Air Quality Assessment
Kirby Road Widening

City of Vaughan

SLR Project No: 241.20105.00000

September 2021

Air Quality Assessment Kirby Road Widening

From Jane Street to Dufferin Street

SLR Project No: 241.20105.00000

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1.0 INTRODUCTION

SLR Consulting (Canada) Ltd., was retained by HDR Inc. to conduct an air quality assessment as part of the Municipal Class Environmental Assessment for the widening of Kirby Road between Jane Street and Dufferin Street, a length of approximately 4.1 kilometres within Vaughan, Ontario. The project involves the widening of Kirby Road to two lanes, with the addition of one or two turning lanes at multiple intersections.

1.1 Study Objectives

The main objective of the study was to assess the local air quality impacts due to the proposed Kirby Road widening from Jane Street to Dufferin Street. The study also includes an overview of construction impacts and a screening level assessment of greenhouse gases (GHG). To meet these objectives, the following scenarios were considered:

- 2019 No Build (NB) – Assess the existing air quality conditions at representative receptors. Predicted contaminant concentrations from the existing traffic levels were combined with hourly measured ambient concentrations to determine combined impacts.
- 2031 Future Build (FB) – Assess the future air quality conditions with the proposed project in place. Predicted contaminant concentrations associated with traffic levels for the preferred alternative were combined with hourly measured ambient concentrations to determine combined impacts.

Given the nature of the roadway improvements and location of sensitive receptors within the study area, HDR Inc. requested a "hotspot analysis" be performed. Rather than assessing the total length of the roadway, the air quality assessment focused on one hotspot within the study area where worst-case impacts are likely to occur. The intersection at Kirby Road and Keele Street was selected to be assessed for air quality impacts. This intersection was identified to have one of the highest future 2031 intersection volumes. The segment also has high concentrations of critical receptors and sensitive receptors in the form of low-rise residential units southeast of the intersection and further along Kirby. This section of the roadway was determined to be representative of worst-case impacts for the air quality study.

The modelling considered vehicle emissions within a 1km hotspot centered at the Kirby Road and Keele Street intersection. The roadway segments considered in this assessment are shown in Figure 1.

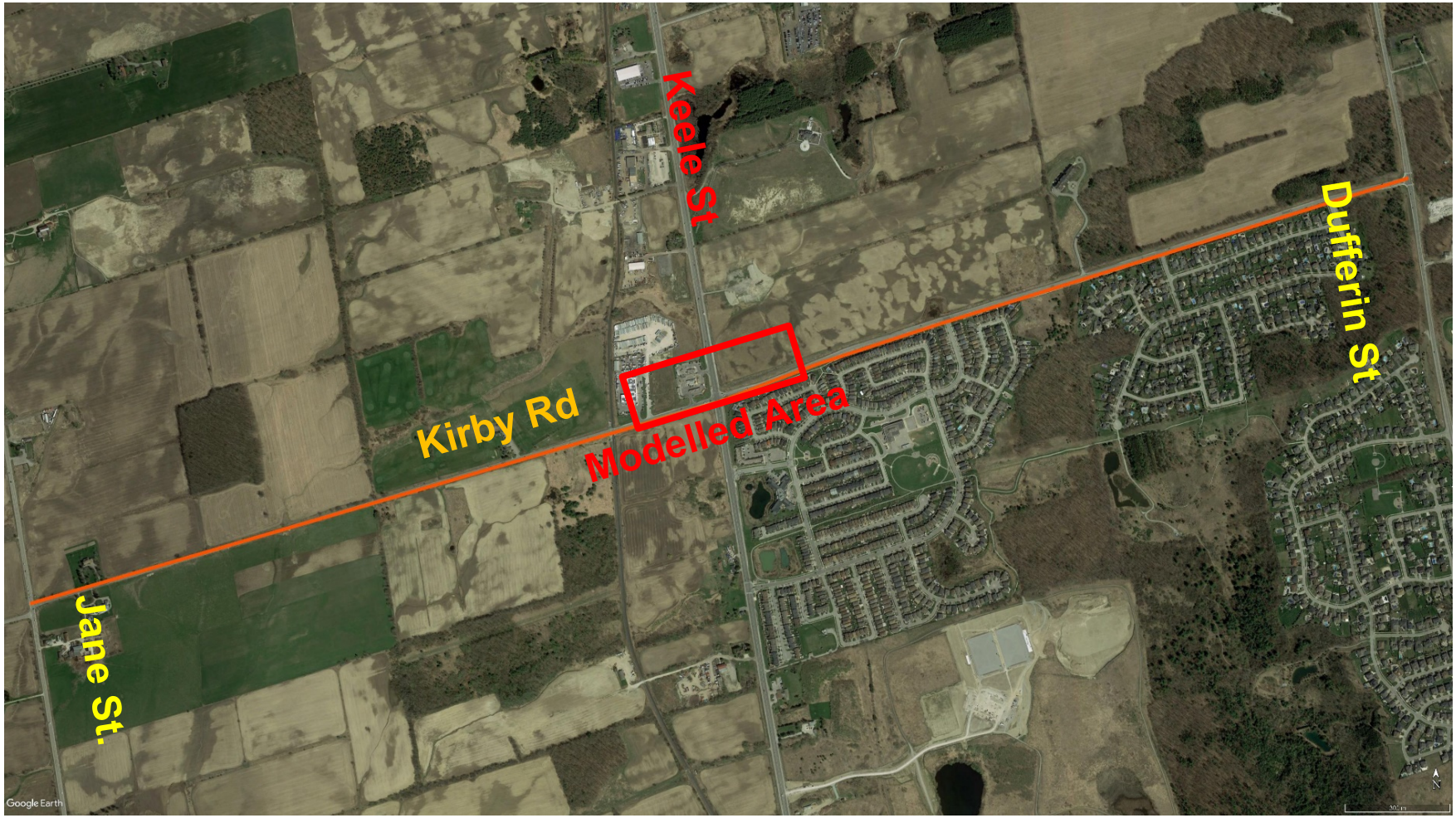


Figure 1: Study Area and Modelled Hotspot

1.2 Contaminants of Interest

The contaminants of interest from vehicle emissions are based on the regularly assessed contaminants of interest for transportation assessments in Ontario, as determined by the Ministry of Transportation Ontario (MTO) and Ministry of Environment, Conservation and Parks (MECP). Motor vehicle emissions have largely been determined by scientists and engineers with United States and Canadian government agencies such as the U.S. Environmental Protection Agency (EPA), the MECP, Environment Canada (EC), Health Canada (HC), and the 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 as illustrated in **Figure 2.** Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions from roadway travel. Instead, these emissions contribute to the overall background levels of the applicable contaminants. All of the selected contaminants are emitted during fuel combustion, while emissions from brake wear, tire wear, and breakdown of road dust include only the particulates. A summary of these contaminants is provided in **Table 1**.

