distance From Dundas Street at Six Lanes (m)
R42	Child Care Facility	415
R43	Educational Facility	164
R44	Residential	267

Figure 6: Sensitive Receptors R1 to R6 and R42

Figure 7 : Sensitive Receptors R7 to R14, R43 and R44

Figure 8 : Sensitive Receptors R15 to R18

Figure 9: Sensitive Receptors R19 to R23

Figure 10: Sensitive Receptors R24 to R29

Figure 11: Sensitive Receptors R30 to R31

Figure 12: Sensitive Receptors R32 to R33

Figure 13: Sensitive Receptors R34 to R36

Figure 14: Sensitive Receptors R37 to R41

Representative worst-case impacts will be predicted by the dispersion model at the sensitive receptors closest to the roadway. This is due to the fact that contaminant concentrations disperse significantly with downwind distance from the motor vehicles resulting in reduced contaminant concentrations. At approximately 500 m from the roadway, contaminant concentrations from the motor vehicles generally become indistinguishable from background levels. The maximum predicted contaminant concentrations at the closest sensitive receptors will usually occur during weather events which produce calm to light winds (< 3 m/s). During weather events with higher wind speeds, the contaminant concentrations disperse much more quickly.

2.5 Road Traffic Data

Existing (Year 2011) road traffic volumes were provided by MRC. Traffic data was provided in the form of hourly movement counts for every intersection along the study area. AM and PM peak factors were used to obtain AADT (annual average daytime traffic) values from the movement counts which were used in the assessment. Future 2021 AADT volumes were provided by MRC based on the anticipated growth to existing AADT values. Also provided by MRC were the traffic volumes on the HOV/transit lanes. Future and existing traffic volumes for Dundas Street are provided in **Table 26**. Vehicle fleet distribution was provided by MRC in the form of medium and heavy duty percentages of 1.1% and 2.2%, respectively for the 2011 assessment. For the 2021 assessment, medium and heavy percentages of 2.6% and 1.8% respectively were provided. Distributions were calculated for eastbound and westbound traffic both on the main road and the HOV/transit lanes, as well as for arterial roads. These hourly distributions were applied in the dispersion model and are shown in **Table 27**.

Table 26: Existing (2011) and Future (2021) Traffic Data for Dundas Street

Section	2011 AADT's		2021 AADT's	
	Eastbound	Westbound	Eastbound	Westbound
Brant Street to Eaglesfield Drive	16,203	13,341	20,393	16,791
Eaglesfield Drive to Blackwood Street	15,218	13,084	19,994	17,190
Blackwood Street to Guelph Line	15,700	13,569	19,946	17,238
Guelph Line to Hwy 407	17,582	15,192	22,337	19,300
Hwy 407 to Northampton Boulevard	17,614	16,121	22,059	20,189
Northampton Boulevard to Walkers Line	18,489	15,967	24,442	21,107
Walkers Line to Berwick Drive	17,546	15,237	24,417	21,203
Berwick Drive to Weslock Drive	19,634	17,551	27,484	24,568
Weslock Drive to Millcroft Park Drive	20,627	17,196	28,874	24,071
Millcroft Park Drive to Appleby Line	21,301	18,854	29,817	26,392
Appleby Line to Sutton Drive	20,354	19,953	28,492	27,930
Sutton Drive to Tremaine Road	20,185	17,844	28,421	25,125
Tremaine Road to Zenon Road	19,165	17,285	28,062	25,310
Zenon Road to Valleyridge Drive	20,901	18,393	31,779	27,967
Valleyridge Crive to Bronte Road	19,977	15,970	22,059	20,189

Table 27: Hourly Traffic Distributions

Hour	Mainline		HOV Lane		Arterial
	Eastbound (%)	Westbound (%)	Eastbound (%)	Westbound (%)	
1	0.357	0.851	0.391	0.88	0.604
2	0.173	0.312	0.189	0.322	0.242
3	0.1236	0.2084	0.1355	0.2154	0.166
4	0.235	0.167	0.258	0.172	0.201
5	0.546	0.163	0.599	0.169	0.355
6	2.603	0.496	2.853	0.512	1.549
7	9.206	2.013	5.175	1.213	5.609
8	12.41	4.149	6.976	2.5	8.28
9	9.657	5.593	5.429	3.37	7.625
10	6.524	4.113	7.153	4.249	5.318
11	4.839	3.782	5.305	3.908	4.311
12	4.781	4.407	5.242	4.553	4.594
13	4.7	4.749	5.153	4.907	4.725
14	4.645	5.305	5.092	5.481	4.975
15	4.796	7.001	5.258	7.234	5.899
16	4.723	9.795	8.115	10.53	7.259
17	5.494	11.26	9.44	12.11	8.377
18	6.212	11.2	10.68	12.04	8.704
19	5.515	8.956	6.046	9.253	7.235
20	3.716	5.766	4.074	5.958	4.741
21	2.414	4.544	2.646	4.695	3.479
22	2.013	3.308	2.206	3.417	2.66
23	1.45	2.243	1.589	2.317	1.846
24	0.914	1.578	1.002	1.631	1.246

Signal timing for the intersections was also provided by MRC. Signal timing was provided for all Dundas Street intersections running from Brant Street to Bronte Road. These timings were applied to Dundas street for the main lanes as well as the HOV/transit lanes. The timings were used to calculate the signal information for the arterial roads, based on the conservative assumption that Dundas Street would have the longest red cycle allowable. The signal timings used in this assessment are shown in **Table 28**.

Table 28: Signal Times for Dundas Street

	Cycle Length (s)	Red Light Time (s)	Clearance Lost Time (s)	Saturation Flow Rate	Signal Type	Arrival Type
Dundas Street	130	59	2	1600	Semi-Actuated	Arrival Type
Arterial	130	71	2	1600	Semi-Actuated	Arrival Type

2.6 Assessment Approach

2.6.1 General Approach

The general assessment approach was as follows:

1) Motor vehicle contaminant concentrations from Dundas Street at the representative receptors were predicted using modelling software on an hourly basis for a five-year period, using 2005-2009 meteorological data from Toronto Pearson International Airport.
2) Hourly ambient concentrations for all available contaminants were determined from MOE and NAPS datasets for the most representative locations.
3) Combined concentrations were determined by adding modelled and background (i.e., ambient data) together on an hourly basis. For ambient data which was not available in hourly form (VOC's), predicted roadway concentrations were added to the 90^{th} percentile of the aggregated data described above.
4) Maximum 1-hour, 8-hour and 24-hour predicted combined concentrations were determined for comparison with the applicable guidelines.

Computer simulations to determine project impacts were conducted using emission and dispersion models published by the U.S. Environmental Protection Agency (U.S. EPA).

2.6.2 Meteorological Data

2005-2009 hourly meteorological data was obtained from Toronto Pearson International Airport and upper air data was obtained from the Buffalo Niagara International Airport. The combined data was processed using Lakes Environmental's PCRAMMET software program which prepares meteorological data for use with the CAL3QHCR model. A wind frequency diagram (wind rose) is shown in **Figure 15**. As can be seen in this figure, predominant winds are from the southwesterly through northerly directions.

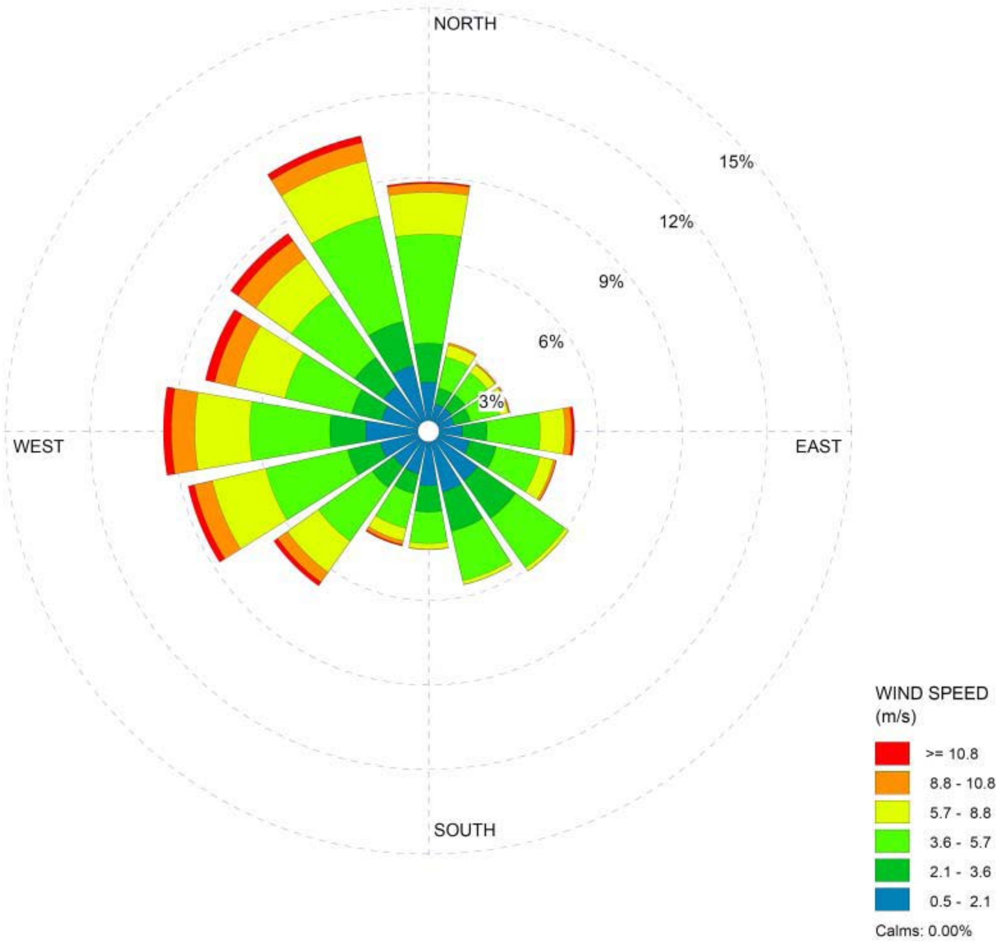


Figure 15: Wind Frequency Diagram for Toronto Pearson International Airport

2.6.3 Motor Vehicle Emission Rates

MOVES is a computer program that provides estimates of current and future emission rates from motor vehicles based on a variety of factors such as local meteorology and vehicle fleet composition. MOVES 2010a, released in August 2010, is the U.S. Environmental Protection Agency's (EPA's) latest tool for estimating vehicle emissions due to the combustion of fuel, brake and tire wear, fuel evaporation, permeation and refuelling leaks. The model is based on "an analysis of millions of emission test results and considerable advances in the Agency's understanding of vehicle emissions and… accounts for changes in emissions due to proposed standards and regulations". For this study, MOVES was used to estimate vehicle emissions based on vehicle type, road type, model year, and vehicle speed. **Table 29** specifies the major inputs into MOVES.

Table 29: MOVES Input Parameters

Parameter	Input
Scale	Custom County Domain
Meteorology	Temperature and relative humidity values were obtained from meteorological data from Toronto Pearson International Airport for the years 2005 to 2009.
Years	2011 (existing) and 2021 (future build)
Geographical Bounds	Custom County Domain
Fuels	Compressed Natural Gas / Diesel Fuels / Gasoline Fuels Note that MOVES assumes a default distribution for each fuel type within the vehicle class.
Source Use Types	Combination Long-haul Truck / Combination Short-haul Truck / Intercity Bus / Light Commercial Truck / Motor Home / Motorcycle / Passenger Car / Passenger Truck / Refuse Truck / School Bus / Single Unit Long-haul Truck / Single Unit Short-haul Truck / Transit Bus
Road Type	Rural Unrestricted Access
Pollutants and Processes	NO_2 / CO / $PM_{2.5}$ / PM_{10} / Acetaldehyde / Acrolein / Benzene / 1,3-Butadiene / Formaldehyde. TSP can't be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.
Vehicle Age Distribution	MOVES defaults based on years selected.

Upon processing of the MOVES outputs, the highest monthly value was selected, which represents a worst-case emission rate. Upon selection of the worst-case emission rate, an adjustment was made to the MOVES output in order to account for the provided medium and heavy duty percentages. The adjusted emission rates used as input into the dispersion model are presented in **Table 30** and **Table 31** below. These emission rates were used for the common lanes on Dundas Street for the years 2011 and 2021. **Table 32** presents the emission rates used for the HOV transit/lanes for the year 2021.

Table 30: Vehicle Fleet MOVES Output Emission Factors for Year 2011 (g/VMT)

Contaminant	Speed (km/hr)						
	Idle	30	40	50	60	70	80
NO_2	0.8691	0.1419	0.1241	0.1145	0.1083	0.1058	0.1038
CO	46.07	7.6731	5.7271	5.3410	4.9446	4.4337	4.2865
$PM_{2.5}$ Total	0.3472	0.0674	0.0498	0.0445	0.0381	0.0325	0.0297
PM_{10} Total	0.3677	0.1140	0.0840	0.0717	0.0598	0.0466	0.0405
TSP[1]	0.3677	0.1140	0.0840	0.0717	0.0598	0.0466	0.0405
Acetaldehyde	0.0476	0.0044	0.0031	0.0027	0.0025	0.0021	0.0019
Acrolein	0.00291	0.00034	0.00025	0.00018	0.00015	0.00014	0.00012
Benzene	0.0971	0.0090	0.0065	0.0057	0.0050	0.0042	0.0039
1,3-Butadiene	0.01599	0.00142	0.00102	0.00089	0.00079	0.00067	0.00062
Formaldehyde	0.06464	0.00561	0.00389	0.00340	0.00306	0.00259	0.00240

1 – Note that TSP cannot be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

Table 31: Vehicle Fleet MOVES Output Emission Factors for Year 2021 (g/VMT)

Contaminant		Speed (km/hr)					
	Idle	30	40	50	60	70	80
NO_2	0.46	0.069	0.056	0.053	0.050	0.049	0.049
CO	18.86	5.29	4.47	4.28	3.97	3.56	3.53
$PM_{2.5}$ Total	0.24	0.033	0.027	0.025	0.023	0.021	0.021
PM_{10} Total	0.25	0.035	0.030	0.027	0.025	0.023	0.023
TSP[1]	0.25	0.035	0.030	0.027	0.025	0.023	0.023
Acetaldehyde	0.014	0.0016	0.0013	0.0012	0.0011	0.00087	0.00081
Arolein	0.0011	0.000088	0.000075	0.000066	0.000059	0.000049	0.000046
Benzene	0.023	0.0030	0.0026	0.0023	0.0021	0.0017	0.0016
1,3-Butadiene	0.0033	0.00041	0.00035	0.00032	0.00028	0.00023	0.00022
Formaldehyde	0.019	0.0018	0.0015	0.0014	0.0012	0.0010	0.00094

1 – Note that TSP cannot be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

Table 32: HOV MOVES Outputs Emission Factors for Year 2021 (g/VMT)

Contaminant	Posted Speed	
	Idle	60 km/hr
NO2	0.255	0.029
CO	17.89	3.91
$PM_{2.5}$	0.21	0.022
PM_{10}	0.223	0.024
TSP[1]	0.223	0.024
Acetaldehyde	0.01	0.00086
Acrolein	0.00045	0.000033
Benzene	0.02	0.0019
1,3-Butadiene	0.003	0.00026
Formaldehyde	0.0097	0.00077

1 – Note that TSP cannot be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

2.6.4 Re-suspended Particulate Matter Emission Rates

A large portion of roadway particulate matter emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the roadway. These emissions are estimated using empirically derived values presented by the U.S. EPA in their AP-42 report. The emissions factors for re-suspended particulate matter were estimated by using the following equation from U.S. EPA's Document AP-42 report, Chapter 13.2.1.3 and are summarized in **Table 33**:

$$E = k(sL)^{0.91} * (W)^{1.02}$$

Where: E = the particulate emission factor

K = the particulate size multiplier

sL = silt loading

W = average vehicle weight (Assumed 3 Tons based on Toyota fleet data and US EPA vehicle weight and distribution)

Table 33: Re-suspended Particulate Matter Emission Factors

Roadway AADT	K ($PM_{2.5}$/PM_{10}/TSP)	sL (g/m^3)	W (Tons)	E (g/VMT)		
				$PM_{2.5}$	PM_{10}	TSP
<500	0.25/1.0/5.24	0.6	3	0.503	2.015	10.561
500-5,000	0.25/1.0/5.24	0.2	3	0.185	0.741	3.886
5,000-10,000	0.25/1.0/5.24	0.06	3	0.061	0.247	1.299
>10,000	0.25/1.0/5.24	0.015	3	0.033	0.132	0.691

2.6.5 Air Dispersion Modelling Using CAL3QHCR

The U.S. EPA's CAL3QHCR dispersion model, based on the Gaussian plume equation, was specifically designed to predict air quality impacts from roadways using site specific meteorological data, vehicle emissions, traffic data, and signal data. The model input requirements include roadway geometry, sensitive receptor locations, meteorology, traffic volumes and motor vehicle emission rates as well as some contaminant physical properties such as settling and deposition velocities. CAL3QHCR uses this information to calculate hourly concentrations which are then used to determine 1-hour, 8-hour and 24-hour averages for the contaminants of interest at the identified sensitive receptor locations. **Table 34** provides the major inputs used in CAL3QHCR. The emission rates used in the model were the outputs from the MOVES and AP-42 models, weighted for the medium and heavy-duty fleet percentages provided. The outputs of CAL3QHCR are presented in the results section (**Section 3**).

Table 34: CAL3QHCR Model Input Parameters

Parameter	Input
Free-Flow Link Traffic Data	Hourly traffic distributions were applied to the AADT traffic volumes in order to input traffic volumes in vehicles/hour. Emission rates from the MOVES output were inputted in grams/VMT.
Queue Link Traffic Data	Average signal cycle length: 130 s Average red time length: 59 s / 71 s Clearance lost time: 2 s Approach traffic volume: hourly AADT values, as described above Idle emission factor: output from MOVES, in grams/hour Saturation flow rate: 1600 vehicles/hour (default value) Signal type: Semi-Actuated Arrival type: Average Progressing
Meteorological Data	2005-2009 data from Toronto Pearson International Airport
Deposition Velocity	$PM_{2.5}$: 0.08 cm/s PM_{10}: 0.2 cm/s TSP: 0.15 cm/s NO_2: 0.1 cm/s CO: 0.03 cm/s VOC's: 0 cm/s
Settling Velocity	$PM_{2.5}$: 0.02 cm/s PM_{10}: 0.3 cm/s TSP: 1.8 cm/s CO, NO_2, and VOC's: 0 cm/s
Surface Roughness	The land type surrounding the project site is categorized as 'Low Intensity Residential'. The average surface roughness for all seasons of 52 cm was applied in the model.
Vehicle Emission Rate	Emission rates calculated in MOVES and AP-42 were inputted in g/VMT

3.0 Detailed Modelling Results

Presented in **Table 35** are the modelling results for the existing and future build scenarios, based on 5 years of meteorological data**.** For each CAC and VOC contaminant, combined concentrations are presented along with the relevant contribution due to the background and roadway. Results in this section are presented for the worst-case sensitive receptor (see **Table 35**), which was identified as the maximum combined concentration for the future build scenario. Results for all modelled receptors are provided in **Appendix A**. A maximum $PM_{2.5}$ concentration contour plot and concentration profiles for each contaminant are provided for a worst-case section of the Dundas Street in order to graphically display results. These figures present concentrations from the roadway only, and are exclusive of background concentrations. These plots show how contaminant concentration decreases as a function of distance from the roadway. It should be noted that the maximum roadway concentration at any sensitive receptor often occurs infrequently and actually may only occur for one hour or day over the 5-year period.

Table 35: Worst-Case Sensitive Receptor for 2021 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	R21
	24-hour	R41
CO	1-hour	R41[1]
	8-hour	R2
$PM_{2.5}$	24-hour	R38
PM_{10}	24-hour	R38
TSP	24-hour	R38
Acetaldehyde	24-hour	R38
Acrolein	24-hour	R38
Benzene	24-hour	R38
1,3-Butadiene	24-hour	R38
Formaldehyde	24-hour	R38

[1] Maximum CO value occurred when the background contribution was 0 $\mu g/m^3$, therefore all receptors were the same. Maximum receptor was assessed against the 98^{th} percentile value.

3.1 Criteria Air Contaminants

Coincidental hourly modelled roadway and background CAC concentrations were added to derive the combined concentration for each hour over a 5 year period. Statistical analysis in the form of maximum, 90^{th} percentile, and average combined concentrations were calculated for the worst-case sensitive receptor for each contaminant and are presented below. The maximum combined concentration was then used to assess compliance with MOE guidelines or CWS. If excesses of the guideline were predicted, frequency analysis was undertaken in order to estimate the number of occurrences above the guideline. Provided below are the modelling results for the CACs: CO, NO_2, $PM_{2.5}$, PM_{10} and TSP.

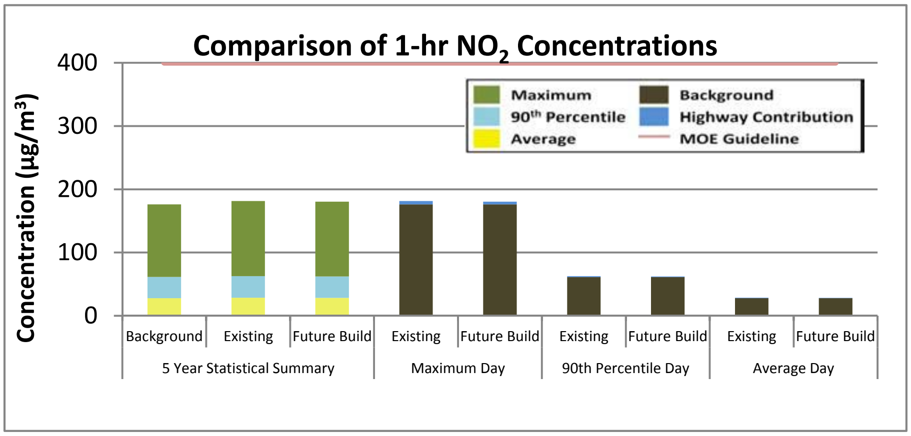
3.1.1 Nitrogen Dioxide

Table 36 presents the combined concentrations for 1-hour and 24-hour NO_2 based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

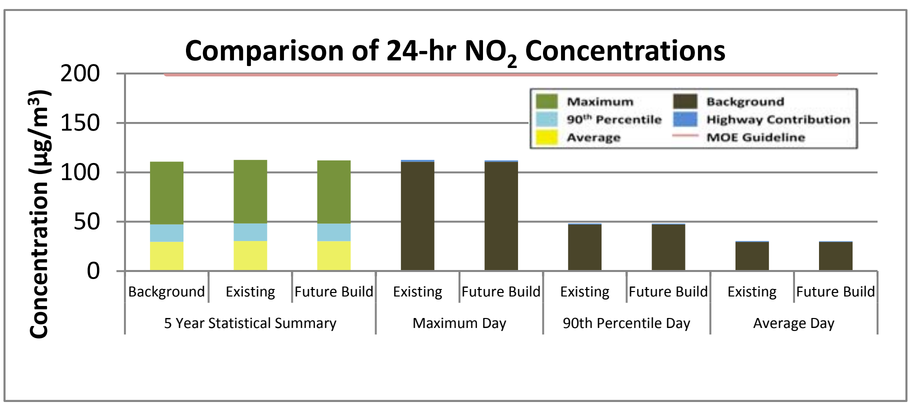
- *Both the maximum 1-hour and 24-hour NO_2 combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 36: Summary of Existing and 2021 Future Build NO_2

Statistical Analysis	5 Year Summary of Future Build	



% of MOE Guideline:	
Maximum	45%
90th Percentile	16%
Average	7%
Roadway Contribution:	
Maximum	2%
90th Percentile	2%
Average	2%
Change from Existing Scenario:	
Maximum	-<1%
90th Percentile	-1%
Average	-1%



% of MOE Guideline:	
Maximum	56%
90th Percentile	24%
Average	15%
Roadway Contribution:	
Maximum	1%
90th Percentile	2%
Average	2%
Change from Existing Scenario:	
Maximum	-<1%
90th Percentile	-<1%
Average	-1%

Conclusions:

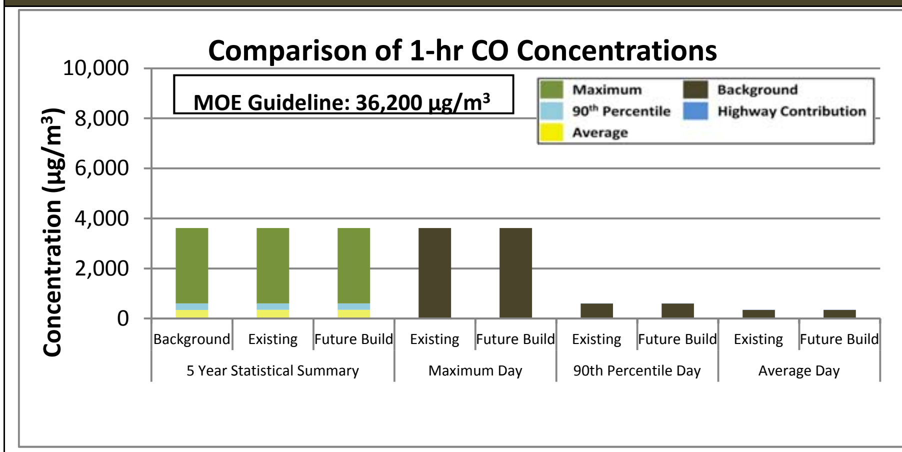
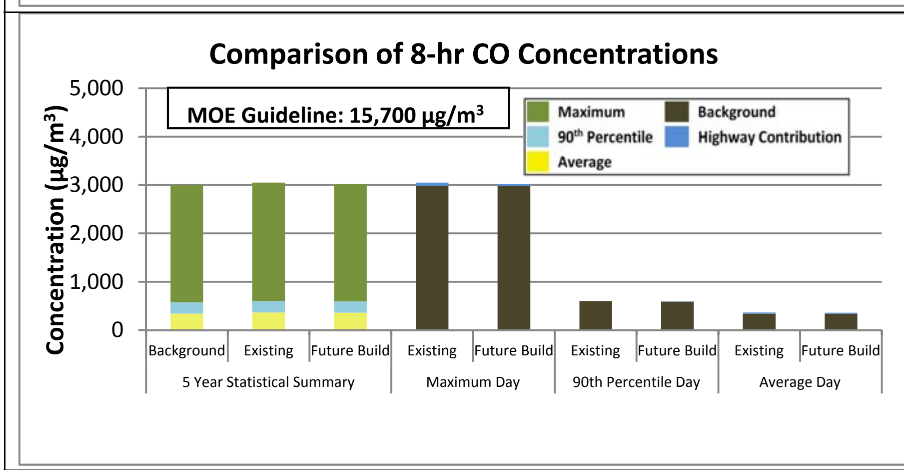
- All combined concentrations were below their respective MOE guidelines.
- The contribution from the roadway to the combined concentrations was 2% or less.
- There was an improvement of approximately 1% from the existing scenario.

3.1.2 Carbon Monoxide

Table 37 presents the combined concentrations for 1-hour and -hour CO based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *Both the maximum 1-hour and 8-hour CO combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 37: Summary of Existing and 2021 Future Build CO

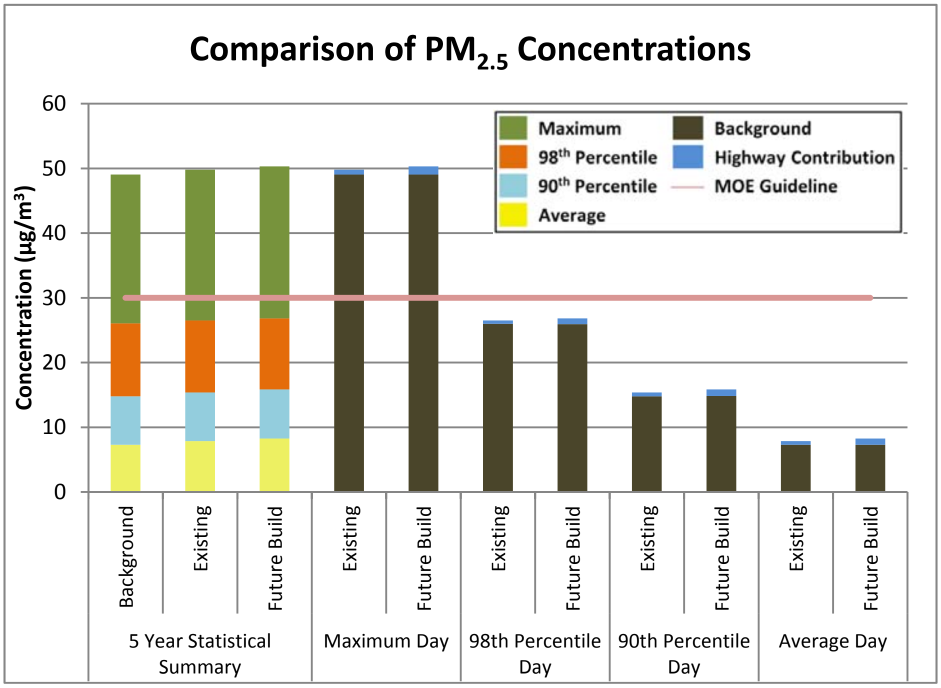
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>10%</td></tr>
<tr><td>90th Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>No change</td></tr>
<tr><td>90th Percentile</td><td>No change</td></tr>
<tr><td>Average</td><td>-<1%</td></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>19%</td></tr>
<tr><td>90th Percentile</td><td>4%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>90th Percentile</td><td>>1%</td></tr>
<tr><td>Average</td><td>5%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>-1%</td></tr>
<tr><td>90th Percentile</td><td>-1%</td></tr>
<tr><td>Average</td><td>-1%</td></tr>
<tr><td colspan="3">Conclusions:
• All combined concentrations were below their respective MOE guidelines.
• The contribution from the roadway to the combined concentrations was 5% or less.
• The change from the existing scenario was insignificant.</td></tr>
</table>

3.1.3 Fine Particulate Matter ($PM_{2.5}$)

Table 38 presents the existing and future build combined concentrations alongside the background concentrations for 24-hour $PM_{2.5}$ based on 5 years of meteorological data. The results conclude that:

- *The average annual 98th percentile 24-hour $PM_{2.5}$ combined concentration, averaged over three consecutive years for the existing and future build scenarios was below the CWS.*

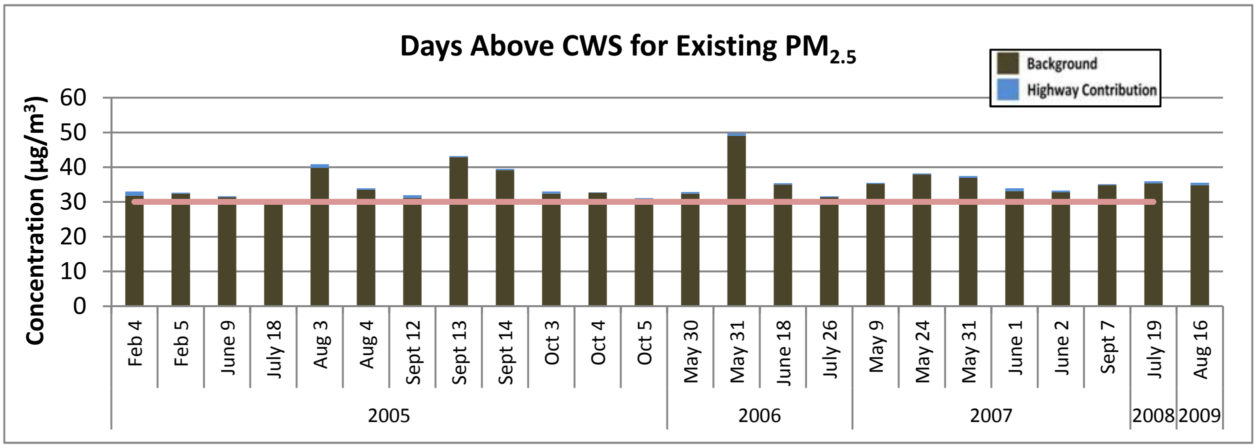
Table 38: Summary of Existing and 2021 Future Build $PM_{2.5}$

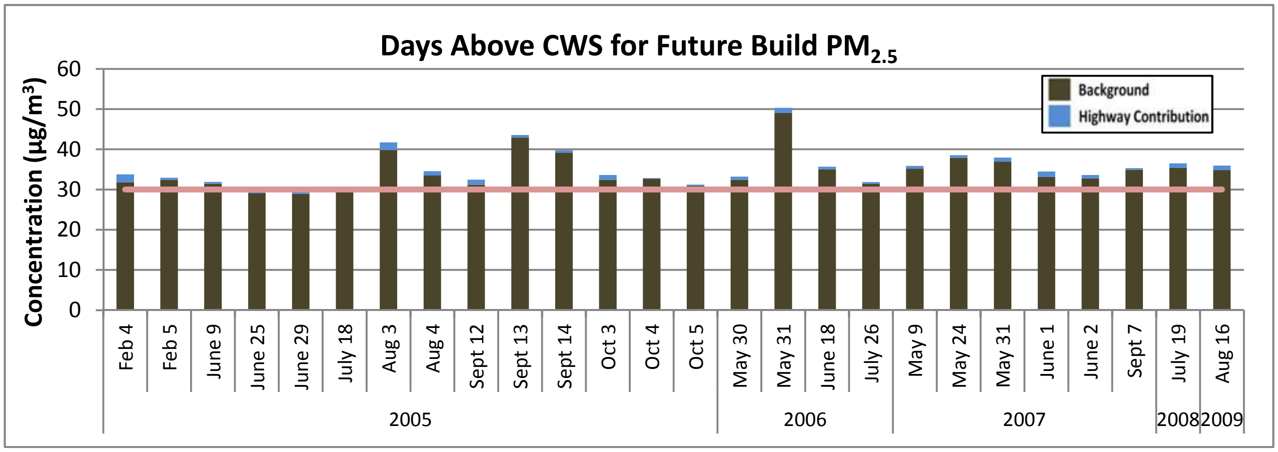
<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="15">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>168%</td></tr>
<tr><td>98th Percentile</td><td>96%</td></tr>
<tr><td>90th Percentile</td><td>53%</td></tr>
<tr><td>Average</td><td>28%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>3%</td></tr>
<tr><td>98th Percentile</td><td>3%</td></tr>
<tr><td>90th Percentile</td><td>6%</td></tr>
<tr><td>Average</td><td>12%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>98th Percentile</td><td>1%</td></tr>
<tr><td>90th Percentile</td><td>3%</td></tr>
<tr><td>Average</td><td>5%</td></tr>
</table>

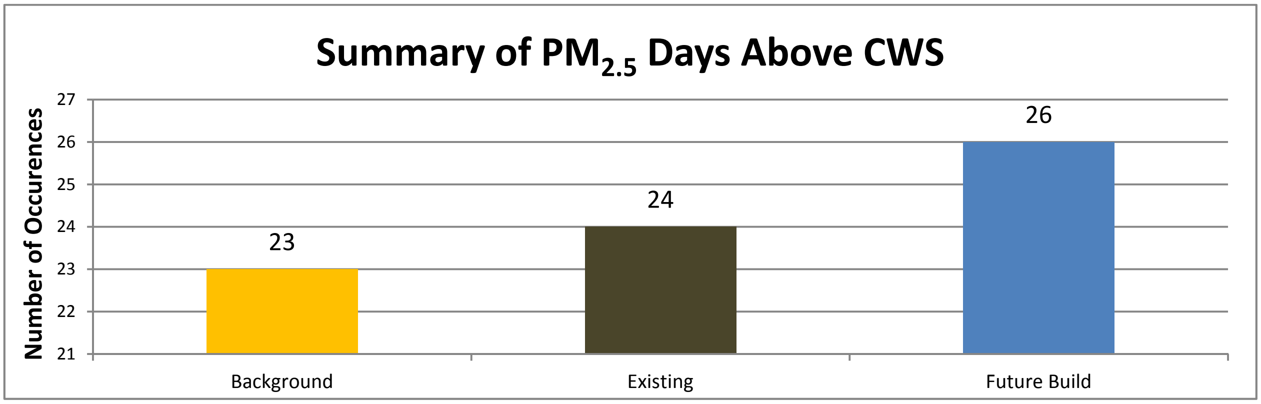
Conclusions:

- The $PM_{2.5}$ results are in compliance with the CWS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 28.9 µg/m^3 (years 2005 to 2007) or 96% of the CWS.
- The contribution from the roadway to the combined concentrations was 12% or less.
- The change from the existing scenario was 5% or less.
- Since there were days where elevated $PM_{2.5}$ concentrations were experienced, frequency analysis was conducted to show that elevated concentrations were not frequent over a 5 year period. This analysis is presented below.

Table 39: 5 Year Frequency Analysis of Existing and 2021 Future PM2.5







Conclusions:

- Two additional day above the CWS is expected due to the project over a 5 year period.
- For the future build scenario the combined concentrations only exceeded the CWS 1% of the time.

It should be understood that infrequent days above the guideline due to background is a common occurrence in all of Southwestern Ontario and is unavoidable due to long-range transport of contaminants from the United States.

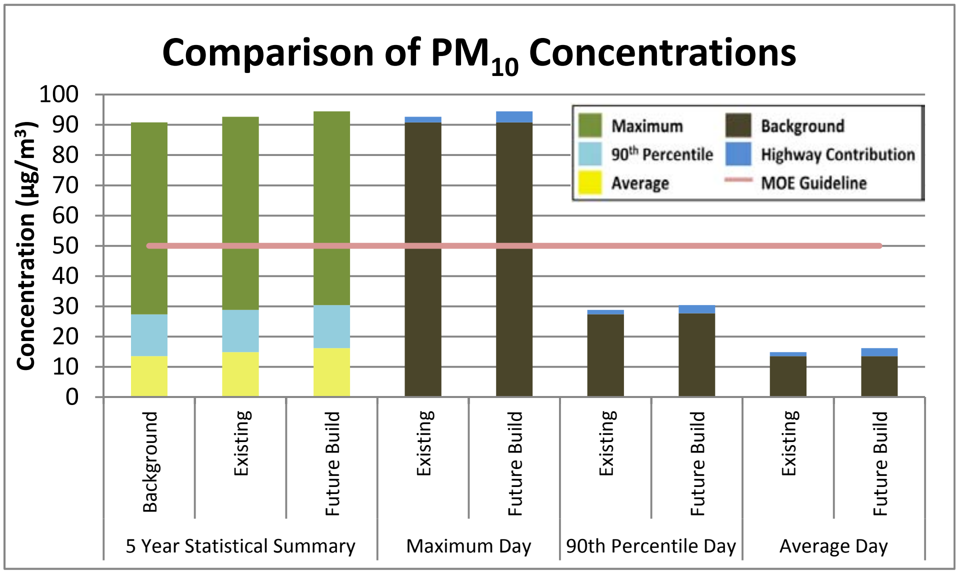
3.1.4 Coarse Particulate Matter (PM_{10})

Table 40 presents the existing and future build combined concentrations alongside the background concentrations for 24-hour PM_{10} based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr PM_{10} combined concentrations for the existing and future build scenarios exceeded the MOE guideline.*

Table 40: Summary of Existing and 2021 Future Build PM_{10}

Statistical Analysis

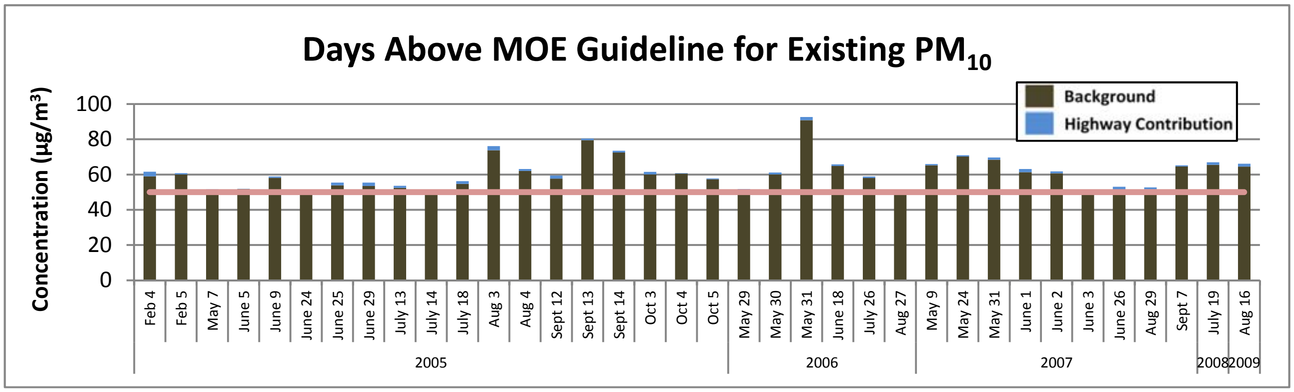


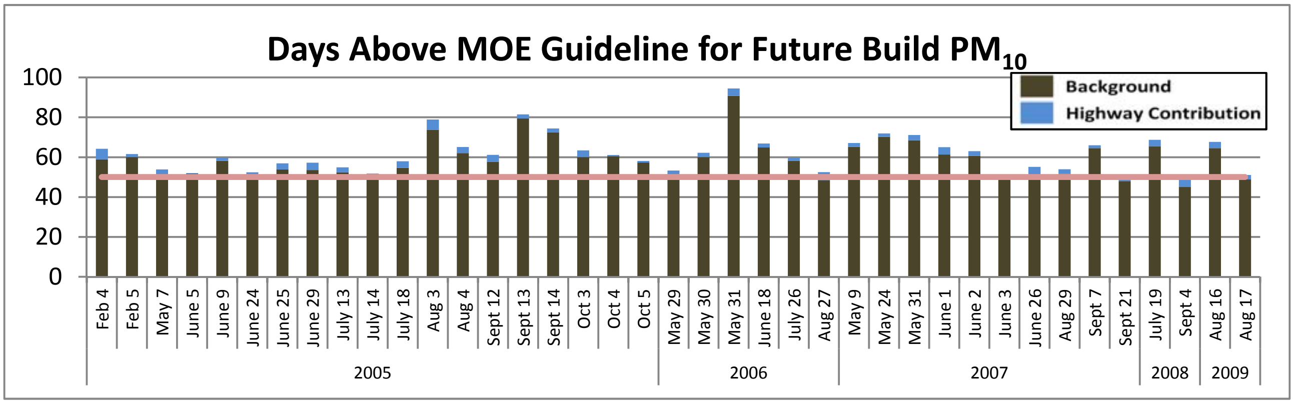
5 Year Summary of Future Build	
% of MOE Guideline:	
Maximum	189%
90th Percentile	61%
Average	32%
Roadway Contribution:	
Maximum	4%
90th Percentile	9%
Average	17%
Change from Existing Scenario:	
Maximum	2%
90th Percentile	6%
Average	9%

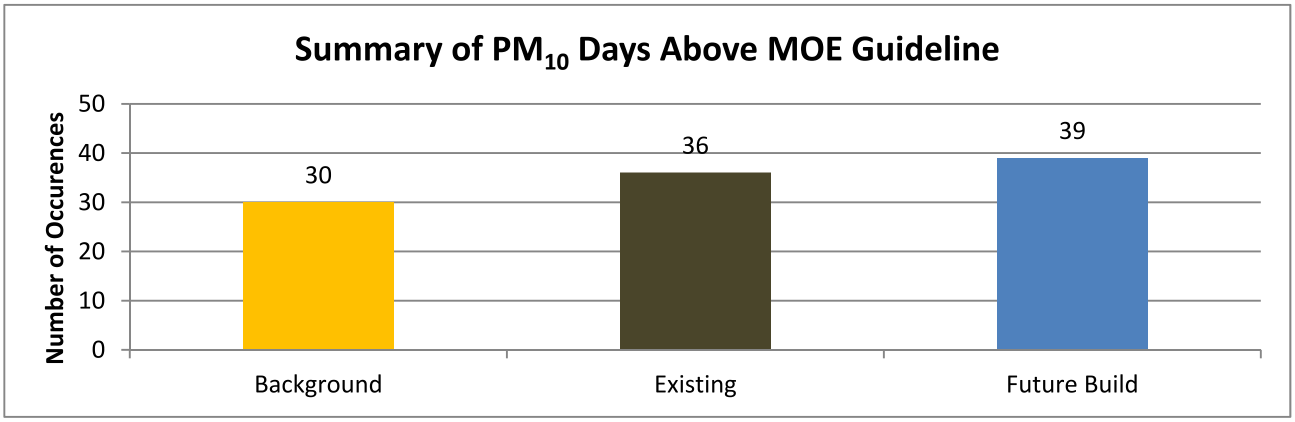
Conclusions:

- The maximum PM_{10} combined concentration exceeded the MOE guideline.
- The contribution from the roadway to the combined concentrations was 17% or less.
- The change from the existing scenario was 9% or less.
- Since there were days where PM_{10} concentrations were above the MOE guideline, frequency analysis was conducted to show that elevated concentrations were not frequent over a 5 year period. This analysis is presented below.