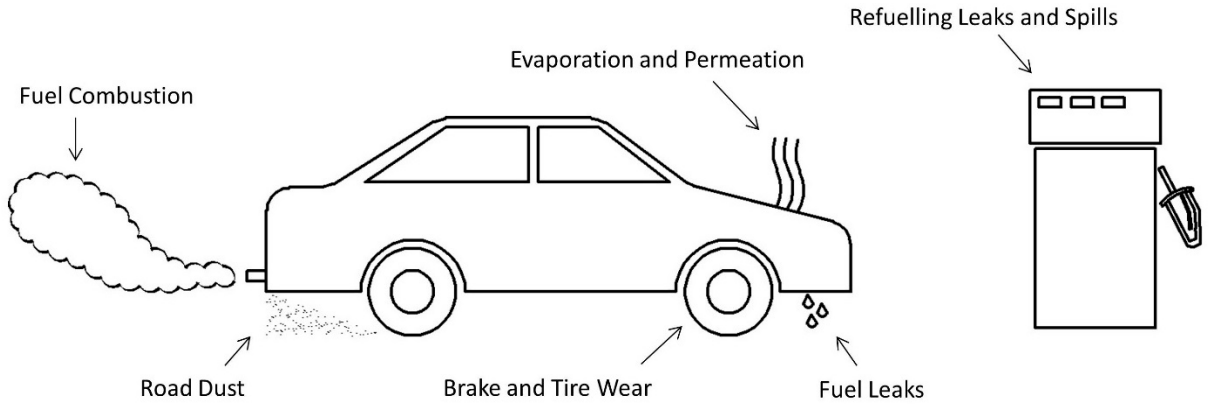


Figure 2: Motor Vehicle Emission Sources

Table 1: Contaminant of Interest

Contaminants		Volatile Organic Compounds (VOCs)	
Name	Symbol	Name	Symbol
Nitrogen Dioxide	NO_2	Acetaldehyde	C_2H_4O
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	CH_2O

1.3 Applicable Guidelines

In order to understand the existing conditions in the modelled area, ambient background concentrations have been compared to guidelines established by government agencies and organizations. Relevant agencies and organizations in Ontario and Canada, and their applicable contaminant guidelines are:

- MECP Ambient Air Quality Criteria (AAQC)
- Health Canada/Environment Canada National Ambient Air Quality Objectives (NAAQOs)
- Canadian Council of Ministers of the Environment (CCME) Canadian Ambient Air Quality Standards (CAAQS).

Within the guidelines, the threshold value for each contaminant and its applicable averaging period were used to assess the maximum predicted impact at sensitive receptors derived from computer simulations. The contaminants of interest are compared against 1-hour, 8-hour, 24-hour, and annual averaging periods. The threshold values and averaging periods used in this assessment are presented in Table 2. It should be noted that the CAAQS for $PM_{2.5}$ is not based on the maximum 24-hour concentration value; $PM_{2.5}$ is assessed based on the annual 98th percentile value, averaged over 3 consecutive years.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value (µg/m3)	Source
NO_2	1	400	AAQC
	24	200	AAQC
	1	79 (42 ppb)[1]	CAAQS (to be phased-in in 2025)
	Annual	23 (12 ppb)[2]	CAAQS (to be phased-in in 2025)
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	27[3]	CAAQS
	Annual	8.8[4]	CAAQS
PM_{10}	24	50	Interim AAQC
TSP	24	120	AAQC
Acetaldehyde	24	500	AAQC
Acrolein	24	0.4	AAQC
	1	4.5	AAQC
Benzene	Annual	0.45	AAQC
	24	2.3	AAQC
1,3-Butadiene	24	10	AAQC
	Annual	2	AAQC
Formaldehyde	24	65	AAQC

[1] The 1-hour NO_2 CAAQs is based on the 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations.
[2] The annual CAAQs is based on the average over a single calendar year of all the 1-hour average NO_2 concentrations.
[3] The 24-hr $PM_{2.5}$ CAAQS is based on the 3-year average of the annual 98th percentile of the 24-hr average concentrations.
[4] The annual $PM_{2.5}$ CAAQS is based on the average of the three highest annual average values over the study period.

1.4 General Assessment Methodology

The worst-case contaminant concentrations due to motor vehicle emissions from the roadways were predicted at nearby receptors using dispersion modelling software on an hourly basis for a five-year period. 2012-2016 historical meteorological data from Pearson International Airport was used. Five years were modelled in order to capture the worst-case meteorological conditions. Two emission scenarios were assessed: 2019 No Build and 2031 Future Build.

Combined concentrations were determined by adding modelled and background (i.e., ambient data) concentrations together on an hourly basis. Background concentrations for all available contaminants were determined from MECP and NAPS (National Air Pollution Surveillance) stations nearest to the modelled area with applicable datasets.

Maximum 1-hour, 8-hour, 24-hour, and annual predicted combined concentrations were determined for comparison with the applicable guidelines using emission and dispersion models published by the U.S. Environmental Protection Agency (EPA). The worst-case predicted impacts are presented in this report; however, it is important to note that the worst-case impacts may occur infrequently and at only one receptor location.

2.0 BACKGROUND AMBIENT DATA

2.1 Overview

Background (ambient) conditions are measured contaminant concentrations that are independent of emissions from the proposed project infrastructure. These concentrations consist of trans-boundary (macro-scale), regional (meso-scale), and local (micro-scale) emission sources and result from 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 which is the major contributor during smog events which usually occur in the summer season (MECP, 2005). During smog episodes, the U.S. contribution to $PM_{2.5}$ can be as much as 90 percent near the southwest Ontario-U.S. border. The effects of U.S. air pollution in Ontario on a high $PM_{2.5}$ day and on an average $PM_{2.5}$ spring/summer day are illustrated in **Figure 3.**

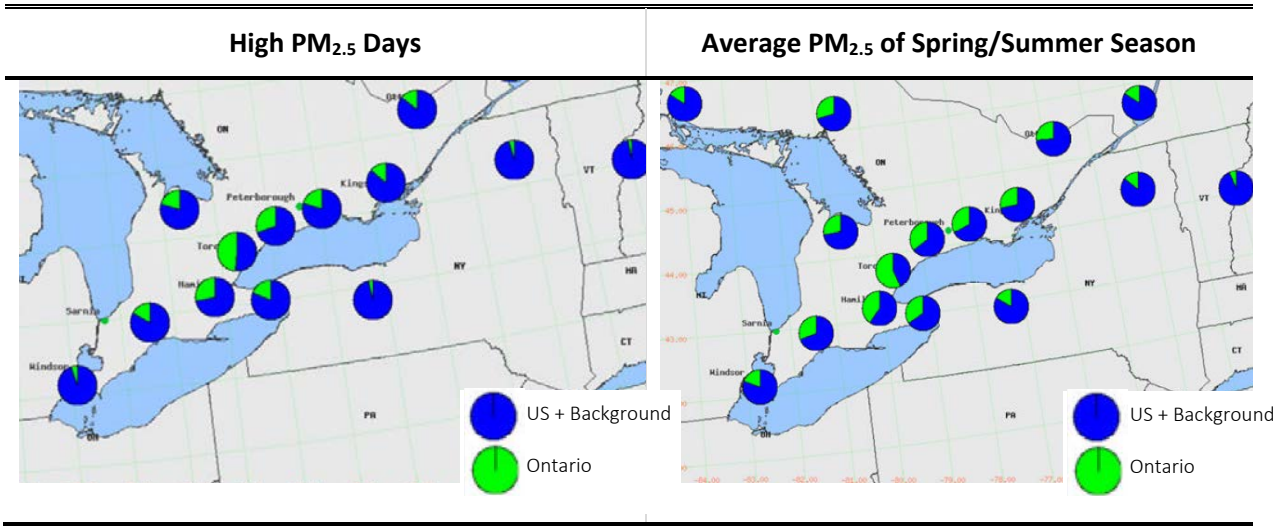


Figure 3: Effect of Trans-Boundary Air Pollution (MECP, 2005)

Air pollution is strongly influenced by weather systems (i.e., meteorology) that commonly 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 blowing from the southwest that can 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 simulation from the Weather Research and Forecasting (WRF) Model.

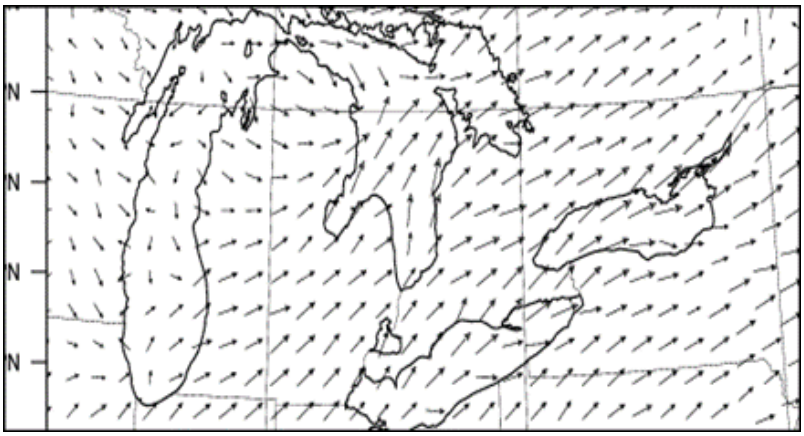


Figure 4: Typical Wind Direction during an Ontario Smog Episode

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

2.2 Selection of Relevant Ambient Monitoring Stations

A review of MECP and NAPS ambient monitoring stations in Ontario was undertaken to identify the monitoring stations that are in relative proximity to the modelled area and that would be representative of background contaminant concentrations in the modelled area. Four MECP (Newmarket, Toronto North, Toronto East, and Toronto West) and five NAPS (Newmarket, Etobicoke South, Etobicoke North, Brampton, and Windsor) stations were selected for the analysis. Note, CO is only monitored at the Toronto West Station, therefore this station was used only to assess background CO concentrations. Also note that Windsor is the only station in Ontario at which background Acrolein, Formaldehyde, and Acetaldehyde are measured in recent years. Only these contaminants were considered from the Windsor station; the remaining contaminants from the Windsor station were not considered given the stations' distance from the modelled area. The locations of the relevant ambient monitoring stations in relation to the modelled area are shown in Figure 5. Station information is presented in Table 3.

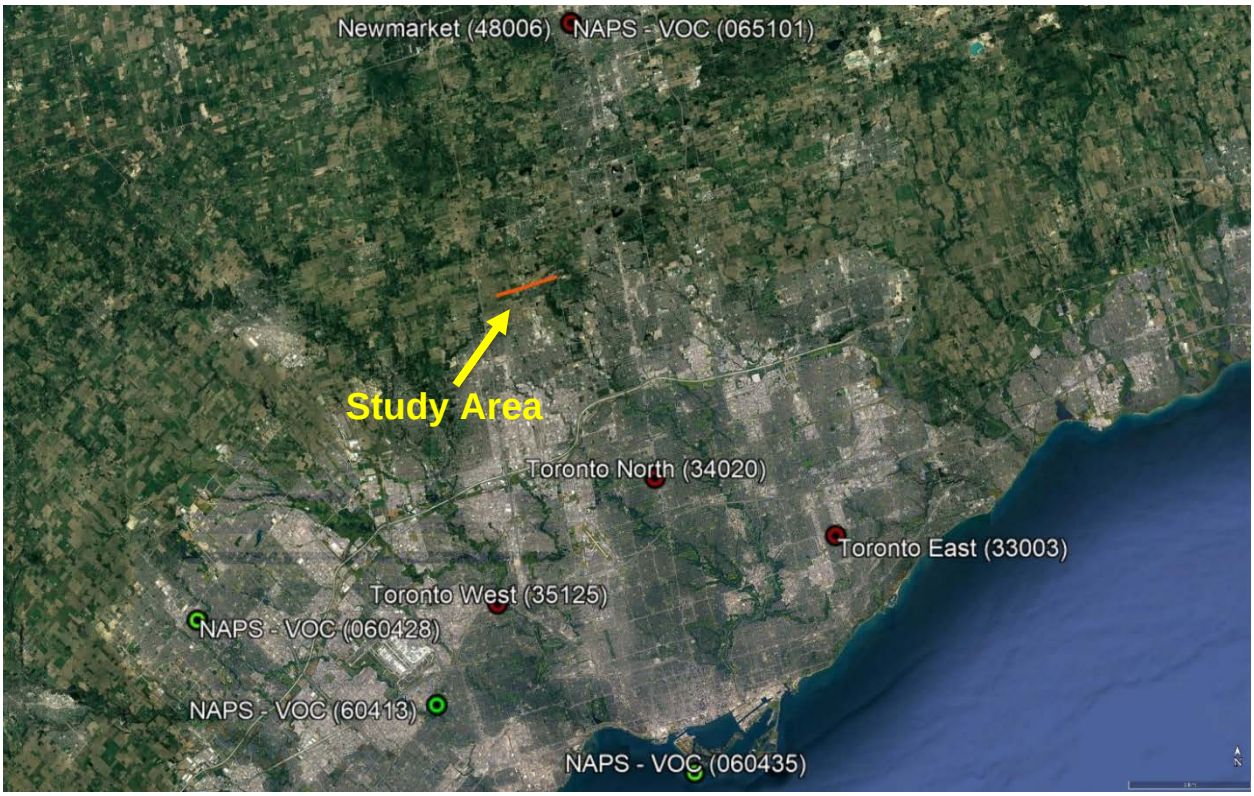


Figure 5: Location of Ambient Monitoring Stations, Relevant to the Study Area

Table 3: Relevant MECP and NAPS Station Information

City/Town	Station ID	Location	Operator	Contaminant
Newmarket	48006	Eagle St. W./Mc Caffrey Rd	MECP	NO_2|$PM_{2.5}$
Toronto East	33003	Kennedy Rd./Lawrence Ave. E.	MECP	NO_2|$PM_{2.5}$
Toronto North	34020	Hendon Ave./Young St.	MECP	NO_2|$PM_{2.5}$
Toronto West	35125	125 Resources Rd	MECP	CO|NO_2|$PM_{2.5}$
Newmarket	65101	Eagle St. W./Mc Caffrey Rd	NAPS	1,3-Butadiene|Benzene
Brampton	60428	525 Main St	NAPS	1,3-Butadiene|Benzene
Etobicoke North	60413	Elmcrest Road	NAPS	1,3-Butadiene|Benzene
Etobicoke South	60435	461 Kipling Ave	NAPS	1,3-Butadiene|Benzene
Windsor	60211	College St/Prince St	NAPS	Formaldehyde |Acetaldehyde | Acrolein