Table 41: 5 Year Frequency Analysis of Existing and 2021 Future Build PM_{10}







Conclusions:

- Three additional days above the MOE guideline are expected due to the project over a 5 year period.
- For the future build scenario the combined concentrations only exceeded the MOE guideline 2% of the time.

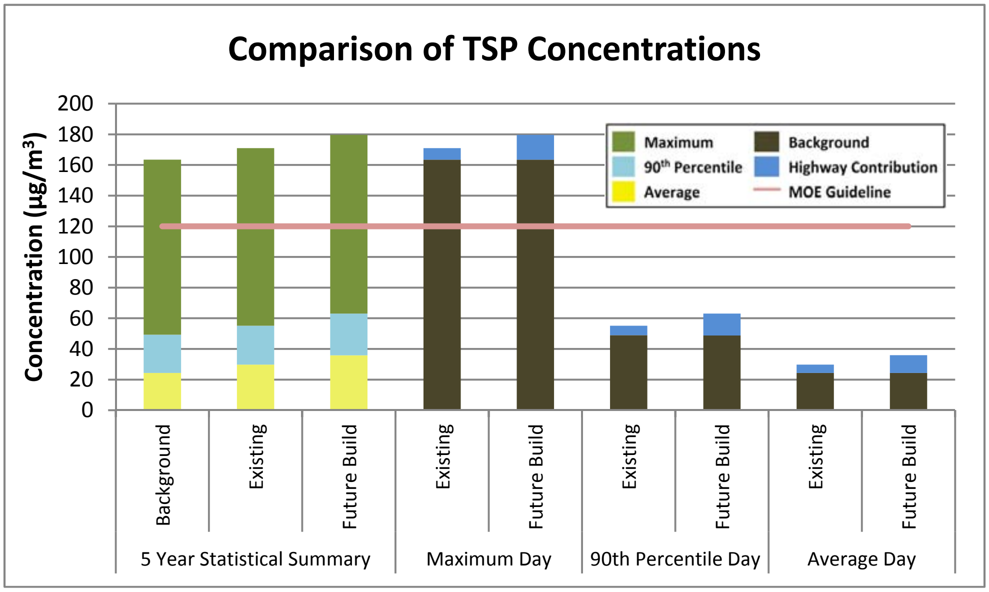
It should be remembered that PM_{10} background concentrations were derived based on their relationship to $PM_{2.5}$ since PM_{10} is not monitored in Ontario. Therefore, considering that there were high days of $PM_{2.5}$ it was also anticipated that there would be high days PM_{10}.

3.1.5 Total Suspended Particulate Matter (TSP)

Table 42 presents the existing and future build combined concentrations alongside the background concentrations for 24-hour TSP based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr TSP combined concentrations for the existing and future build scenarios exceeded the MOE guideline.*

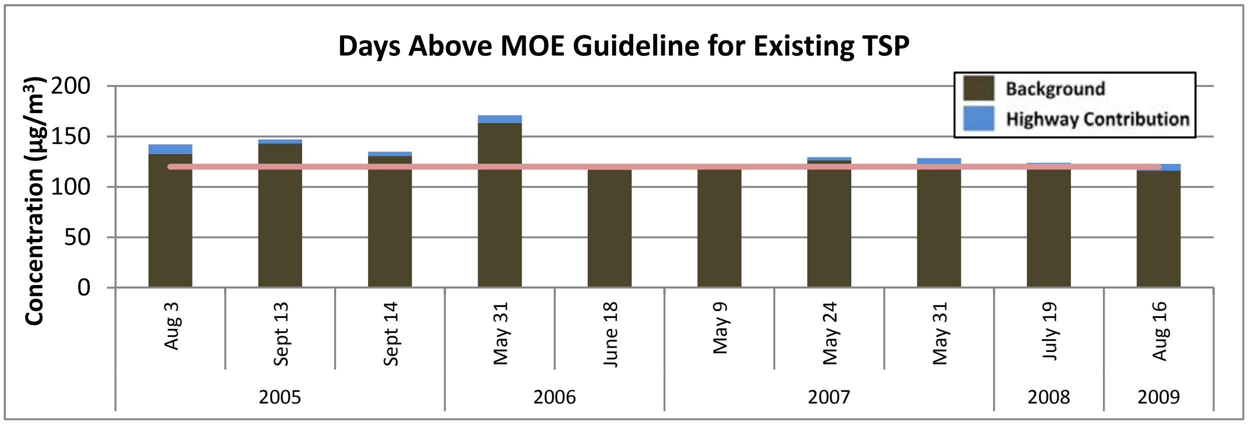
Table 42: Summary of Existing and 2021 Future Build TSP

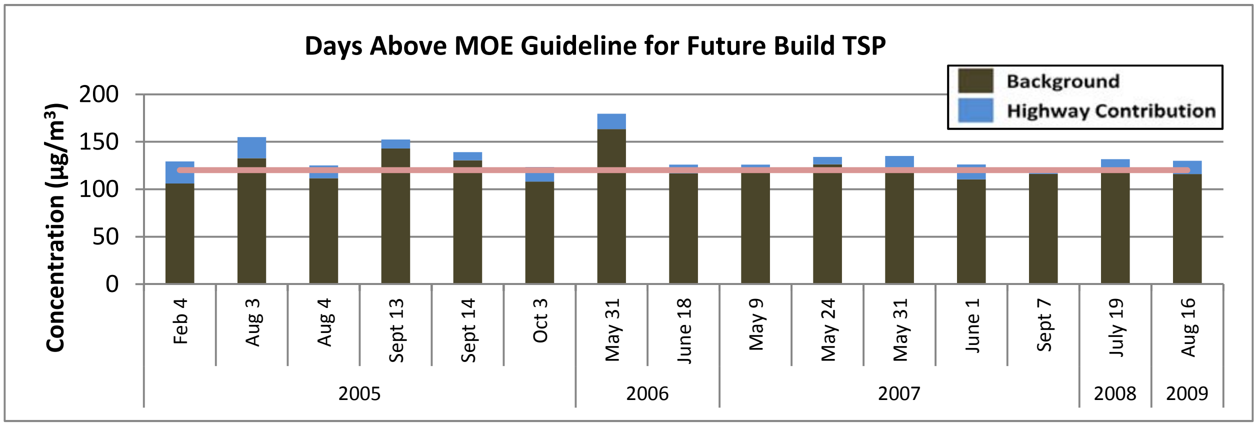
Statistical Analysis	5 Year Summary of Future Build	
	**% of MOE Guideline:**	
	Maximum	150%
	90th Percentile	53%
	Average	30%
	Roadway Contribution:	
	Maximum	9%
	90th Percentile	23%
	Average	32%
	Change from Existing Scenario:	
	Maximum	5%
	90th Percentile	14%
	Average	20%

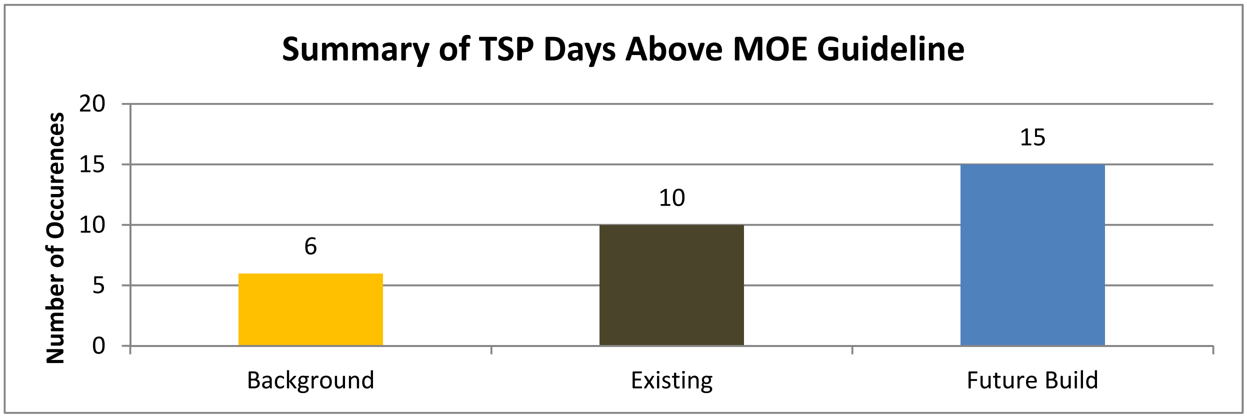
Conclusions:

- The maximum TSP combined concentration exceeded the MOE guideline.
- The contribution from the roadway to the combined concentrations was 32% or less.
- The change from the existing scenario was 20% or less.
- Since there were days where TSP concentrations were above the MOE guideline, frequency analysis was conducted to show that elevated concentrations were not frequent over a 5 year period. This analysis is presented in **Table 43**.

Table 43: 5 Year Frequency Analysis of Existing and 2021 Future Build TSP







Conclusions:

- Five additional days above the MOE guideline are expected due to the project over a 5 year period.
- For the future build scenario the combined concentrations only exceeded the MOE guideline 1% of the time.

It should be remembered that TSP background concentrations were derived based on their relationship to $PM_{2.5}$ since TSP is not monitored in Ontario. Therefore, considering that there were elevated days of $PM_{2.5}$ it was also anticipated that there would be elevated days TSP.

3.2 Volatile Organic Compounds (VOCs)

Due to the lack of hourly and daily background monitoring data, statistical analysis (maximum, 90th percentile, and average) could not be conducted. Instead, the 90th percentile background concentration for each VOC was calculated from available data in the 5 year dataset. The 90th percentile background concentration was then added to the maximum modelled roadway concentration in order to estimate a reasonable worst-case combined concentration. The combined concentration was then used to assess compliance with MOE guidelines. Provided below are the modelling results for the VOCs: acetaldehyde, acrolein, benzene, 1,3-butadiene and formaldehyde.

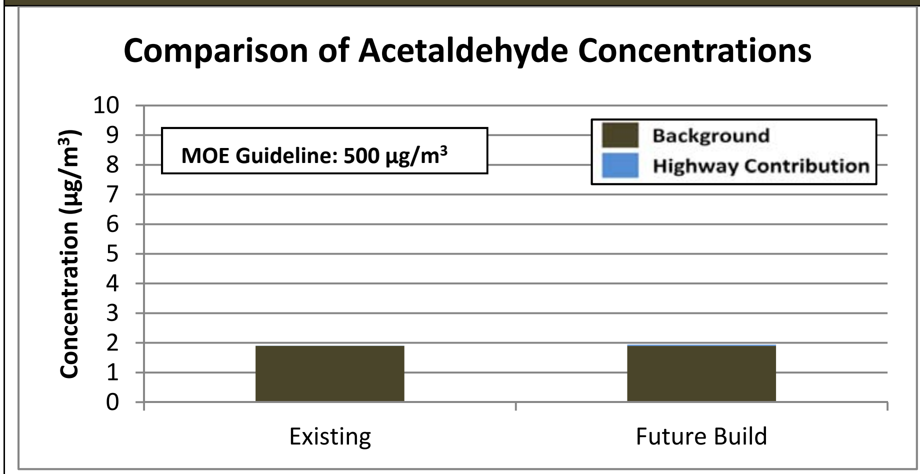
3.2.1 Acetaldehyde

Table 44 presents the combined concentrations for 24-hour acetaldehyde based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour acetaldehyde combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 44: Summary of Existing and 2021 Future Build Acetaldehyde

Statistical Analysis



5 Year Summary of Future Build	
% of MOE Guideline:	
Maximum	<1%
90th Percentile	<1%
Average	<1%
Roadway Contribution:	
Maximum	2%
90th Percentile	3%
Average	1%
Change from Existing Scenario:	
Maximum	7%
90th Percentile	3%
Average	1%

Conclusions:

- The maximum acetaldehyde combined concentration was below the MOE guideline.
- The contribution from the roadway to the combined concentrations was 3% or less.
- There was an improvement of up to 7% from the existing scenario.

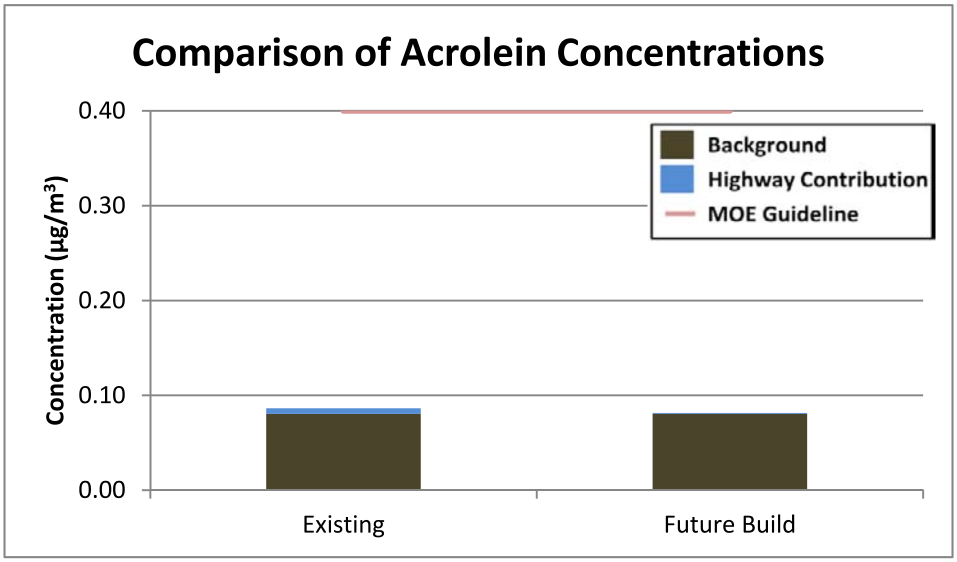
3.2.2 Acrolein

Table 45 presents the combined concentrations for 24-hour acrolein based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour acrolein combined concentrations for the existing and future build scenarios were below their respective MOE guidelines.*

Table 45: Summary of Existing and 2021 Future Build Acrolein

Statistical Analysis



5 Year Summary of Future Build	
% of MOE Guideline:	
Maximum	22%
90^{th} Percentile	21%
Average	20%
Roadway Contribution:	
Maximum	3%
90^{th} Percentile	3%
Average	1%
Change from Existing Scenario:	
Maximum	-10%
90^{th} Percentile	-3%
Average	-1%

Conclusions:

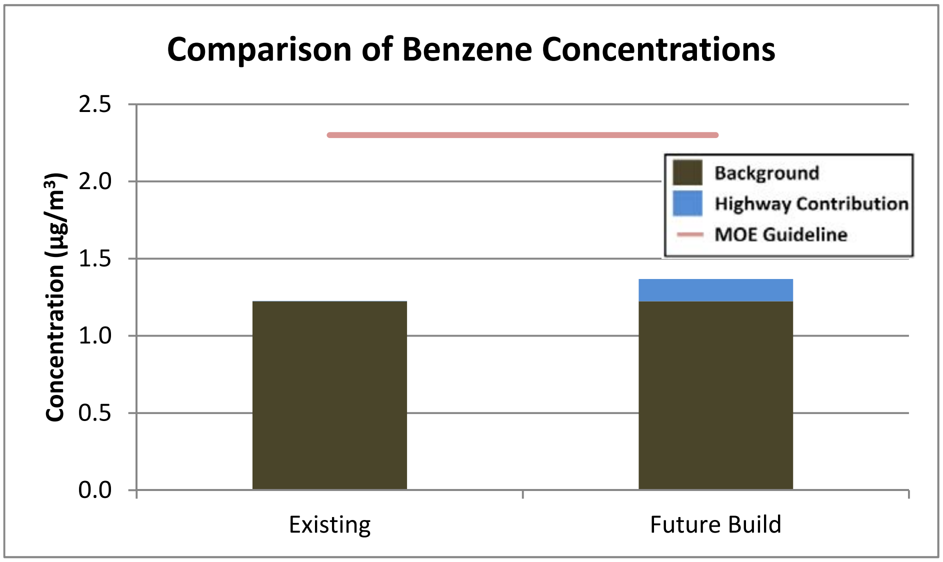
- The maximum acrolein combined concentration was below the MOE guideline.
- The contribution from the roadway to the combined concentrations was 3% or less.
- There was an improvement of up to 10% from the existing scenario.

3.2.3 Benzene

Table 46 presents the combined concentrations for 24-hour benzene based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour benzene combined concentrations for the existing and future build scenarios were below their respective MOE guidelines.*

Table 46: Summary of Existing and 2021 Future Build Benzene

<table>
<tr><th>Statistical Analysis</th><th colspan="2">5 Year Summary of Future Build</th></tr>
<tr><td rowspan="12">
</td><td colspan="2">% of MOE Guideline:</td></tr>
<tr><td>Maximum</td><td>60%</td></tr>
<tr><td>90th Percentile</td><td>56%</td></tr>
<tr><td>Average</td><td>55%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>10%</td></tr>
<tr><td>90th Percentile</td><td>5%</td></tr>
<tr><td>Average</td><td>3%</td></tr>
<tr><td colspan="2">Change from Existing Scenario:</td></tr>
<tr><td>Maximum</td><td>12%</td></tr>
<tr><td>90th Percentile</td><td>6%</td></tr>
<tr><td>Average</td><td>3%</td></tr>
<tr><td colspan="3">Conclusions:
• The maximum benzene combined concentration was below the MOE guideline.
• The contribution from the roadway to the combined concentrations was 10% or less.
• There was an increase of up to 12% from the existing scenario.</td></tr>
</table>

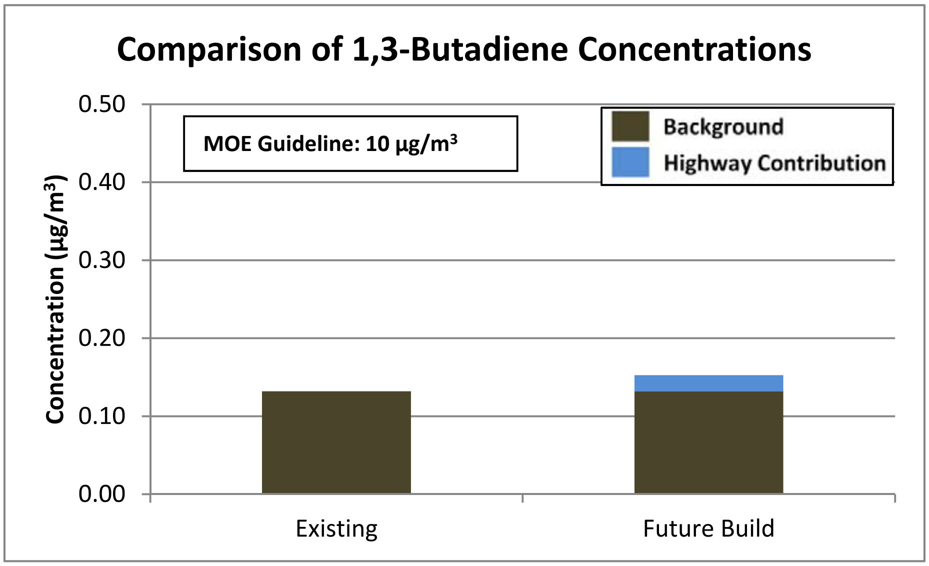
3.2.4 1,3-Butadiene

Table 47 presents the combined concentrations for 24-hour 1,3-butadiene based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour 1,3-butadiene combined concentrations for the existing and future build scenarios were well below their respective MOE guidelines.*

Table 47: Summary of Existing and 2021 Future Build 1,3-Butadiene

Statistical Analysis



5 Year Summary of Future Build	
% of MOE Guideline:	
Maximum	2%
90th Percentile	1%
Average	1%
Roadway Contribution:	
Maximum	14%
90th Percentile	7%
Average	4%
Change from Existing Scenario:	
Maximum	16%
90th Percentile	8%
Average	4%

Conclusions:

- The maximum 1,3-butadiene combined concentration was below the MOE guideline.
- The contribution from the roadway to the combined concentrations was 14% or less.
- There was an increase of up to 16% from the existing scenario.