2.3 Detailed Analysis of Selected Worst-case Monitoring Stations

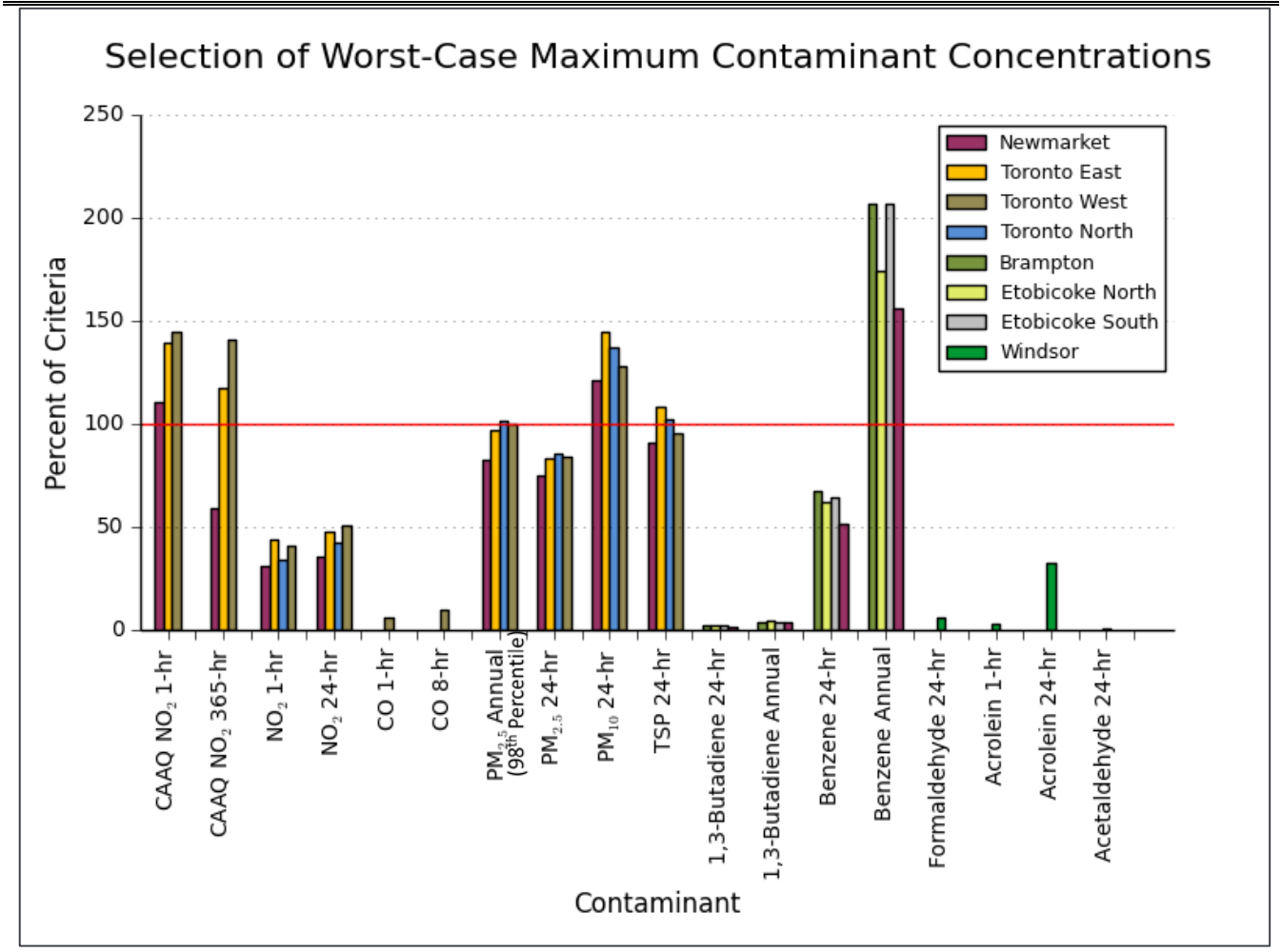
Year 2012 to 2016 hourly ambient monitoring data from the selected stations were statistically summarized for the desired averaging periods: 1-hour, 8-hour, 24-hour, and annual. Note that for the NAPS stations (VOCs), formaldehyde, acetaldehyde and acrolein are only measured at the Windsor station, and were not measured after 2010. Therefore 2006-2009 data was used for these VOCs.

Note that PM_{10} and TSP are not measured in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54 and a $PM_{2.5}$/TSP ratio of 0.3 (Lall et al., 2004). Ambient VOC data is not monitored hourly but is typically measured every six days. To combine this dataset with the hourly modelled concentrations, each measured six-day value was applied to all hours between measurement dates, when there were 6 days between measurements. When there was greater than 6 days between measurements, the 90th percentile measured value for the year in question was applied for those days in order to determine combined concentrations. This method is conservative as it applies a concentration that is higher than 90% of the measured concentrations whenever data was not available.

Table 4 shows the selected monitoring station for the various contaminants considered in the assessment. Figure 5 provides a detailed statistical analysis of the selected worst-case maximum contaminant concentrations at background monitoring stations in the region for various contaminants.

Table 4: Selection of Background Monitoring Stations

Contaminant	Worst-Case Station	Contaminant	Worst-Case Station
CAAQ NO_2 (1-Hr)	Toronto West	TSP	Toronto East
CAAQ NO_2 (ann)	Toronto West	1,3-Butadiene (24-hr)	Etobicoke North
NO_2 (1-Hr)	Toronto East	1,3-Butadiene (ann)	Etobicoke North
NO_2 (24-Hr)	Toronto West	Benzene (24-hr)	Brampton
CO (1-Hr)	Toronto West	Benzene (ann)	Brampton
CO (8-hr)	Toronto West	Formaldehyde	Windsor
$PM_{2.5}$ (24-hr)	Toronto North	Acrolein	Windsor
$PM_{2.5}$ (ann)	Toronto North	Acetaldehyde	Windsor
PM_{10}	Toronto East		



Note: PM_{10} and TSP are not measured in Ontario; therefore, background concentrations were estimated from $PM_{2.5}$ concentrations

Figure 5: Selection of Worst-Case Maximum Contaminant Concentrations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants was performed and is summarized in **Figure 6**. Presented is the average, 90th percentile, and maximum concentrations as a percentage of the guideline for each contaminant from the worst-case monitoring station determined above. Maximum ambient concentrations represent a single worst-case value. The 90th percentile concentration represents a reasonably worst-case background concentration, and the average concentration represents a typical background value. The 98th percentile concentration is shown for $PM_{2.5}$, as the guideline for $PM_{2.5}$ is based on 98th percentile concentrations.

Based on a review of ambient monitoring data from 2012-2016, background concentrations were generally below their respective guidelines. The exceptions are particulate matter and benzene, as well as the 1-hour and annual NO_2 CAAQS. In many cases the exceedances represent maximum concentrations and the 90th percentile and/or average concentrations are below the guideline. It should be noted that PM_{10} and TSP were calculated based on their relationship to $PM_{2.5}$.