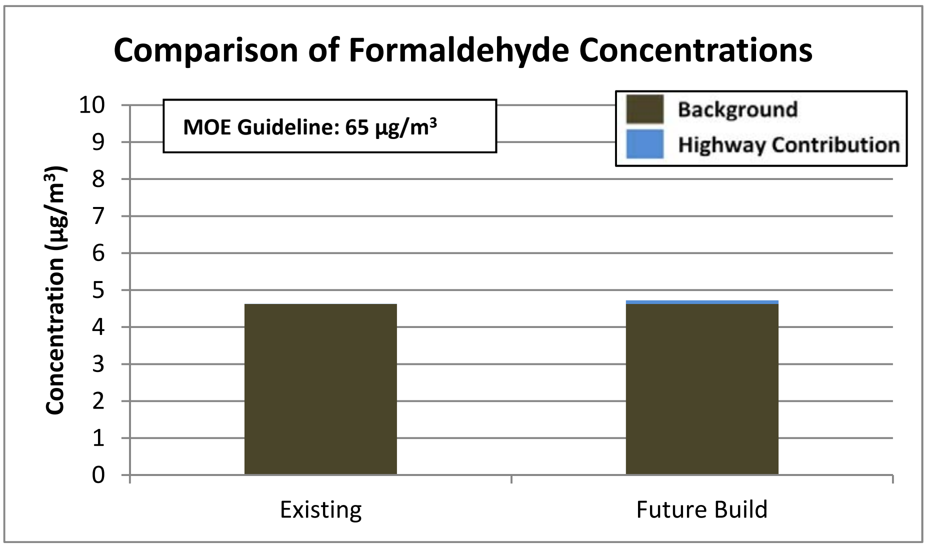
3.2.5 Formaldehyde

Table 48 presents the combined concentrations for 24-hour formaldehyde based on 5 years of meteorological data. Results shown are at the worst-case sensitive receptor for the future build scenario. The results conclude that:

- *The maximum 24-hour formaldehyde combined concentrations for the existing and future build scenarios were below their respective MOE guidelines.*

Table 48: Summary of Existing and 2021 Future Build Formaldehyde

Statistical Analysis	5 Year Summary of Future Build



% of MOE Guideline:	
Maximum	7%
90th Percentile	7%
Average	7%
Roadway Contribution:	
Maximum	2%
90th Percentile	1%
Average	1%
Change from Existing Scenario:	
Maximum	2%
90th Percentile	1%
Average	1%

Conclusions:

- The maximum formaldehyde combined concentration was below the MOE guideline.
- The contribution from the roadway to the combined concentrations was 2% or less.
- There was an increase of up to 2% from the existing scenario.

3.3 Concentration Contour Plot

A maximum $PM_{2.5}$ roadway concentration contour plot is provided below for a worst-case section of Dundas Street, for the 2021 future build scenario, in order to graphically display results. The plot also shows how contaminant concentration decreases as a function of distance from the roadway. The plot was constructed by modelling a fine Cartesian Grid of hypothetical receptors and determining the maximum roadway concentration at each receptor. It should be noted that from the modelling results the roadway contribution to the $PM_{2.5}$ combined concentration was small in comparison to the background and that the roadway contribution falls off quickly with downwind distance from the roadway, as shown in the contour plot. Typically, at distances of 300 to 500 m from the roadway, the combined concentration is almost all due to the background.

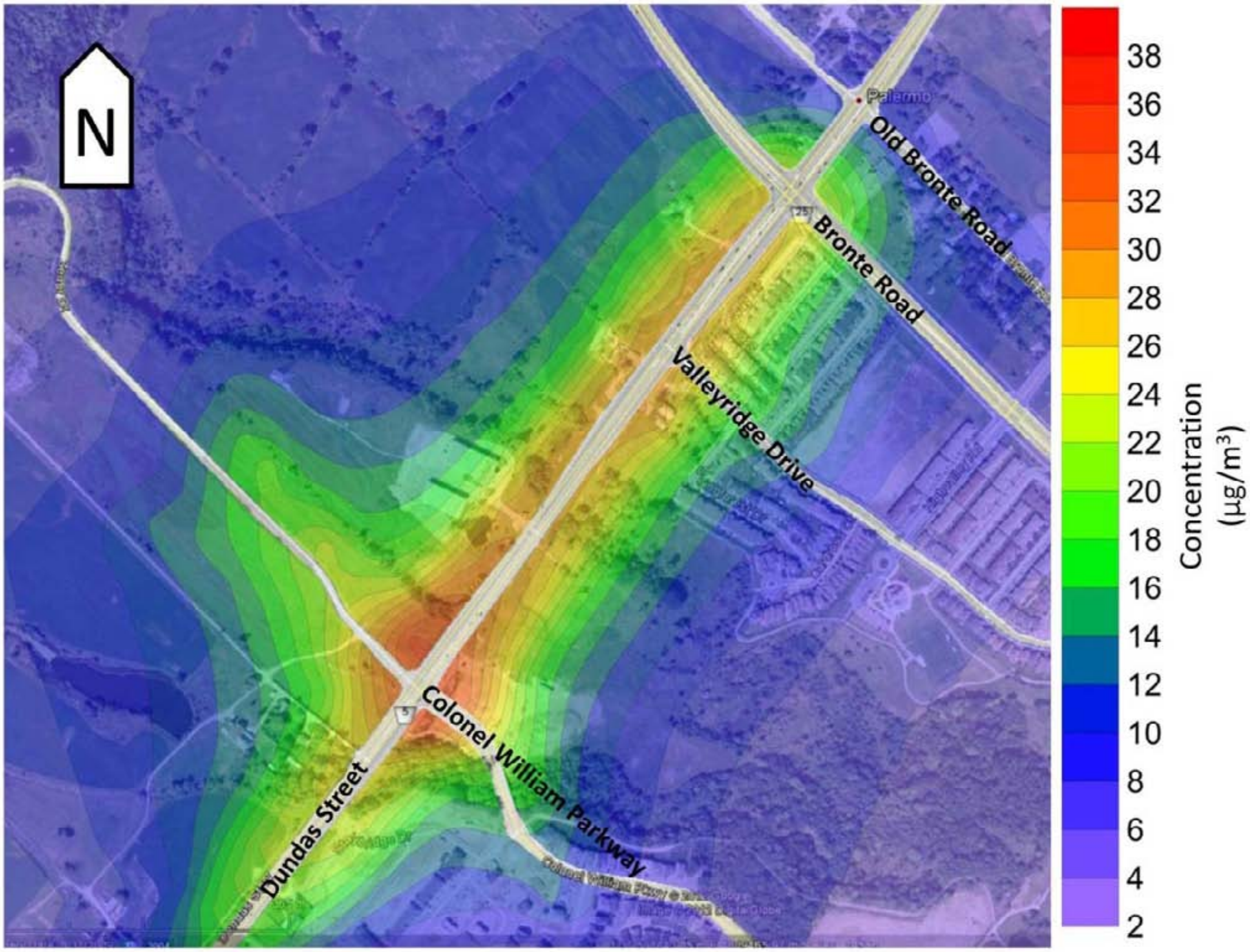
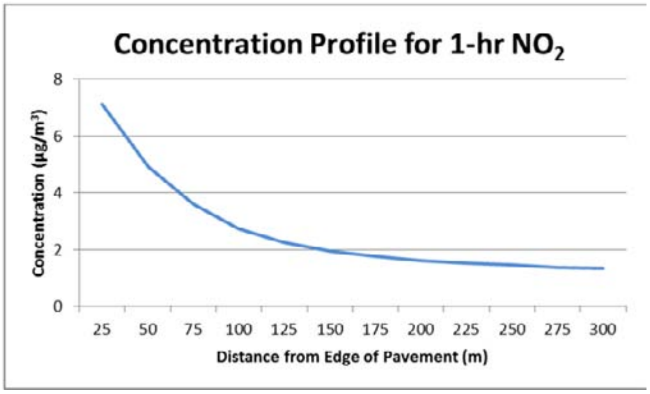


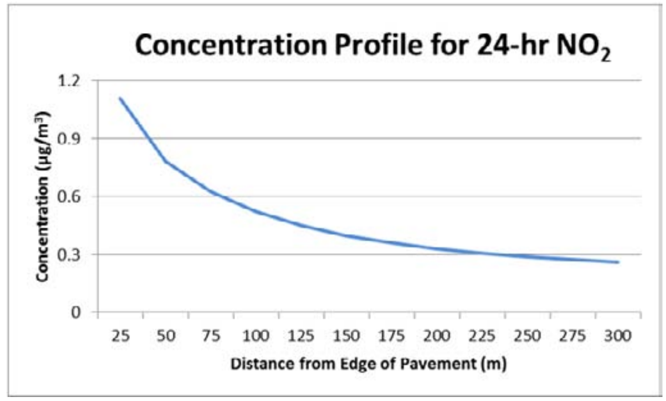
Figure 16: Concentration Contour Plot of Maximum $PM_{2.5}$ Concentrations

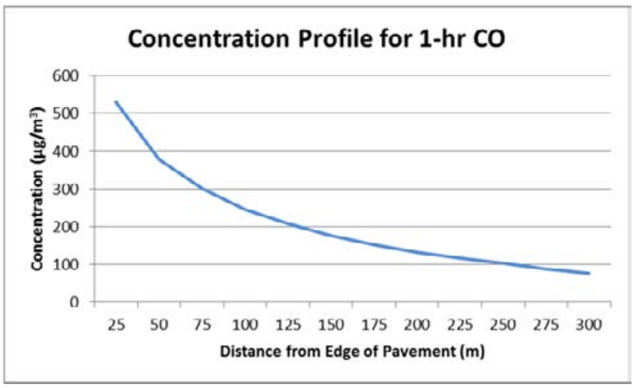
3.4 Concentration Profiles

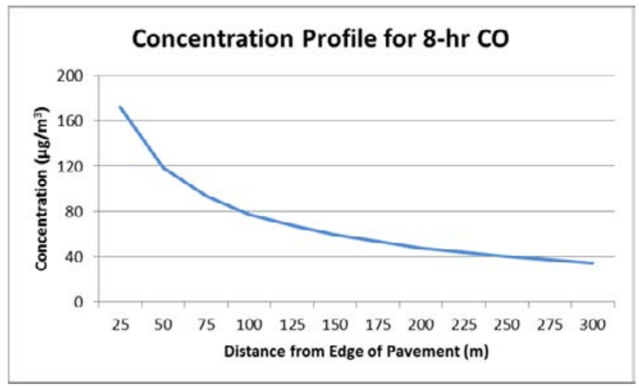
Presented in **Table 49** are concentration profile curves for each of the modelled contaminants for a worst-case section of Dundas Street These concentration profiles show how contaminant concentrations decrease as a function of distance from the roadway. The profiles were constructed by modelling a line of receptors spaced 25 m apart to a distance of 300 m from the roadway edge of pavement. These results show only the emissions from the roadway (i.e. background concentrations are not included). At a distance of 300 to 500 m from the roadway, contaminant levels are dominated by background concentration.

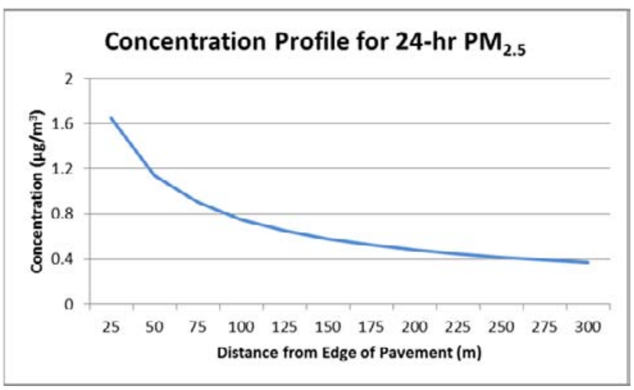
Table 49: Concentration Profiles

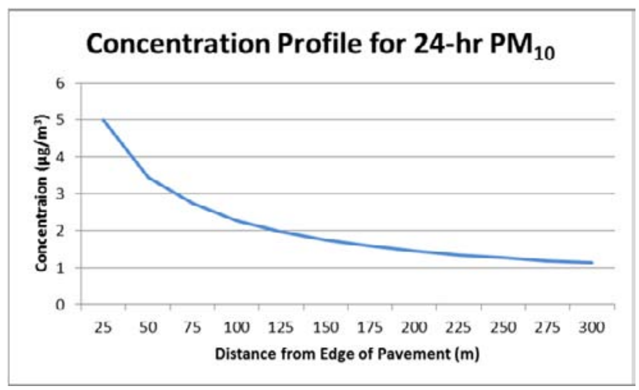


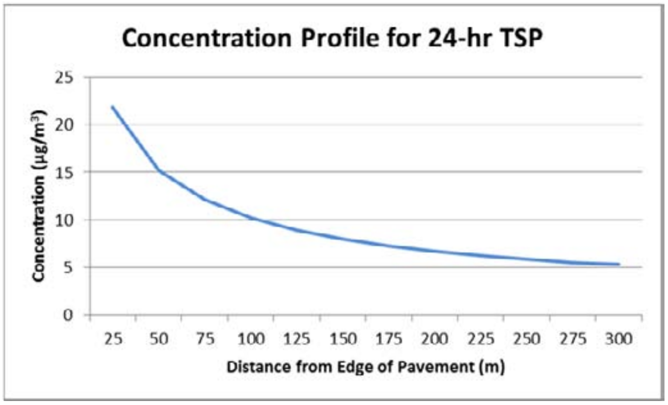


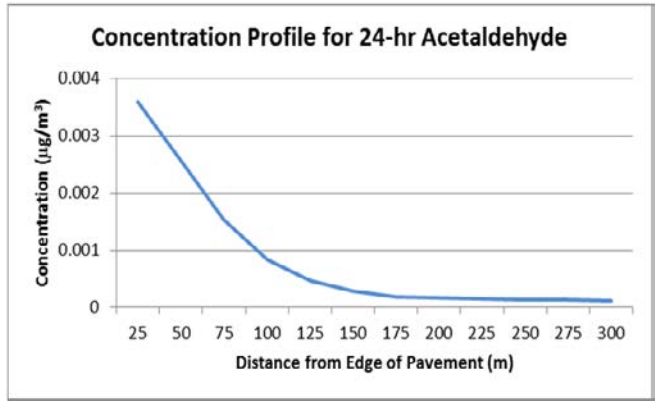


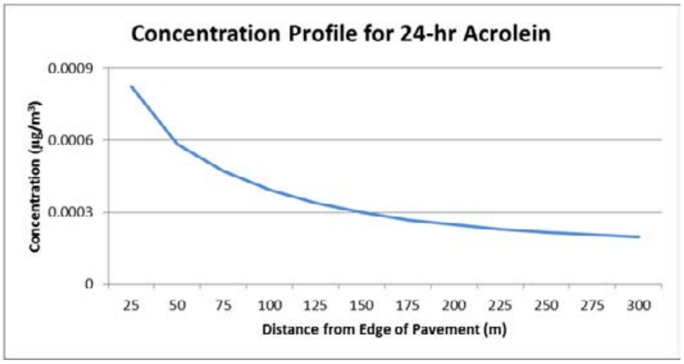


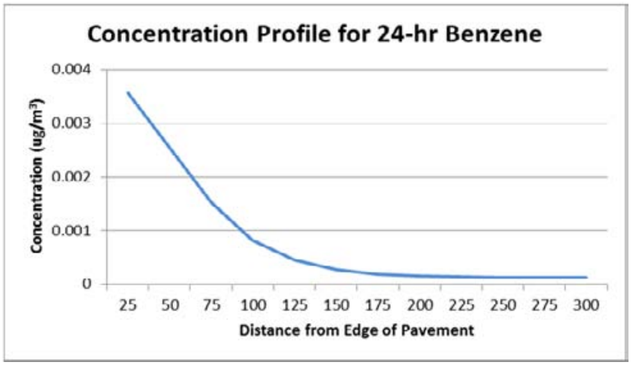


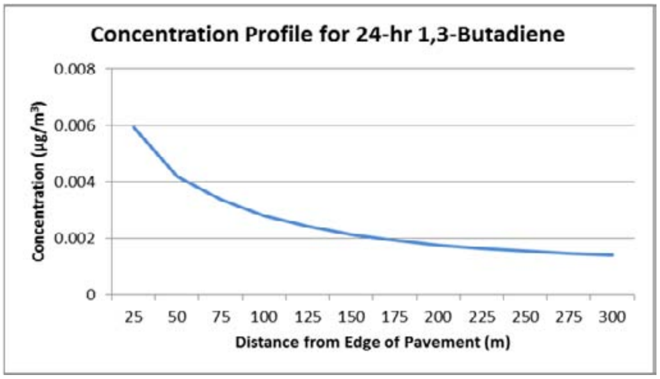


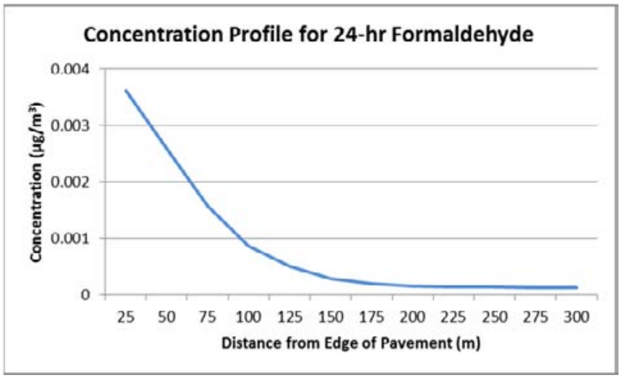

Concentration Profile for 24-hr TSP
Concentration (µg/m³)
0
5
10
15
20
25
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Acetaldehyde
Concentration (µg/m³)
0
0.001
0.002
0.003
0.004
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Acrolein
Concentration (µg/m³)
0
0.0003
0.0006
0.0009
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Benzene
Concentration (µg/m³)
0
0.001
0.002
0.003
0.004
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement


Concentration Profile for 24-hr 1,3-Butadiene
Concentration (µg/m³)
0
0.002
0.004
0.006
0.008
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)


Concentration Profile for 24-hr Formaldehyde
Concentration (µg/m³)
0
0.001
0.002
0.003
0.004
25 50 75 100 125 150 175 200 225 250 275 300
Distance from Edge of Pavement (m)

3.5 Implications of Air Quality on Human Health

As noted in Section 2.6, the predicted maximum combined concentrations experienced at the worst-case sensitive receptor location along the corridor for all evaluated contaminants of concern were below their corresponding air quality guideline, with the exception of particulate matter (*i.e.*, $PM_{2.5}$, PM_{10}, and TSP). As such, for those predicted worst-case exposures that did not exceed the regulatory guideline, no potential health risks would be expected to even sensitive members of the population. As such, only the potential health risks related to particulate matter (PM) need be discussed further in this report.

PM consists of airborne particles in solid or liquid form, the size of ambient PM ranging from approximately 0.005 to 100 microns (µm) in aerodynamic diameter (WHO, 2005). PM is operationally separated into three groups: i) total suspended particulate (TSP); ii) inhalable coarse particles (PM_{10}); and, iii) fine or respirable particles ($PM_{2.5}$). It is important to recognize that TSP contains all particles smaller than 44 microns; PM_{10} contains all particles with a mean aerodynamic diameter of 10 microns or less; and $PM_{2.5}$ contains particles equal to or smaller than 2.5 microns as well as ultrafine PM of less than 0.1 micron.

When evaluating the potential health implications arising from exceedances of the various regulatory guidelines pertaining to PM, the most relevant guideline is for the fine particulate matter size fraction (*i.e.*, $PM_{2.5}$). Fine particulate matter (*i.e.*, particulates smaller than 2.5 microns in size) largely originates from combustion processes. Particle size is a very important factor in determining the inhalability and eventual deposition of particulate matter within the respiratory tract (Health Canada, 1999). Particles between 2 and 3 µm or smaller are able to reach the alveoli in the distal parts of the lung, and therefore, have been termed respirable (Health Canada, 1999). Those particles that penetrate the lowest reaches of the lungs typically have the greatest potential for health impacts to the individual.

Epidemiological studies have indicated a positive association between particulate matter and health outcomes such as daily mortality, impaired lung function, adverse respiratory symptoms and medication use, respiratory and cardiovascular hospitalizations, frequency of reported chronic respiratory disease and restricted activity days (Environment Canada, 2000).

Time-series epidemiological studies estimate that a 10 $\mu g/m^3$ increase in mean 24-hour $PM_{2.5}$ concentration increases the relative risk for daily cardiovascular mortality by approximately 0.4% to 1.0%. Despite theoretical statistical risks ascribed to all individuals, this elevated risk from exposure is not equally distributed within a population. At present-day levels, $PM_{2.5}$ likely poses an acute threat principally to susceptible people, even if seemingly healthy, such as the elderly and those with (unrecognized) existing coronary artery or structural heart disease. Research has indicated that a 10 $\mu g/m^3$ increase during the preceding day contributes on average to the premature death of approximately one susceptible person per day in a region of 5 million people (based on annual US death rates in 2005). However, when one extrapolates this to the small impact area that may actually be exposed to these concentrations along a transportation corridor, it would be difficult to detect any increase in premature death from a statistical point-of-view.