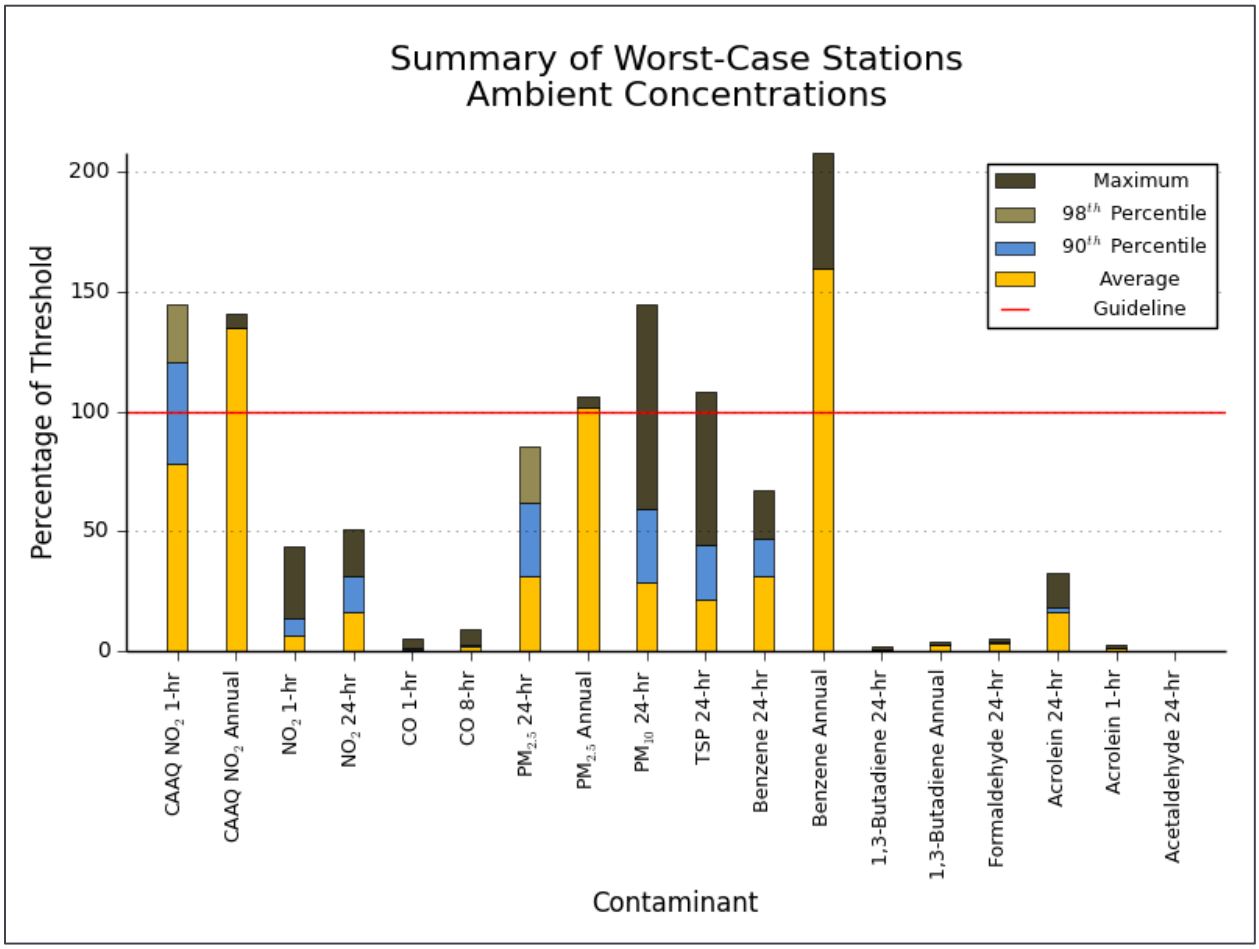


Figure 6: Worst-Case Summary of Ambient Background Concentrations

3.0 LOCAL AIR QUALITY ASSESSMENT

3.1 Location of Sensitive Receptors within the Modelled 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
- Childcare facilities
- Educational facilities
- Places of worship
- Residential dwellings.

Nineteen sensitive receptor locations were selected to be representative of potential impacts within the modelled area. They are all residences with the closest proximity to the study intersection, and thus the most likely impacted by the lane expansion. The receptors are distributed between the residences along Kirby Road southeast of the study intersection as shown in Figure 7.

Figure 7: Sensitive Receptor Locations Within Modelled Hotspot Area

3.2 Road Traffic Data

Traffic data was provided by HDR Inc. in the form of annual average daily traffic (AADT) for the major intersections within the study area for both the 2019 No Build and 2031 Future Build configurations. The AADT volumes used in the assessment of the modelled area are shown in **Table 5** and **Table 6**. Vehicle posted speed limits of 60km/h and 70km/h were applied for Kirby Road and Keele Street, respectively.

Lastly, a heavy-duty vehicle percentage was also provided by HDR for Kirby Road and Keele Street as shown in **Table 5** and **Table 6**. Hourly traffic volumes were not available; therefore, the US EPA standard rural weekday hourly distribution was used for these roadways. The hourly distributions applied in this assessment are shown in **Table 7.**

Table 5: Traffic Volumes (AADT – Vehicles/Day) Used in the Assessment

Along Kirby Road (Eastbound and Westbound)								
Location	2019 No Build				2031 Future Build			
	AADT	% Trucks	% Medium Trucks Split	% Heavy Truck Splits	AADT	% Trucks[1]	% Medium Trucks Split	% Heavy Truck Splits
Between Jane Street and Keele Street	6,300	8.10%	4.90%	3.20%	15,400	10%	5%	5%
Between Keele Street and Dufferin Street	8,600	4.01%	3.67%	0.34%	18,200	10%	5%	5%

[1] – As per York Region's direction, future truck percentage on Kirby Rd between Jane St and Bathurst St is assumed to be 10% with a 50%/50% division between medium and heavy trucks.

Table 6: Traffic Volumes (AADT – Vehicles/Day) Used in the Assessment

Keele Street (Northbound and Southbound)					
Location	2019 No Build AADT	2031 Future Build AADT	% Trucks[1]	% Medium Trucks Split	% Heavy Truck Splits
Keele Street	18,300	19,754	6.70%	4.40%	2.30%

[1] – Future Build truck % assumed to be same as No Build scenario.

Table 7: Hourly Vehicle Distribution Used in the Assessment

Hour	US EPA Weekday	US EPA Weekend
1	1.0%	1.8%
2	0.7%	1.1%
3	0.6%	0.9%
4	0.7%	0.8%
5	0.9%	0.8%
6	2.0%	1.0%
7	4.1%	1.9%
8	5.8%	2.7%
9	5.4%	3.9%
10	5.3%	5.2%
11	5.5%	6.3%
12	5.8%	7.0%
13	5.9%	7.2%
14	6.0%	7.2%
15	6.6%	7.3%
16	7.2%	7.4%
17	7.8%	7.3%
18	7.6%	7.0%
19	5.9%	6.1%
20	4.3%	5.1%
21	3.6%	4.1%
22	3.1%	3.3%
23	2.4%	2.6%
24	1.8%	2.0%

3.3 MeTeorological Data

2012-2016 hourly meteorological data was obtained from the Pearson International Airport in Toronto and upper air data was obtained from Buffalo, New York as recommended by the MECP for the modelled area. The combined data was processed to reflect conditions at the modelled area using the U.S. EPA's PCRAMMET software program which prepares meteorological data for use with the CAL3QHCR vehicle emission dispersion model. A wind frequency diagram (wind rose) representing winds blowing from a certain direction is shown in Figure 8.