The primary health concern with respect to particulate matter is related to chronic exposures to elevated concentrations. When focussing on $PM_{2.5}$, the regulatory benchmark (*i.e.*, Canada Wide Standard, or CWS) is 30 $\mu g/m^3$ over a 24-hour averaging time. In this case, the air quality benchmark is a risk management objective intended to provide protection for human health effects for the vast majority of the normal population. It is not intended to be considered a level at which no health impacts could occur. The CWS benchmark is calculated based on the 98th percentile of ambient measurements annually, averaged over the three consecutive years. As such, the intention is to identify those circumstances where concentrations would be consistently exceeding the established benchmark, resulting in significant health impacts on individuals with the exposure area.

In the case of the current assessment, background concentrations of $PM_{2.5}$ (*i.e.*, in absence of contribution from the corridor) exceed the CWS approximately 4.6 days in a year (*i.e.*, 23 days over a five year period). These would be considered “bad air days” where regional air quality is poor, and health departments send out advisories to avoid heavy exercise outdoors, particularly if you are an individual with pre-existing health concerns. On these days, there is definitely the potential for health concerns for susceptible individuals. However, the results of the current assessment indicate that the proposed 2021 future build scenario would result in only two additional day that would exceed the regulatory benchmark, when compared to the existing conditions.

While worst-case exposures are important for evaluating the potential health impacts, and research has demonstrated any increase in ambient $PM_{2.5}$ concentrations has been shown to be statistically linked to an increase in adverse health outcomes in an overall population, the frequency of the occurrence of these elevated concentrations is also an important piece of the puzzle. While the maximum day concentration greatly exceeds the regulatory benchmark, both the 90th percentile and average days show significantly lower concentrations. Therefore, while those days that approach and exceed the risk management guideline could result in acute respiratory issues for sensitive individuals, given the typical ambient concentrations are significantly lower; the potential for chronic health concerns related to the proposed project would be low. Furthermore, the 98th percentile $PM_{2.5}$ combined concentration averaged over a 3 year period for the future build scenario was estimated to be 28.9µg/m^3, which did not exceed the CWS benchmark of 30 µg/m^3.

4.0 Conclusions and Recommendations

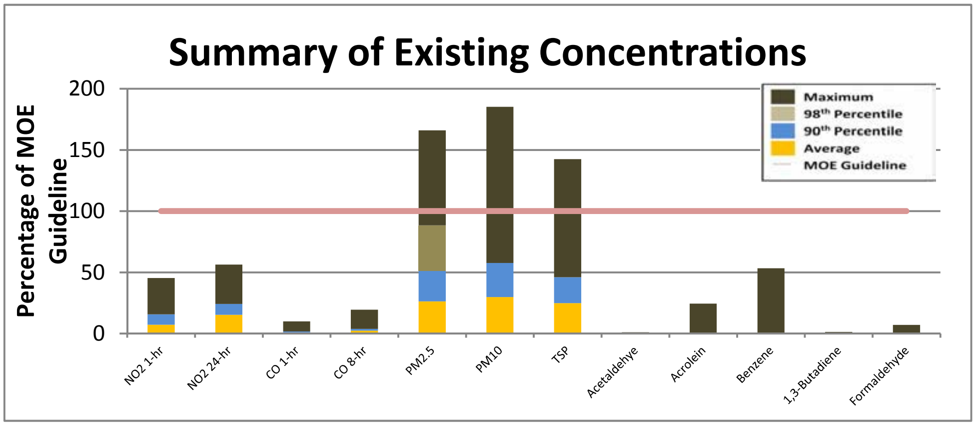
The potential air quality impacts of the existing and proposed project for the 2021 future build scenario have been assessed and are summarized in **Table 50**. The following conclusions and recommendations are a result of this assessment.

- *The maximum combined concentrations for the existing and 2021 future build scenarios were all below their respective MOE guidelines or CWS, with the exception of* PM_{10} *and TSP.*
- *Frequency Analysis determined that the project exceeded the* PM_{10} *and TSP guidelines 3 and 5 additional days respectively over the 5 year period. This equates to <1% of the time.*
- *The average percentage change of maximum combined concentrations from existing scenario to future build scenario for all contaminants was 1.7%. This represents marginal increase.*
- *The potential for chronic health concerns would be low.*
- *Mitigation measures are not warranted, due to the fact that only 3 and 5 additional days above the guideline for* PM_{10} *and TSP respectively are predicted over a 5 year period.*

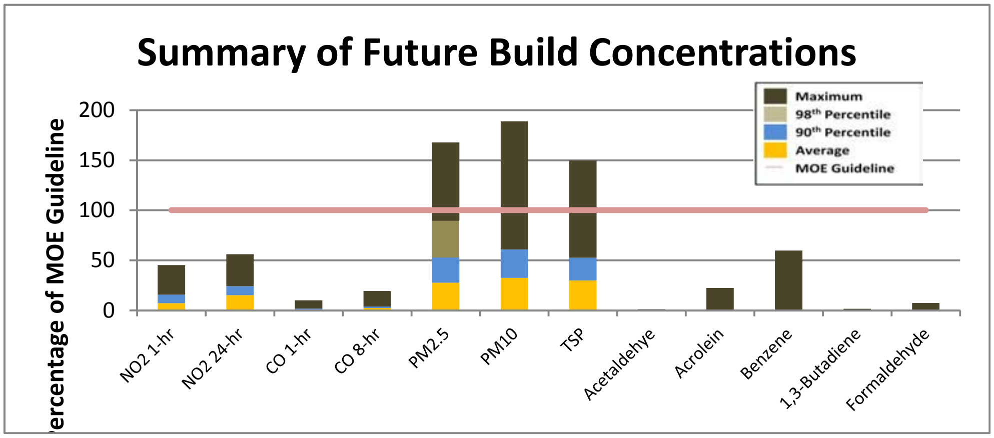
Comparing the predicted air quality impacts of the 2021 future build scenario presented in this report to the 2031 ultimate (i.e., dedicated Bus Rapid Transit (BRT)) future build scenario presented in companion report "Novus Environmental, November 27, 2012, *Air Quality Assessment, Dundas Street Corridor Improvements, Brant Street to Trafalgar Road*", it is concluded that air quality impacts will marginally improve in the ultimate scenario. This improvement is mainly the result of decreased motor vehicle emissions due to improvements in fuel formulations and vehicle control technologies.

Table 50: Summary of Existing and 2021 Future Build Results

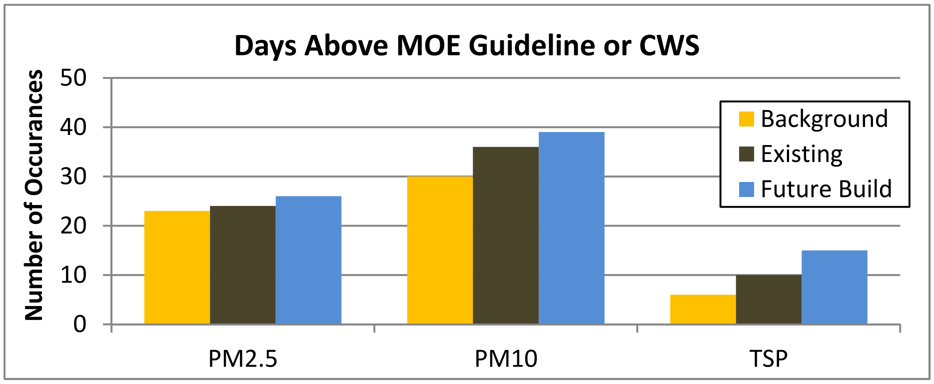
5 Year Statistical Summary



Note: The $PM_{2.5}$ concentration for the existing scenario is in compliance with the CWS. The highest 3-year rolling average of the yearly 98th percentile concentration was calculated to be 28.43 µg/m^3 (2005-2007) or 95% of the standard.



Note: The $PM_{2.5}$ concentration for the future build scenario is in compliance with the CWS. The highest 3-year rolling average of the yearly 98th percentile concentration was calculated to be 28.9 µg/m^3 (2005-2007) or 96% of the standard.



% of Guideline

Existing Scenario:

NO_2 (1-hr)	45%
NO_2 (24-hr)	56%
CO (1-hr)	10%
CO (8-hr)	19%
$PM_{2.5}$	95%
PM_{10}	185%
TSP	142%
Acetaldehyde	<1%
Acrolein	24%
Benzene	53%
1,3-Butadiene	1%
Formaldehyde	7%

Future Build Scenario:

NO_2 (1-hr)	45%
NO_2 (24-hr)	56%
CO (1-hr)	10%
CO (8-hr)	19%
$PM_{2.5}$	96%
PM_{10}	189%
TSP	150%
Acetaldehyde	<1%
Acrolein	22%
Benzene	60%
1,3-Butadiene	2%
Formaldehyde	7%

Additional Days Above Guideline Due to Project:

$PM_{2.5}$	2
PM_{10}	3
TSP	5

5.0 References

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Appendix A

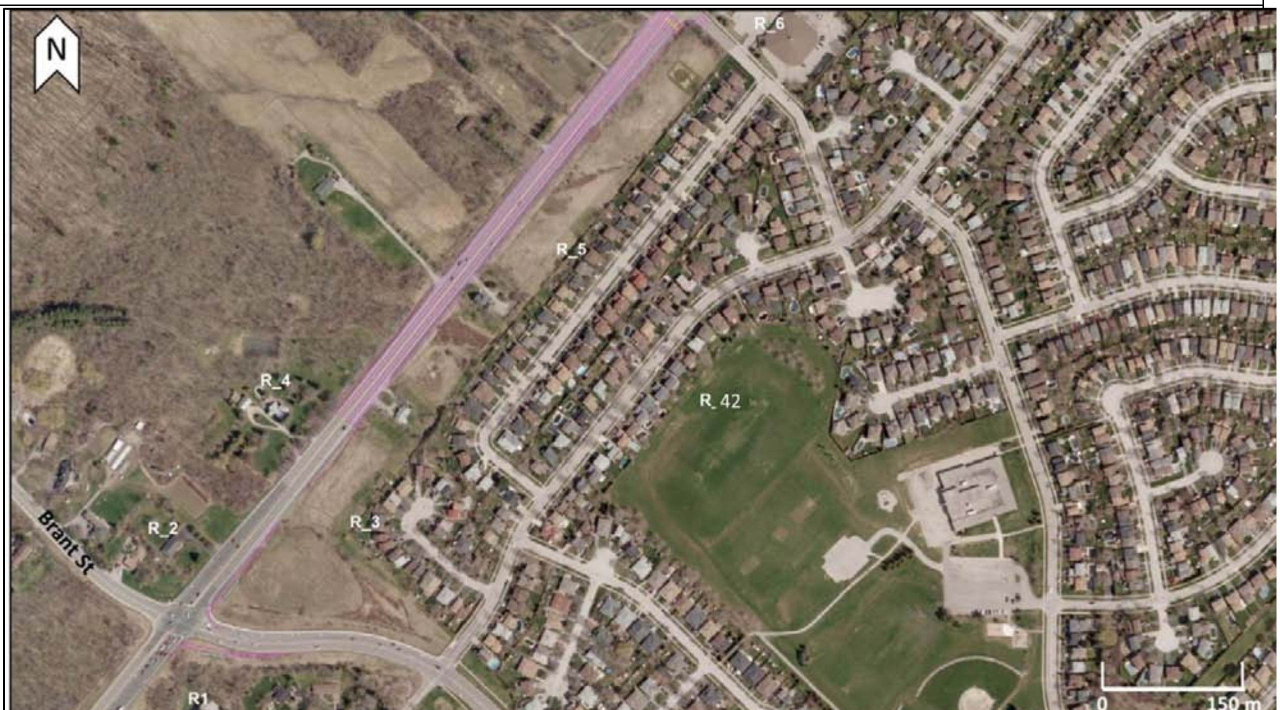
Individual Sensitive Receptor Results

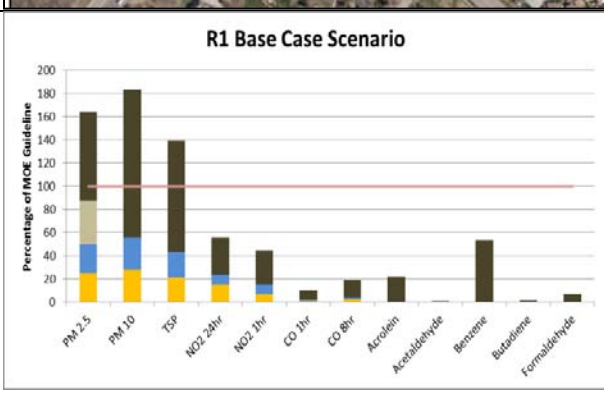
5 Year Statistical Summary for All Modelled Sensitive Receptors

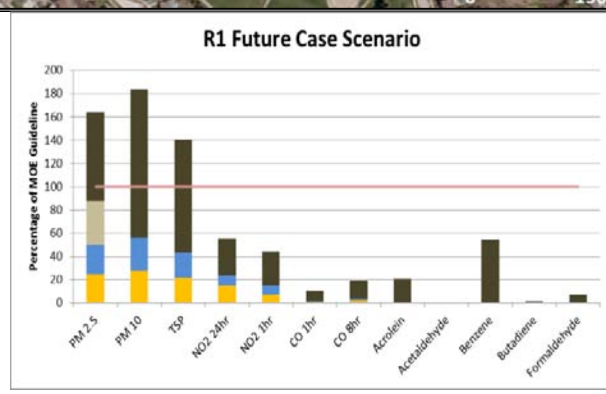
Legend:

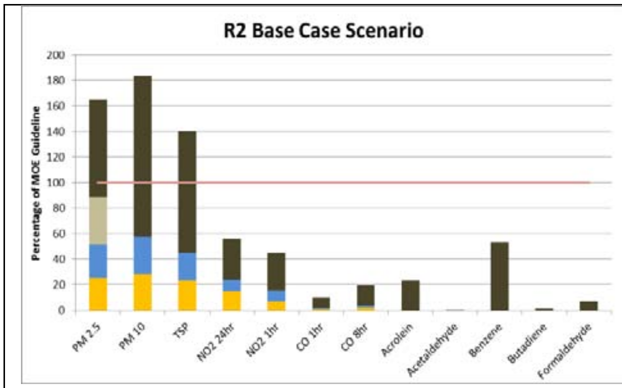
- Maximum
- 98th Percentile
- 90th Percentile
- Average
- MOE Guideline

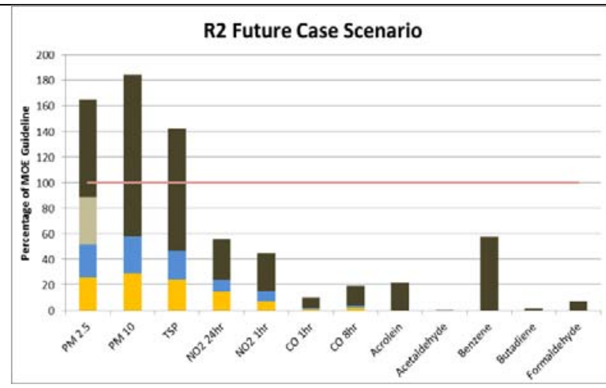
R1 - R6, R42

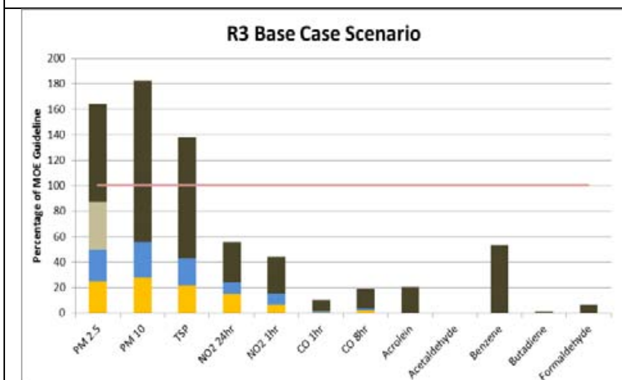


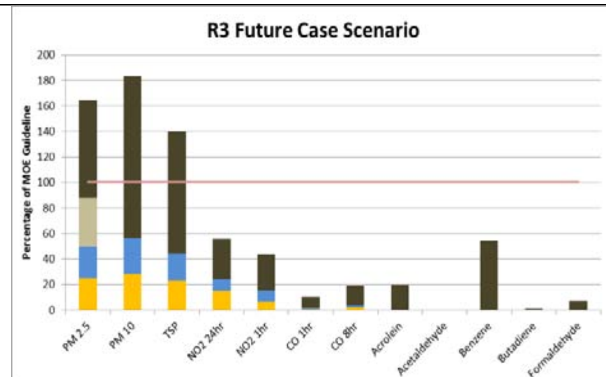


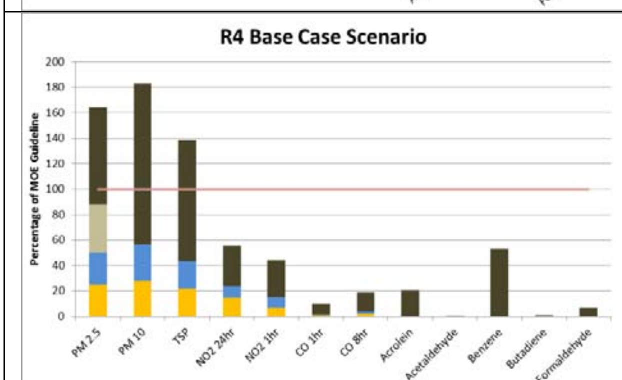


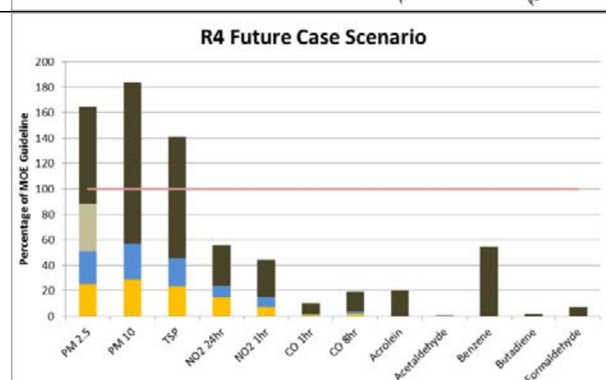

R2 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

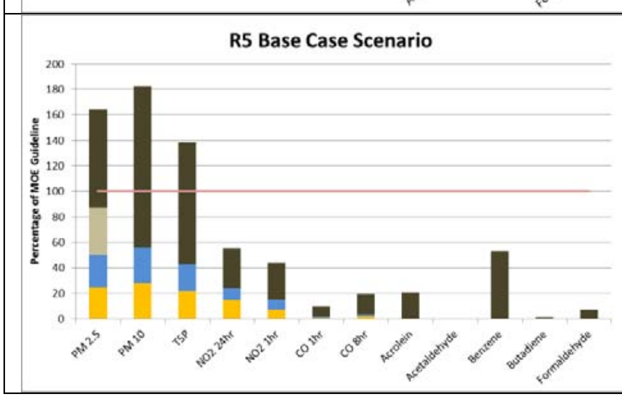

R2 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

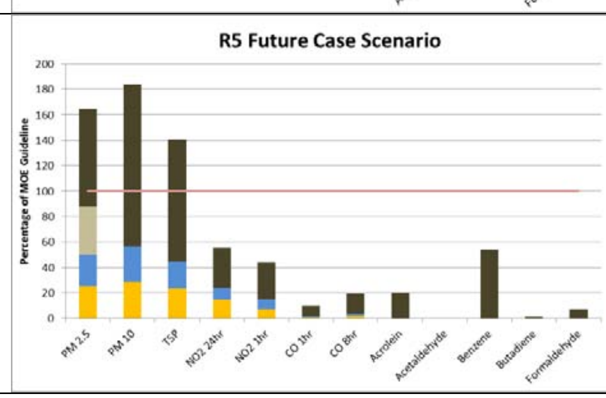

R3 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

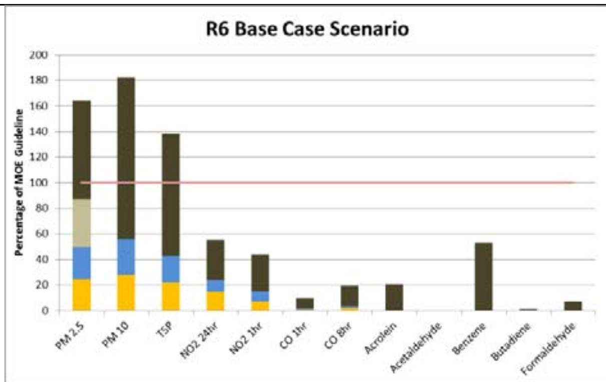

R3 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

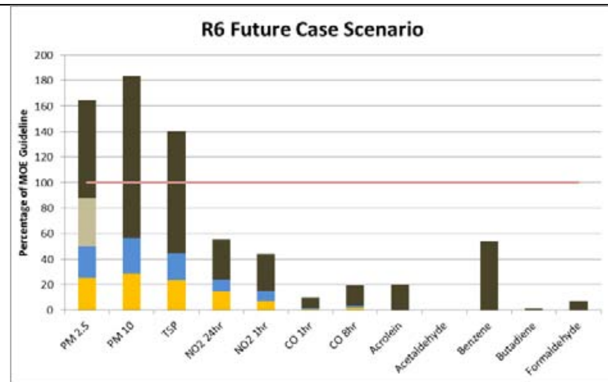

R4 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

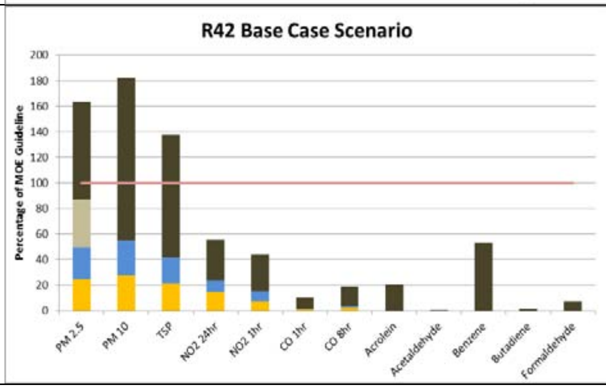

R4 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

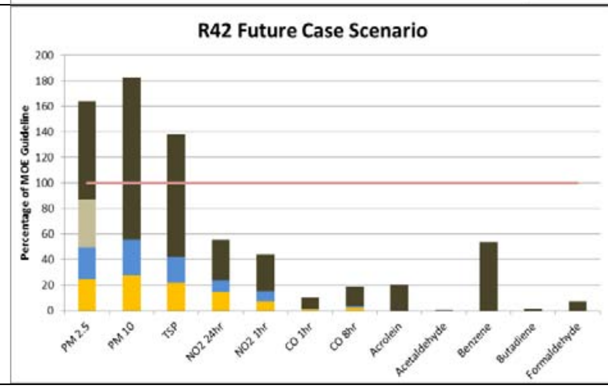

R5 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R5 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

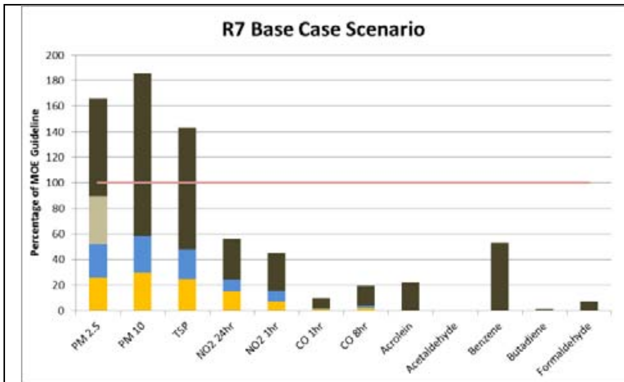


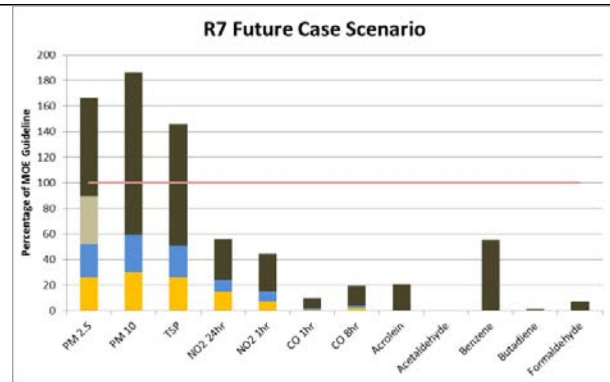


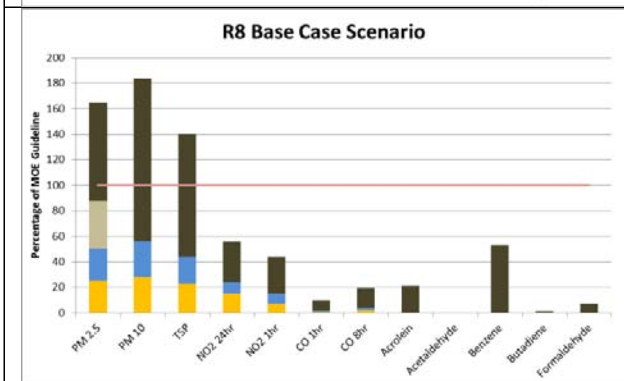


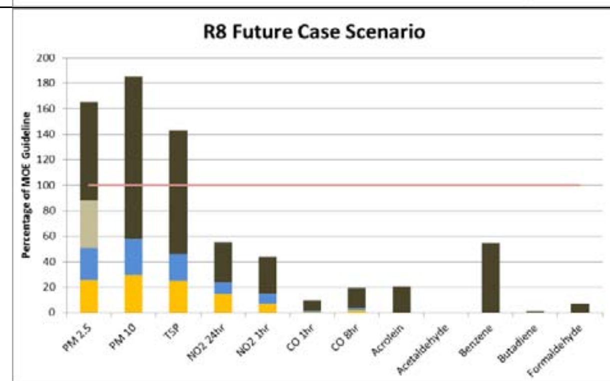


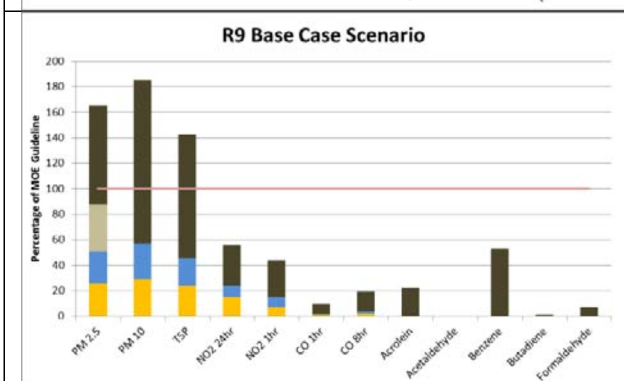
R7 - R14, R43, R44

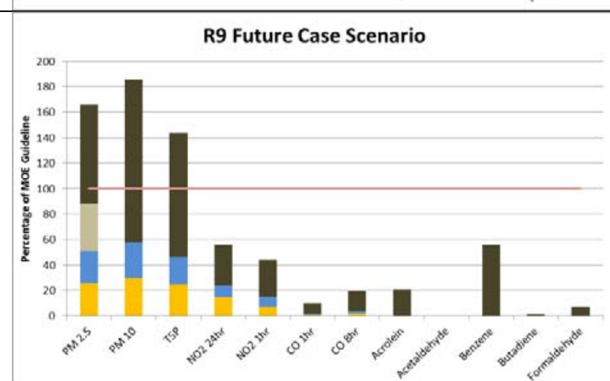

R7 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R7 Future Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R8 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R8 Future Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R9 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R9 Future Case Scenario
Percentage of MOE Guideline
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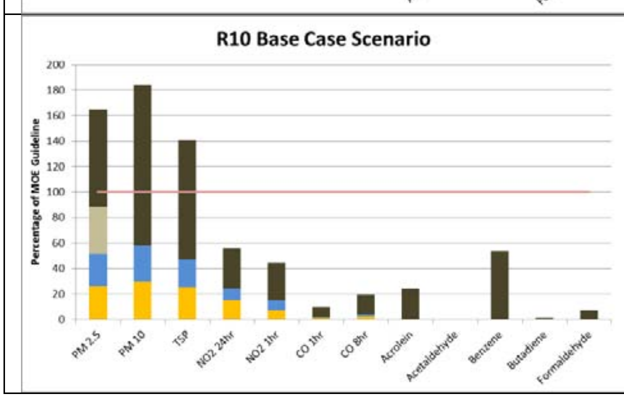
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R10 Base Case Scenario
Percentage of MOE Guideline
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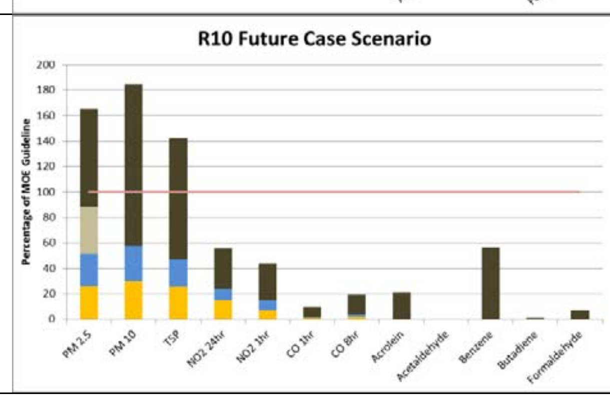
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde


R10 Future Case Scenario
Percentage of MOE Guideline
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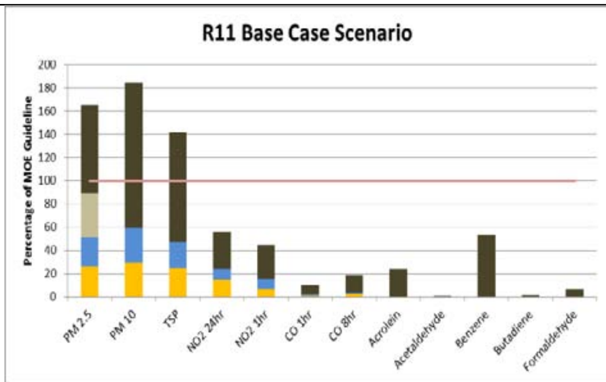
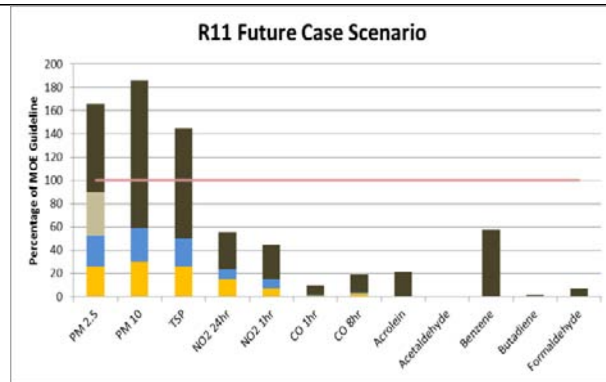
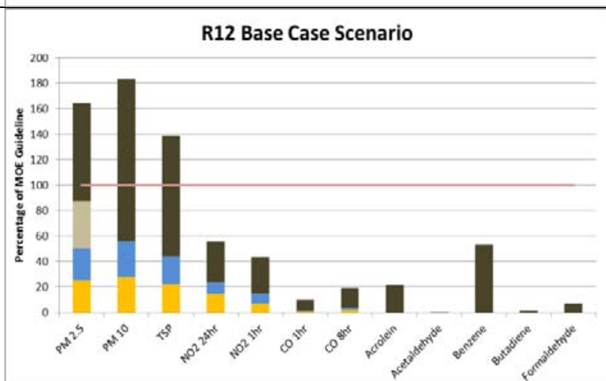
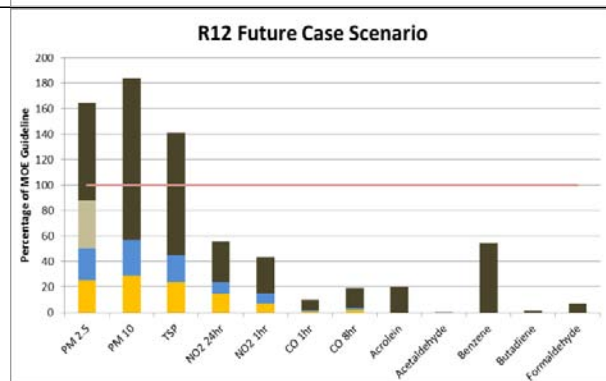
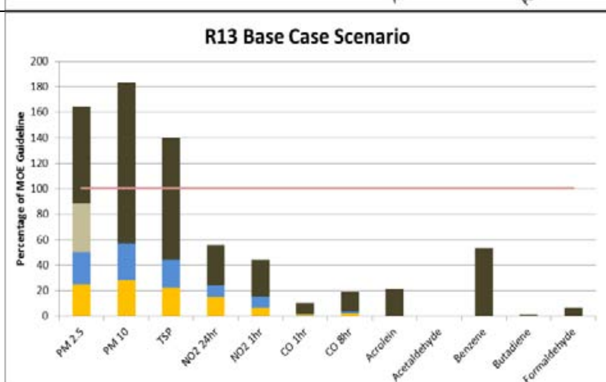
PM 2.5 PM 10 TSP NO2 24hr NO2 1hr CO 1hr CO 8hr Acrolein Acetaldehyde Benzene Butadiene Formaldehyde

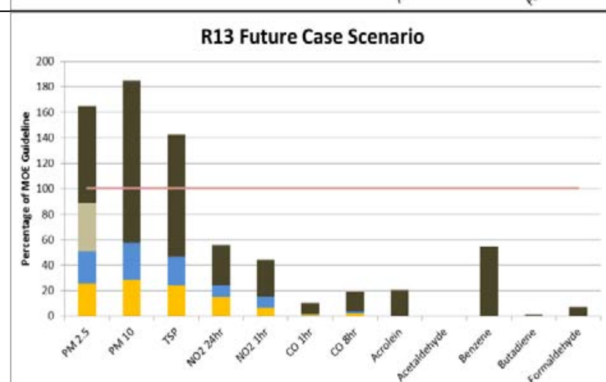

R11 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

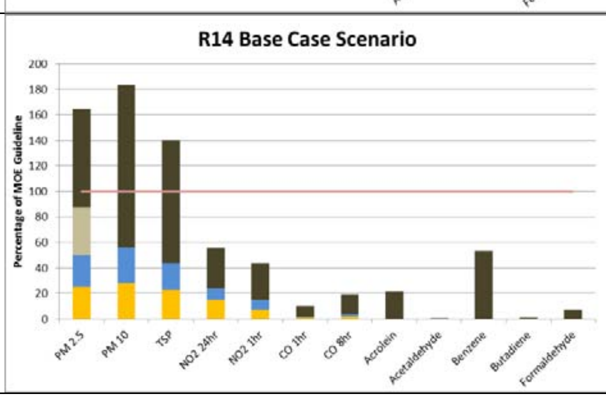

R11 Future Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

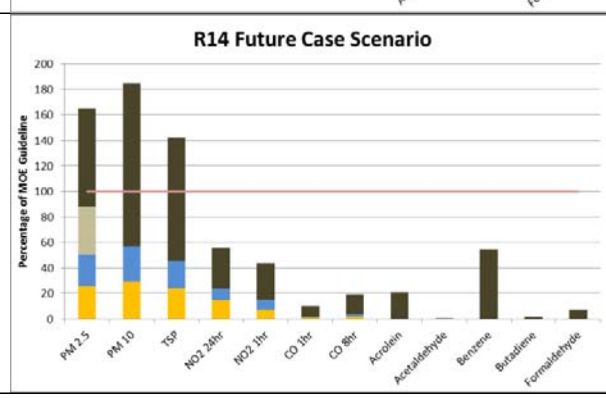

R12 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

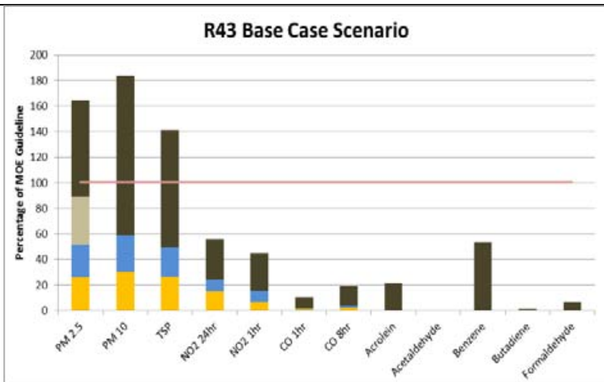

R12 Future Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

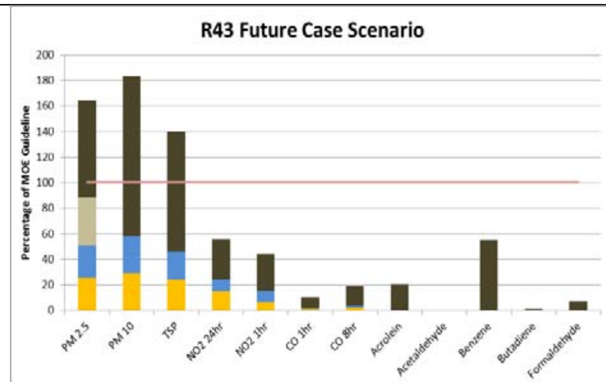

R13 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

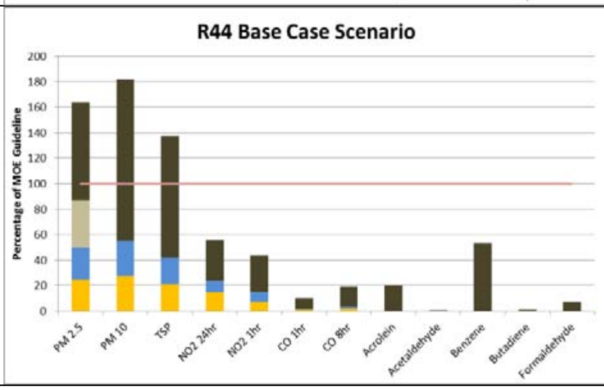

R13 Future Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

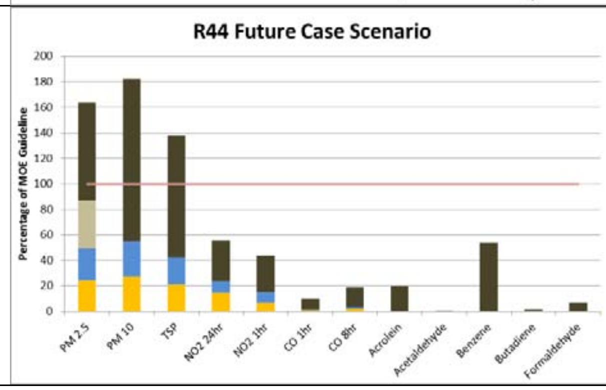

R14 Base Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R14 Future Case Scenario
Percentage of MOE Guideline
0 20 40 60 80 100 120 140 160 180 200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R43 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

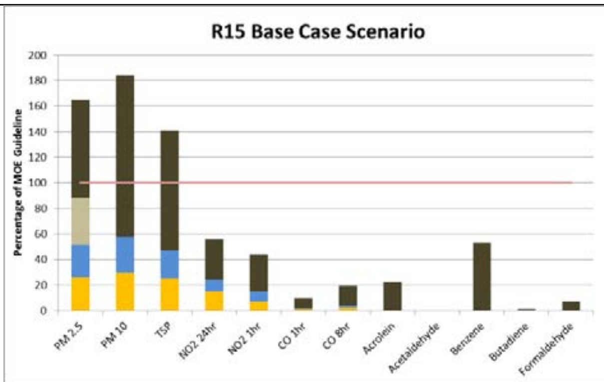

R43 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

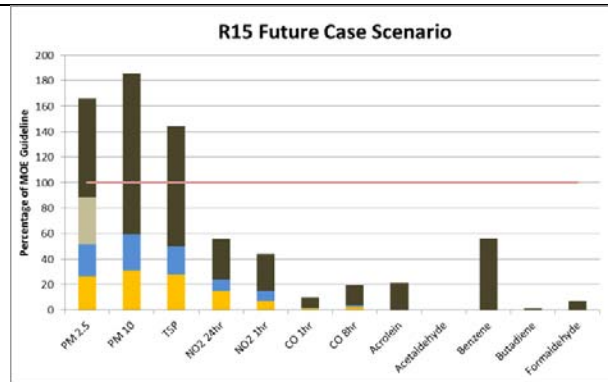

R44 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

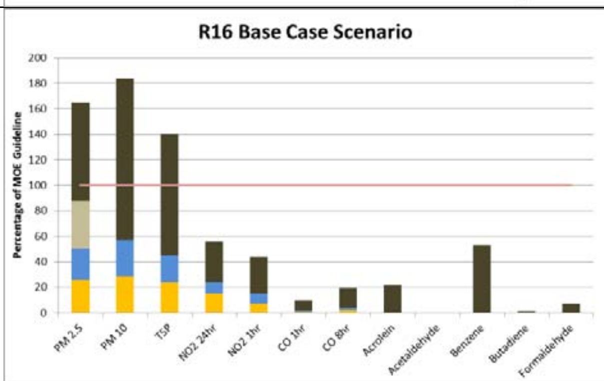

R44 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

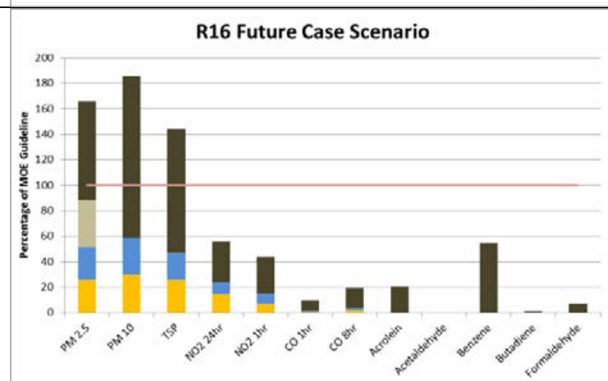
R15 - R18

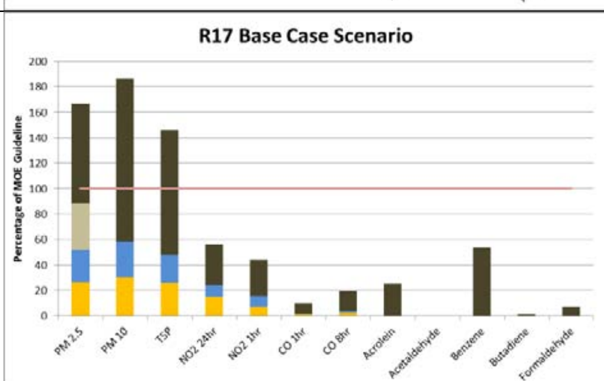

N
R_18
R_17
R_16
R_15
Highway 407
0
150 m

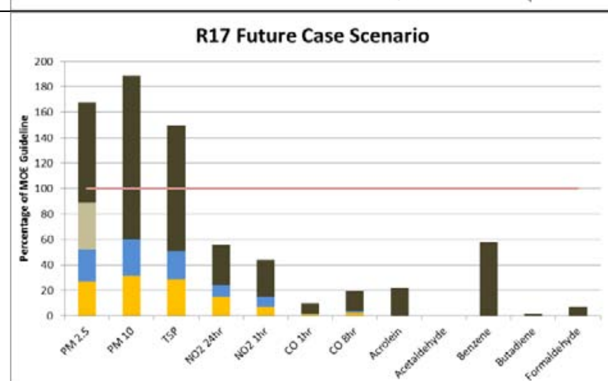

R15 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

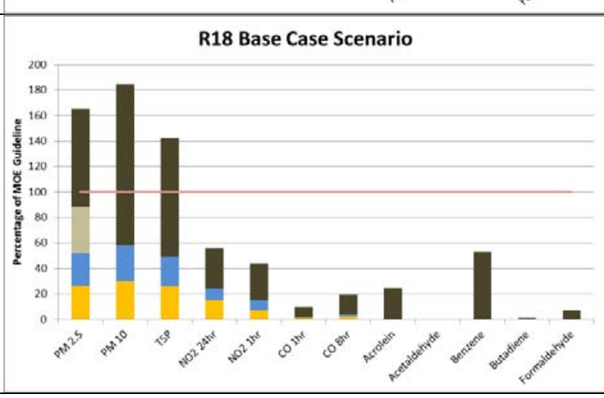

R15 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

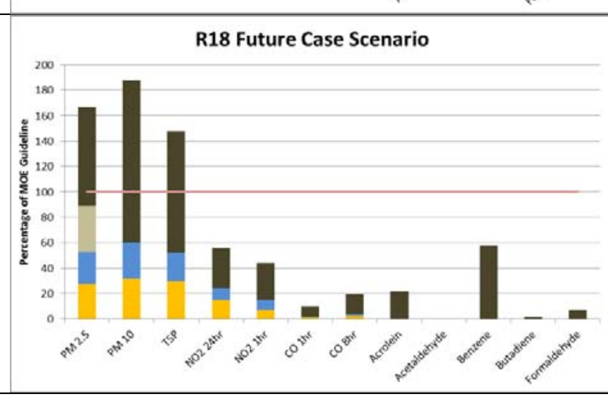

R16 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R16 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R17 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