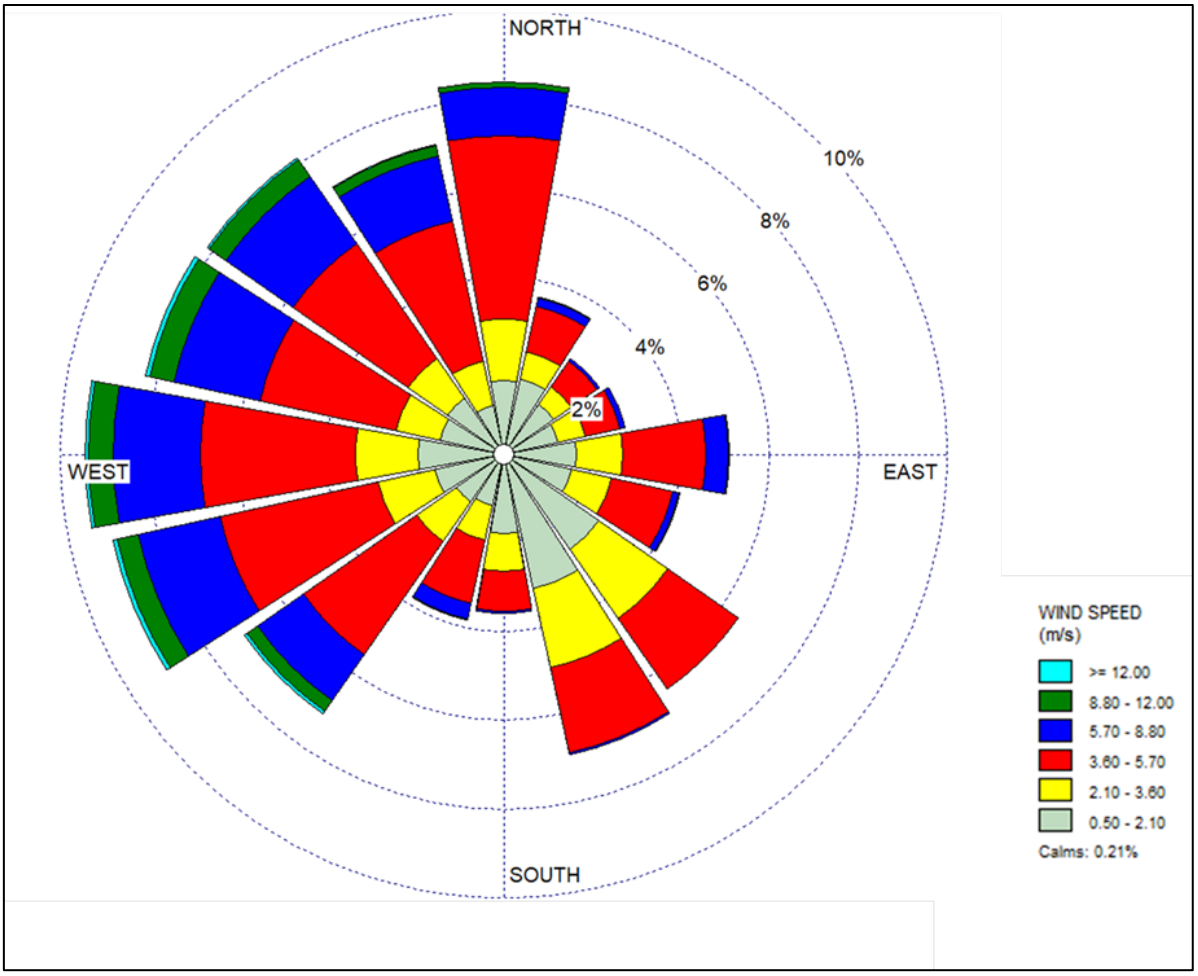


Figure 8: Wind Frequency Diagram for Pearson International Airport (2012-2016)

3.4 Motor Vehicle Emission Rates

The U.S. EPA's Motor Vehicle Emission Simulator (MOVES) model provides estimates of current and future emission rates from motor vehicles based on a variety of factors such as local meteorology, vehicle fleet composition and speed. MOVES 2014b, released in December 2018, is the U.S. EPA's 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. Emission rates were estimated based on the heavy-duty vehicle percentages provided by HDR. Vehicle age was based on the U.S. EPA's default distribution. Table 8 specifies the major inputs into MOVES.

From the MOVES outputs, the highest monthly value for each contaminant was selected to represent a worst-case emission rate. The emission rates for each vehicle speed and contaminant modelled are shown in Table 9 for the No Build and Future Build years, for a heavy and medium duty vehicle percentage of 3.2% and 4.9%, respectively. As shown in Table 9, emissions in the future year are generally predicted to decrease.

Table 8: MOVES Input Parameters

Parameter	Input
Scale	Custom County Domain
Meteorology	Temperature and Relative Humidity were obtained from meteorological data from the Environment Canada Toronto INTL A station for the years 2012 to 2016.
Years	2019 (No Build) and 2031 (Future Build)
Geographical Bounds	Custom County Domain
Fuels	Compressed Natural Gas / Diesel Fuels / Gasoline Fuels
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 Local
Contaminants and Processes	NO_2 / CO / $PM_{2.5}$ / PM_{10} / Acetaldehyde / Acrolein / Benzene / 1,3-Butadiene / Formaldehyde/Equivalent CO_2. 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 for the roadway.

Table 9: MOVES Output Emission Factors for Roadway Vehicles (g/VMT); Idle Emission Rates are Grams per Vehicle Hour (g/hr)

Year	Speed (Km/hr)	CO	NO_X	Benzene	1,3-Butadiene	Formald-ehyde	Acetalde-hyde	Acrolein	$PM_{2.5}$	PM_{10}	TSP[1]
2019	60	2.64	0.30	0.0020	0.000119	0.0017	0.0008	0.00010	0.016	0.060	0.060
2019	70	2.35	0.27	0.0018	0.000100	0.0013	0.0006	0.00008	0.012	0.037	0.037
2019	Idle	10.06	2.98	0.0367	0.003774	0.0371	0.0188	0.00244	0.175	0.193	0.193
2031	60	1.23	0.11	0.0010	0.000003	0.0009	0.0003	0.00004	0.011	0.054	0.054
2031	70	1.13	0.10	0.0009	0.000002	0.0006	0.0002	0.00003	0.007	0.032	0.032
2031	Idle	2.61	0.64	0.0117	0.000077	0.0121	0.0044	0.00062	0.052	0.057	0.057

[1] –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.

3.5 Re-suspended Particulate Matter Emission Rates

A large portion of highway particulate matter emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the highway. 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 PM 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 10.