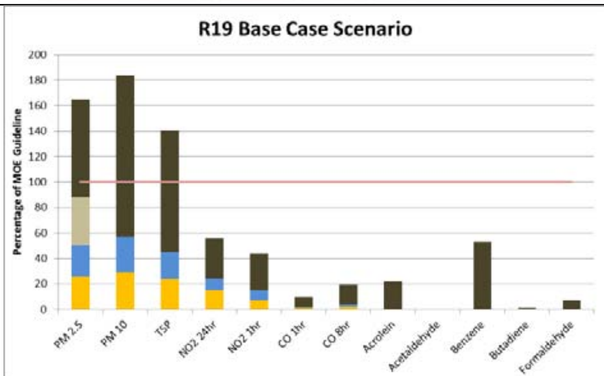

R17 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

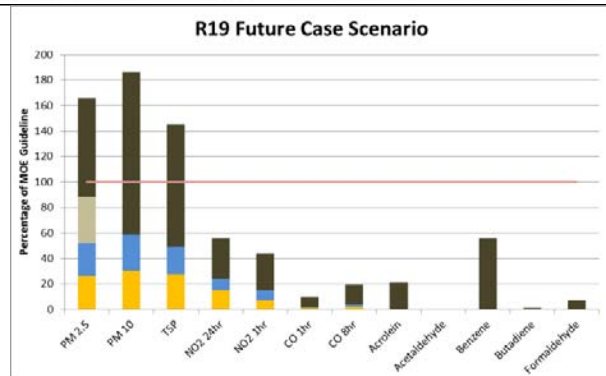

R18 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

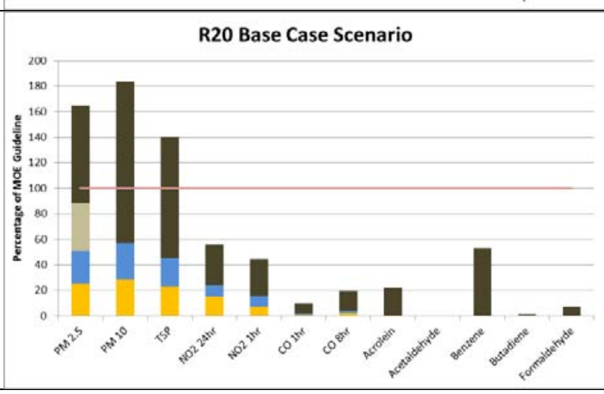

R18 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

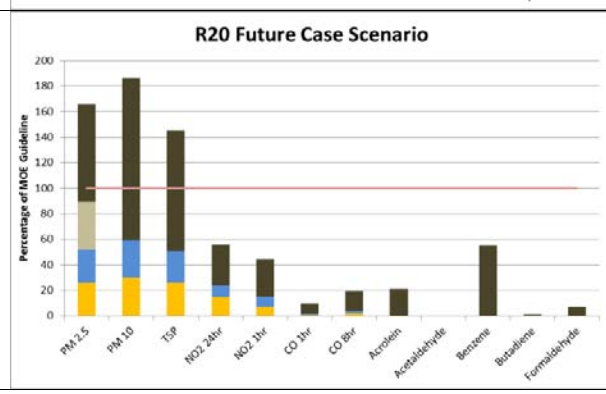
R19 - R23

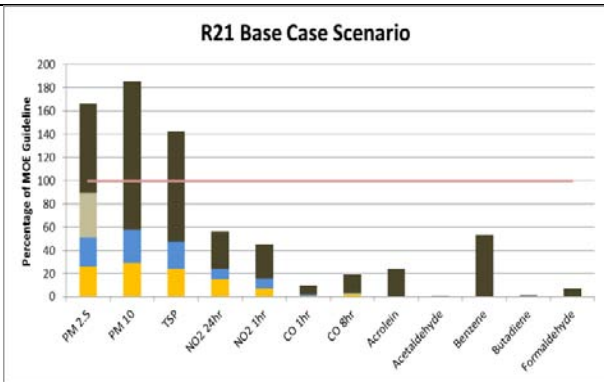

N
R_23
R_22
R_21
R_20
R_19
Walkers Line
0
150 m

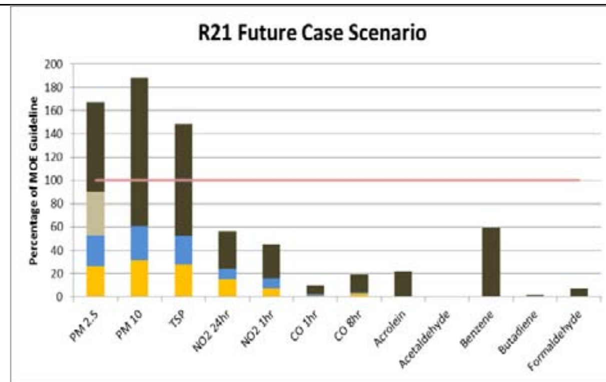

R19 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

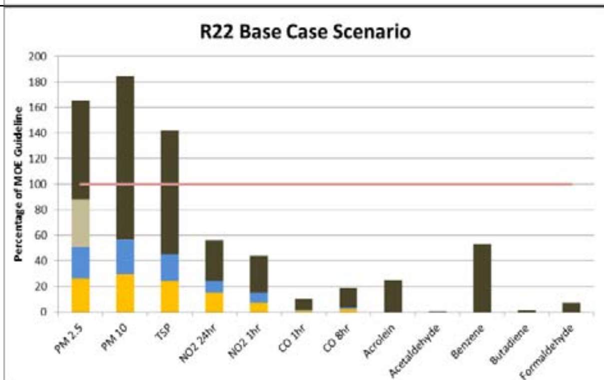

R19 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

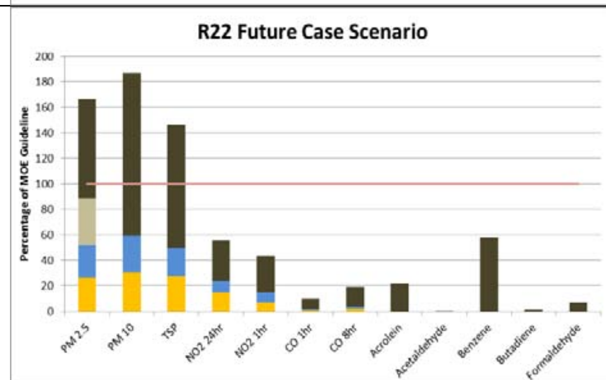

R20 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

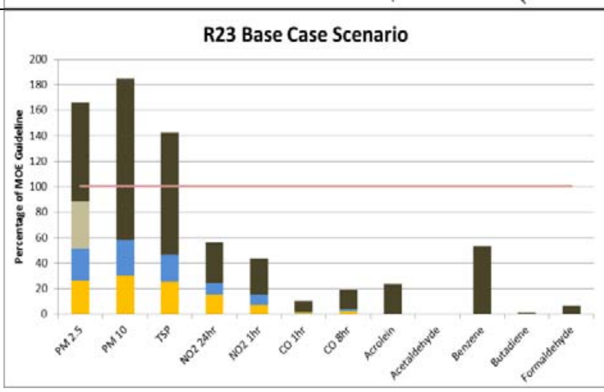

R20 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

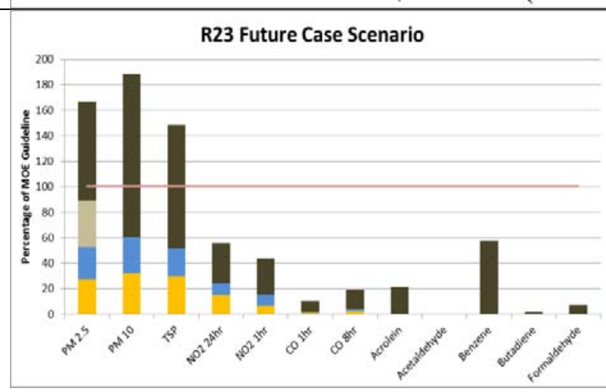

R21 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R21 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

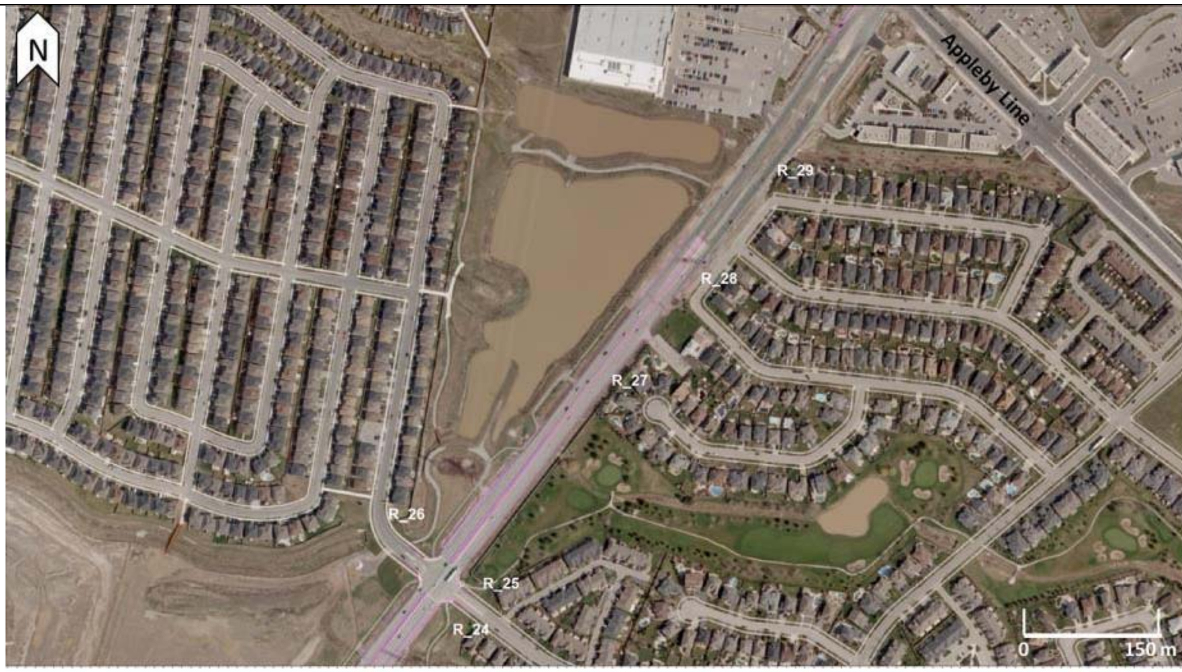

R22 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

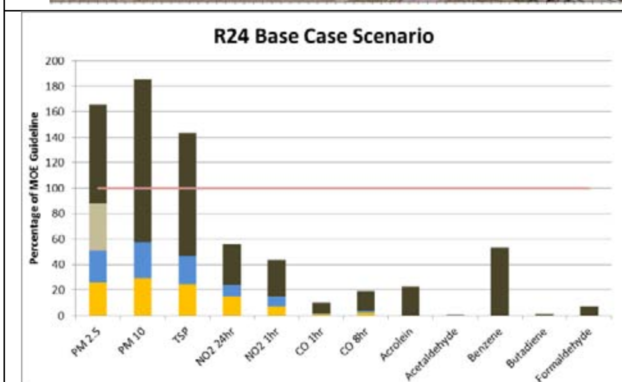

R22 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

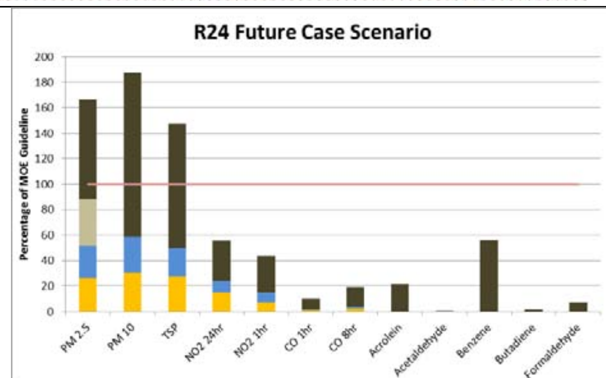

R23 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

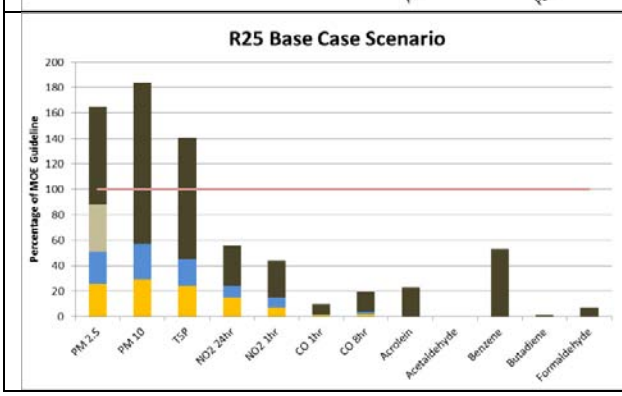

R23 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

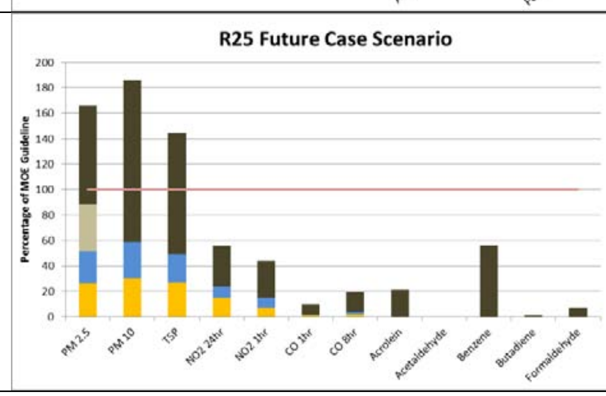
R24 - R29

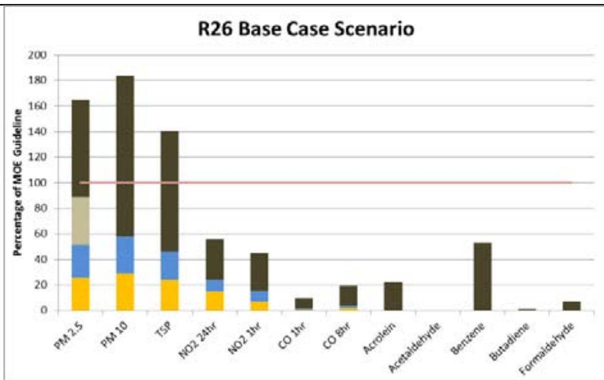

N
Appleby Line
R_29
R_28
R_27
R_26
R_25
R_24
0
150 m

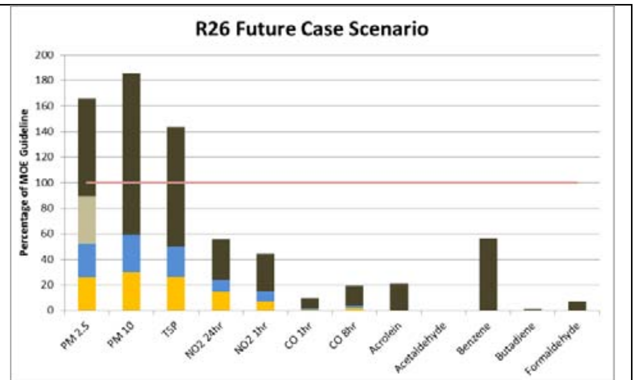

R24 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

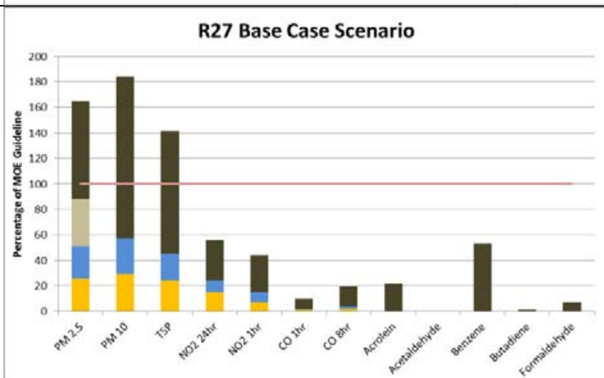

R24 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

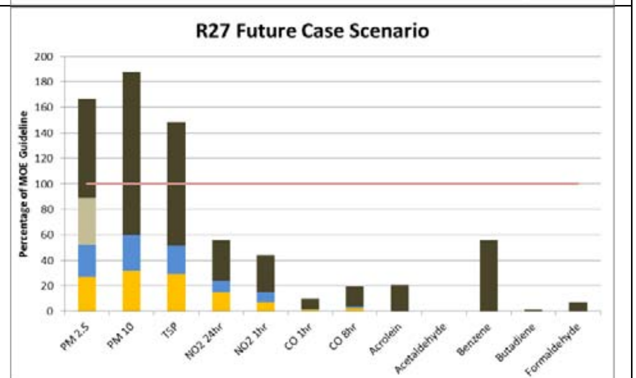

R25 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

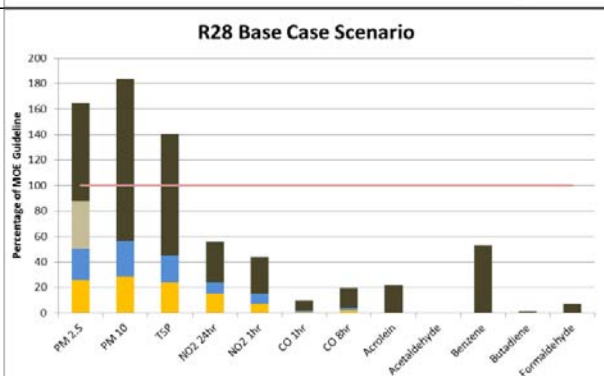

R25 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

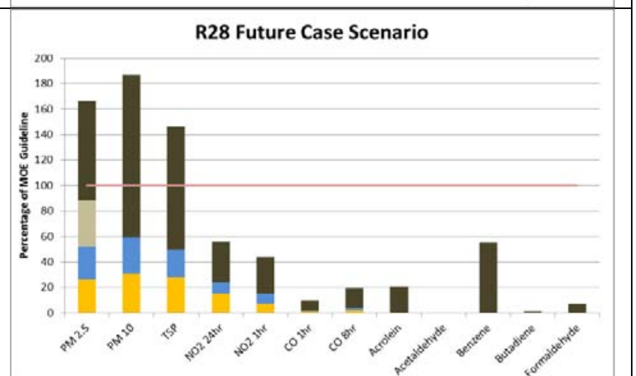

R26 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

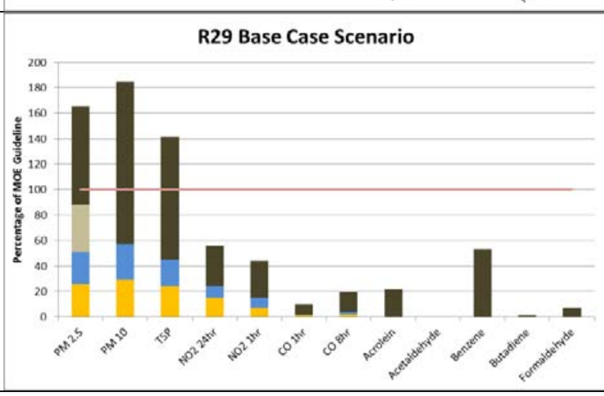

R26 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

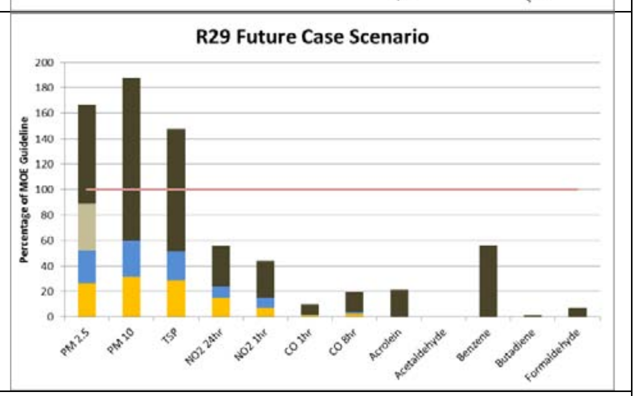

R27 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R27 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R28 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