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

Where: E = the particulate emission factor
k = the particulate size multiplier
sL = silt loading
W = average vehicle weight (Assumed 3 Tons based on fleet data and U.S. EPA vehicle weight and distribution)

Table 10: Re-suspended Particulate Matter Emission Factors

Roadway AADT	K ($PM_{2.5}$/PM_{10}/TSP)	sL (g/m^2)	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	0.03	3	0.03299	0.13195	0.368

3.6 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, 24-hour and annual averages for the contaminants of interest at the identified sensitive receptor locations. **Table 11** 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 vehicle fleet distributions provided. The outputs of CAL3QHCR are presented in the results section.

Table 11: CAL3QHCR Model Input Parameters

Parameter	Input
Free-Flow and Queue 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 input in grams/VMT or grams per vehicle hour. Signal timings for the traffic signal were input in seconds.
Meteorological Data	2012-2016 data from Pearson International Airport
Deposition Velocity	$PM_{2.5}$: 0.1 cm/s PM_{10}: 0.5 cm/s TSP: 0.15 cm/s NO_2, CO and VOCs: 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 VOCs: 0 cm/s

Parameter	Input
Surface Roughness	The land type surrounding the project site is categorized as suburban. Therefore, a surface roughness height of 52cm was applied in the model.
Vehicle Emission Rate	Emission rates calculated in MOVES and AP-42 were input in g/VMT

3.7 Modelling Results

Presented below are the modelling results for the 2019 No Build and 2031 Future Build scenarios based on 5-years of meteorological data. For each 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 receptors for each contaminant and averaging period (see Table 12), which were identified as the maximum combined concentration for the 2031 Future Build scenario. Results for all modelled receptors are provided in Appendix A. It should be noted that the maximum combined concentration at any sensitive receptor often occurs infrequently and may only occur for one hour or day over the 5-year period.

Table 12: Worst-Case Sensitive Receptors for 2031 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
CAAQ NO_2	1-hour	18
	Annual	18
NO_2	1-hour	19
	24-hour	7
CO	1-hour	11
	8-hour	11
$PM_{2.5}$	24-hour	18
	Annual	18
PM_{10}	24-hour	18
TSP	24-hour	18
1,3-Butadiene	24-hour	19
	Annual	18
Formaldehyde	24-hour	18
Benzene	24-hour	18
	Annual	18
Acrolein	1-hour	18
	24-hour	18
Acetaldehyde	24-hour	18

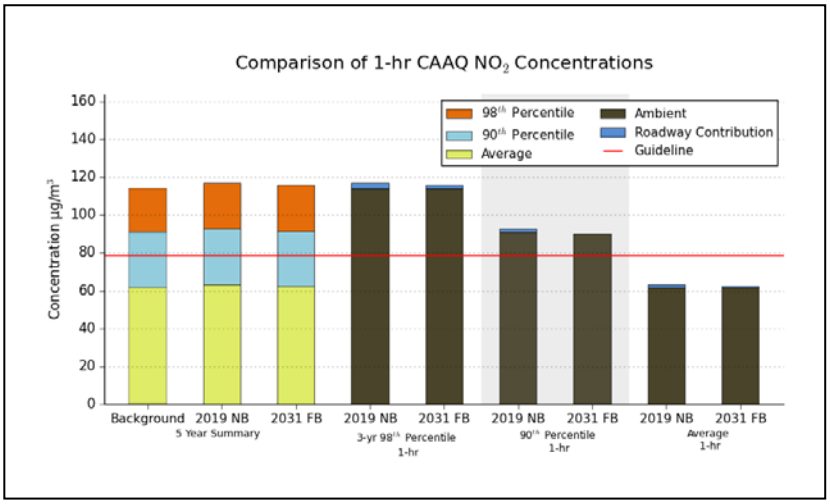
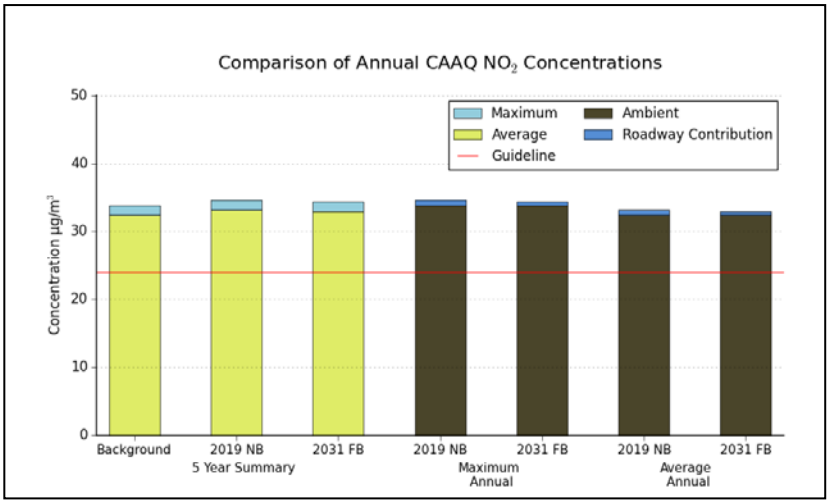
Coincidental hourly modelled roadway and background concentrations were added to derive the combined concentration for each hour over the 5-year period. Hourly combined concentrations were then used to determine contaminant concentrations based on the applicable averaging period. Statistical analysis in the form of maximum, 90th percentile, and average combined concentrations were calculated for the worst-case sensitive receptor for each contaminant and are presented below. The maximum combined concentration (or 3-year average annual 98th percentile concentration in the case of $PM_{2.5}$) was used to assess compliance with MECP guidelines or CAAQS. If concentrations in excess of the guideline were predicted, a frequency analysis was undertaken in order to estimate the number of occurrences above the guideline. Provided below are the modelling results for the contaminants of interest.

3.7.1 Nitrogen Dioxide CAAQs

Table 13 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and annual NO_2 based on 5 years of meteorological data. The results conclude that:

- The annual 98th percentile of daily maximum 1-hour NO_2 concentrations, averaged over three consecutive years exceeds the CAAQs with a 6% contribution from the roadway.
- The annual average concentration exceeds the CAAQs guideline with a 2% contribution from the roadway.