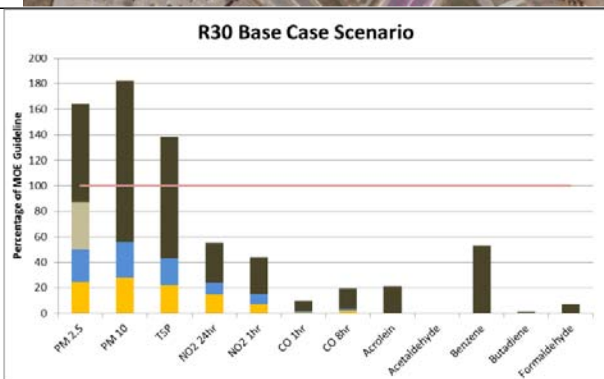

R28 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

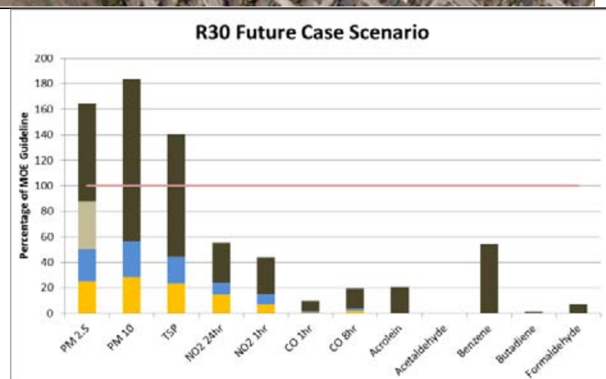

R29 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

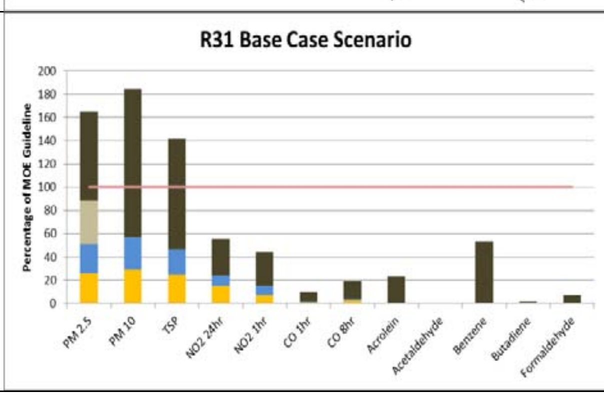

R29 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

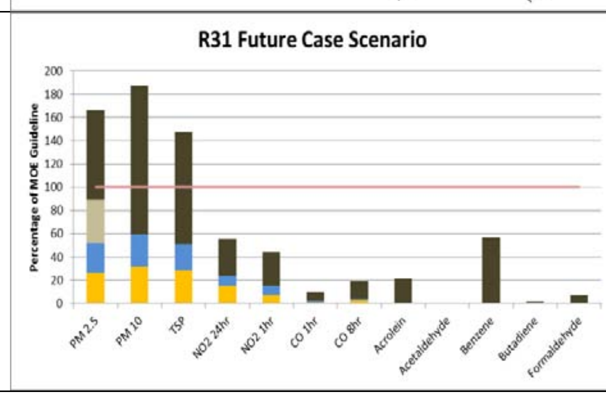
R30 - R31


N
R_31
R_30
Sutton Dr
0
150 m


R30 Base Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

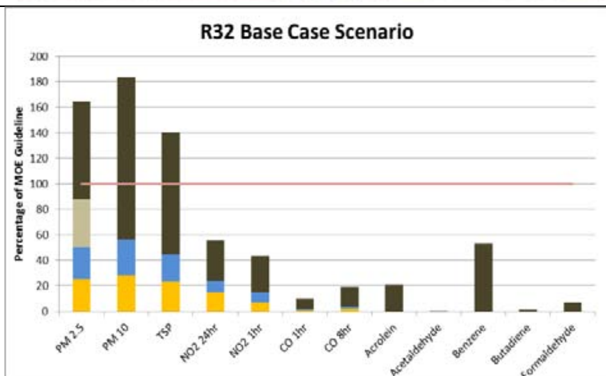

R30 Future Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

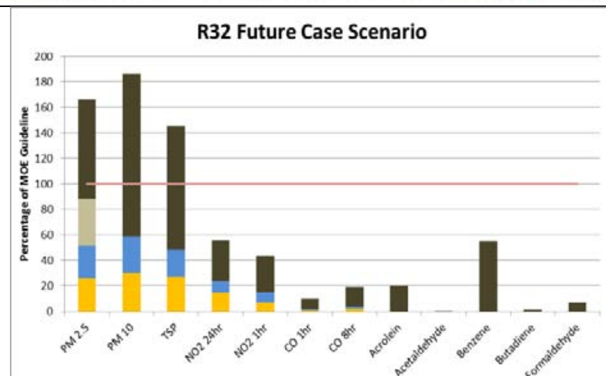

R31 Base Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

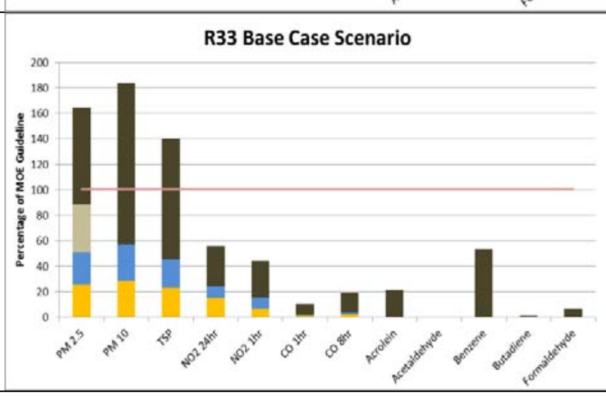

R31 Future Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

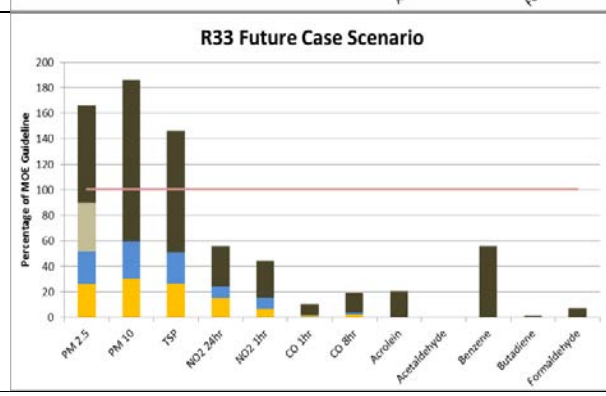
R32 - R33


N
Tremain Rd
R_33
R_32
0
150 m


R32 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

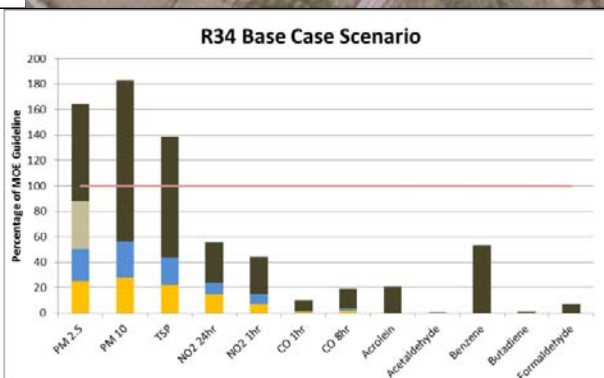

R32 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

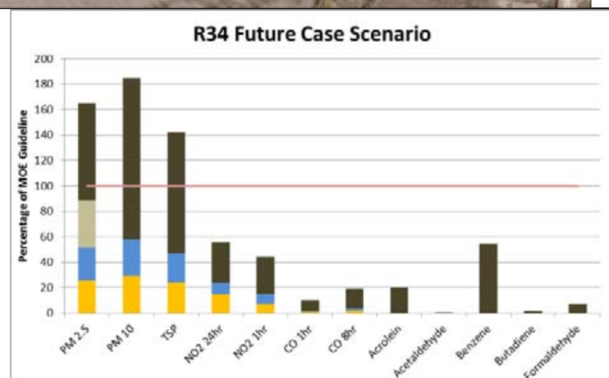

R33 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

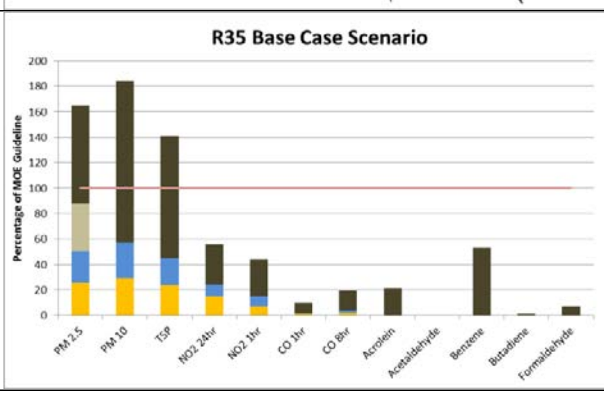

R33 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

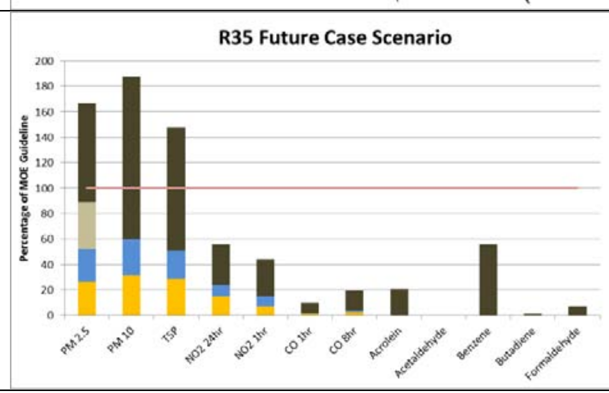
R34 - R36

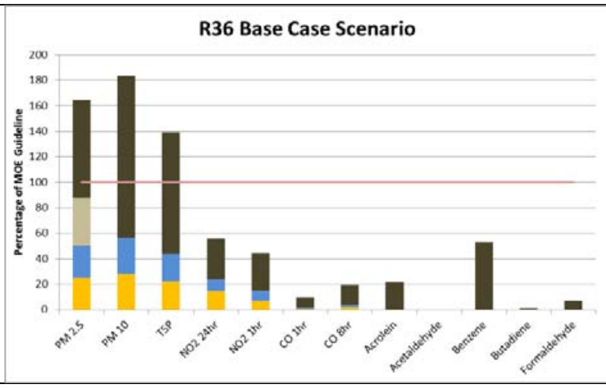

N
R_36
R_35
R_34
Colonel William Pkwy
0
150 m

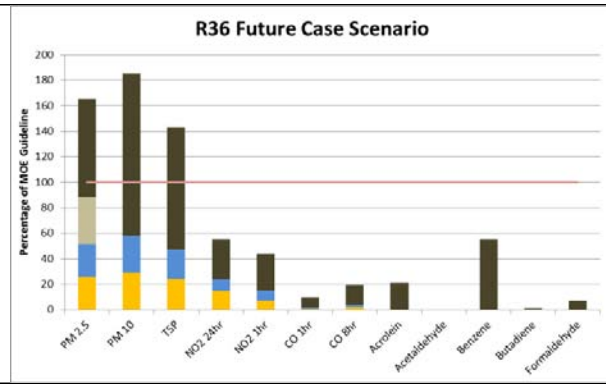

R34 Base Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R34 Future Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R35 Base Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

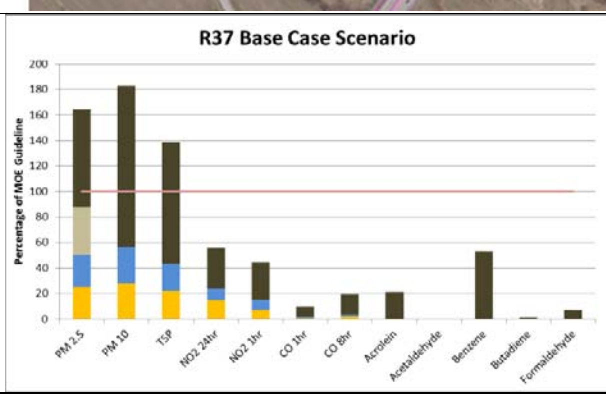

R35 Future Case Scenario
Percentage of MOE Guideline
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

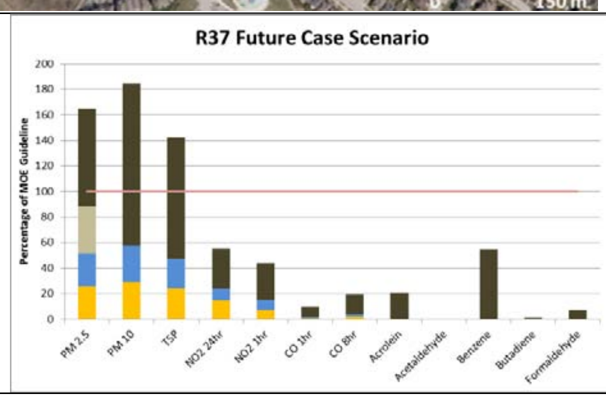

R36 Base Case Scenario
Percentage of MOE Guideline
200
180
160
140
120
100
80
60
40
20
0
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

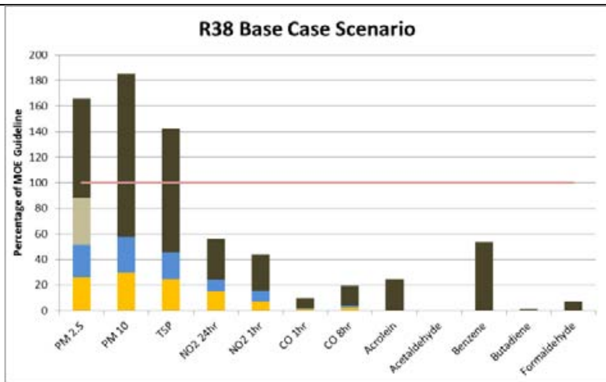

R36 Future Case Scenario
Percentage of MOE Guideline
200
180
160
140
120
100
80
60
40
20
0
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

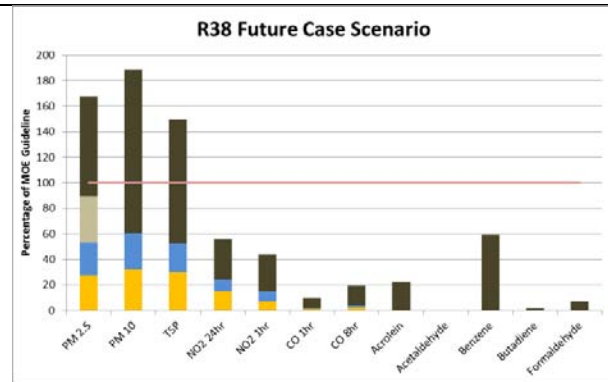
R37 - R41

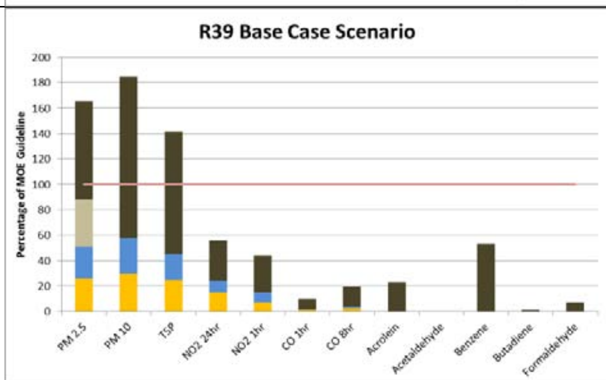

N
R_41
Bronte Rd
R_40
R_39
R_38
R_37
0
150 m

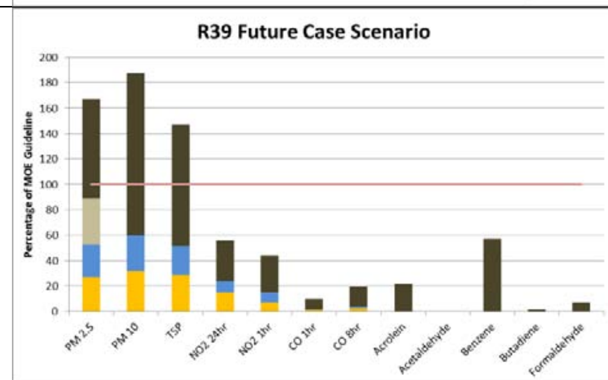

R37 Base Case Scenario
Percentage of MOE Guideline
200
180
160
140
120
100
80
60
40
20
0
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

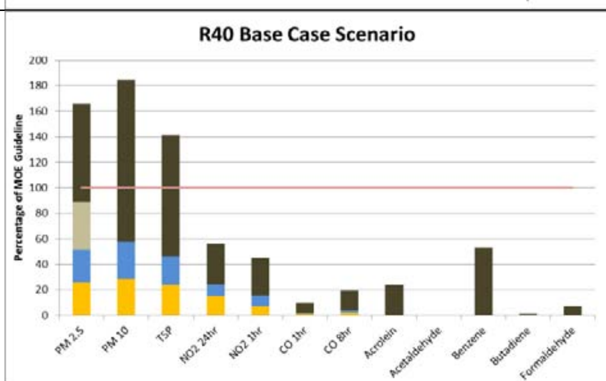

R37 Future Case Scenario
Percentage of MOE Guideline
200
180
160
140
120
100
80
60
40
20
0
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

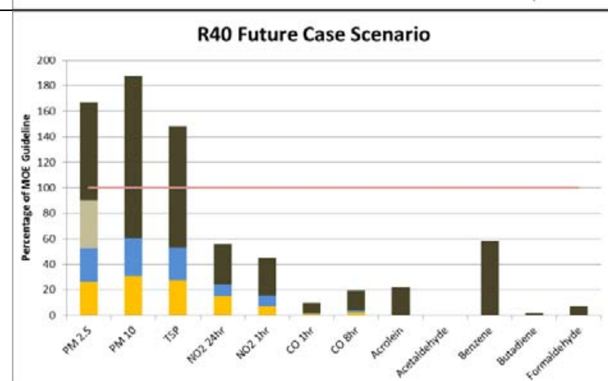

R38 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

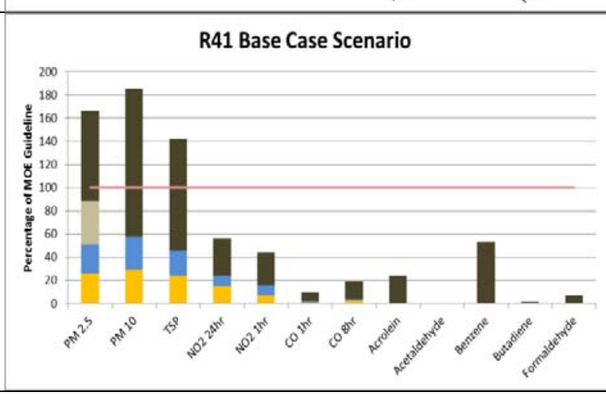

R38 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde

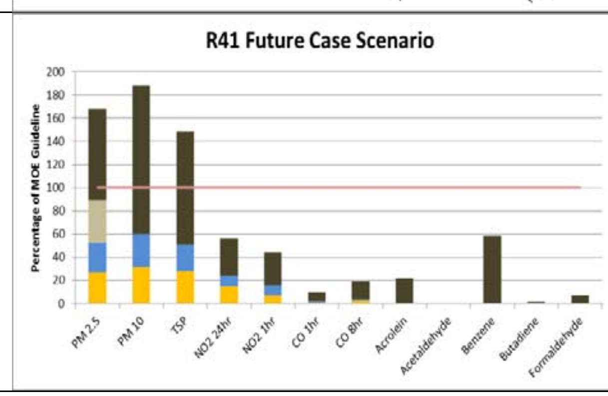

R39 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R39 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R40 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R40 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R41 Base Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde


R41 Future Case Scenario
Percentage of MOE Guideline
0
20
40
60
80
100
120
140
160
180
200
PM 2.5
PM 10
TSP
NO2 24hr
NO2 1hr
CO 1hr
CO 8hr
Acrolein
Acetaldehyde
Benzene
Butadiene
Formaldehyde