Table 13: Summary of Predicted NO_2 Concentrations

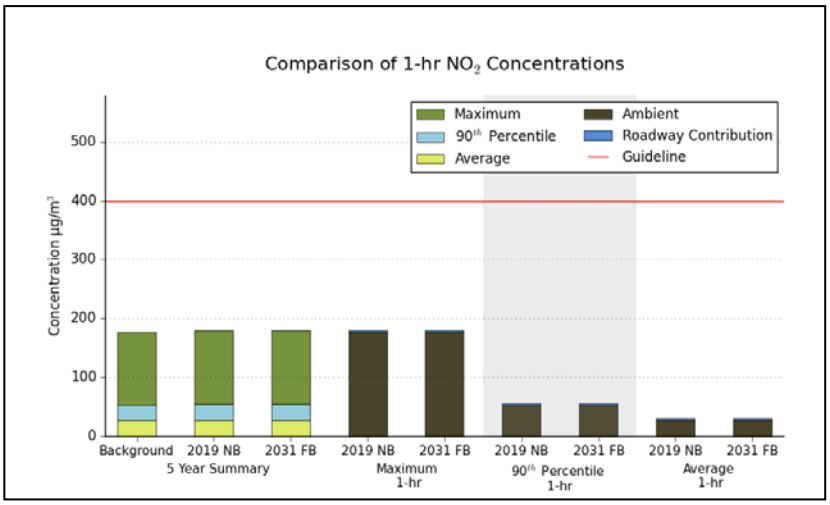
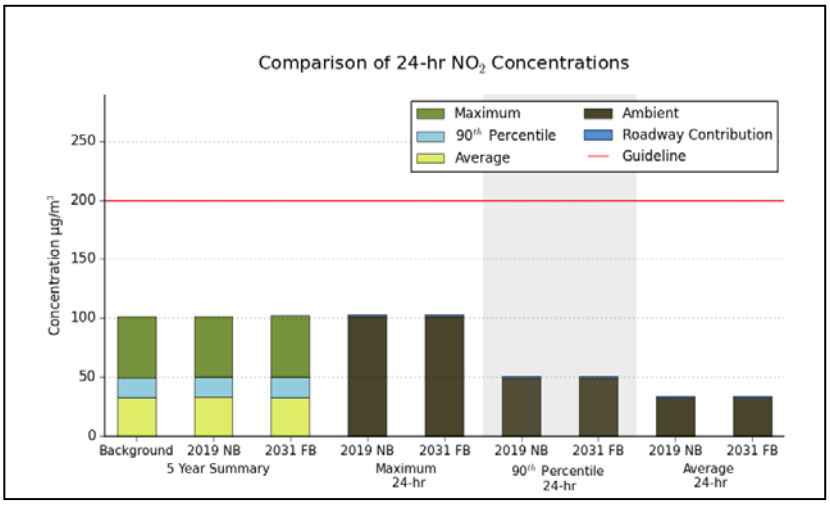
Statistical Analysis	2031 FB	
	**% of CAAQs Guideline:**	
	98th Percentile	146%
	90th Percentile	115%
	Average	79%
	Roadway Contribution:	
	98th Percentile	6%
	90th Percentile	1%
	Average	1%
	98th Percentile combined concentrations exceed the 1-hour CAAQ Guideline. Note that the background concentrations alone exceed the CAAQ's 1-hr guideline of 79 µg/m³. Also note that this objective is based on the 3-year average of the annual 98th percentile of the NO_2 daily-maximum 1-hour average concentrations.	
	**% of CAAQs Guideline:**	
	Maximum	143%
	Average	137%
	Roadway Contribution:	
	Maximum	2%
	Average	2%
	Maximum combined concentrations exceeds the annual CAAQ Guideline of 24 µg/m³ at 34 µg/m³. Note that the background concentrations alone exceed the CAAQ's guideline.	

3.7.2 Nitrogen Dioxide

Table 14 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 24-hour NO_2 based on 5 years of meteorological data. The results conclude that:

- Both the maximum 1-hour and 24-hour NO_2 combined concentrations were below their respective MECP guidelines.

Table 14: Summary of Predicted NO_2 Concentrations

Statistical Analysis	2031 FB	
	**% of MECP Guideline:**	
	Maximum	45%
	90th Percentile	13%
	Average	7%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	1%
	Average	2%
	**% of MECP Guideline:**	
	Maximum	51%
	90th Percentile	25%
	Average	16%
	Roadway Contribution:	
	Maximum	1%
	90th Percentile	1%
	Average	1%

Conclusions:

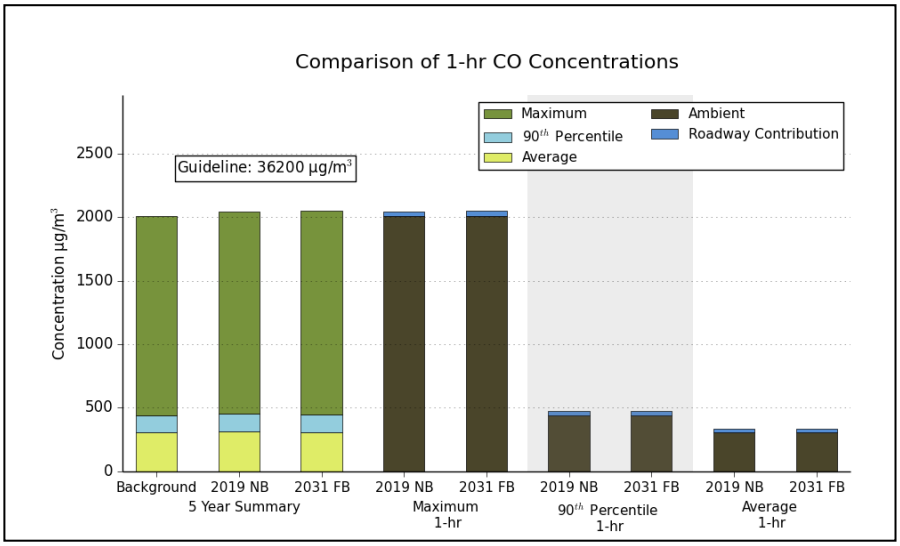
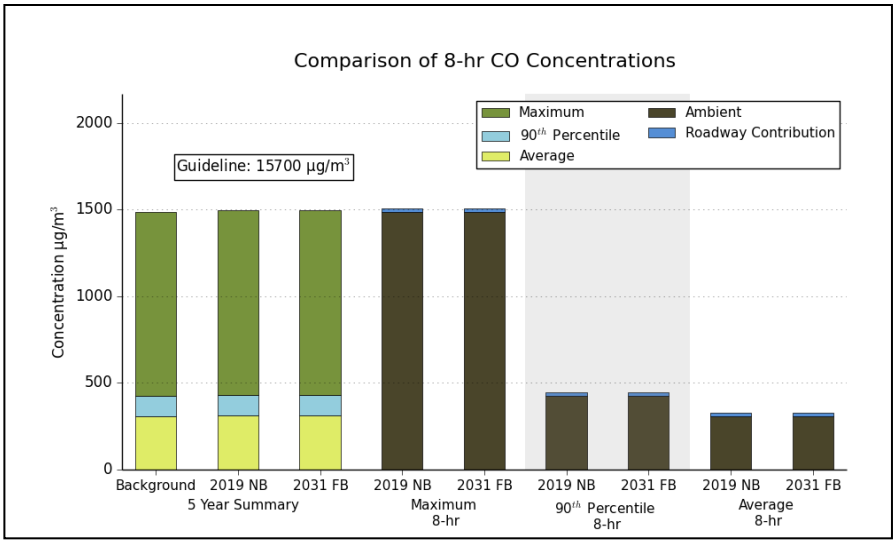
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 2% or less.

3.7.3 Carbon Monoxide

Table 15 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 8-hour CO based on 5 years of meteorological data. The results conclude that:

- Both the maximum 1-hour and 8-hour CO combined concentrations were well below their respective MECP guidelines.

Table 15: Summary of Predicted CO Concentrations

Statistical Analysis	2031 FB	
	**% of MECP Guideline:**	
	Maximum	6%
	90th Percentile	1%
	Average	1%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	2%
	Average	2%
	**% of MECP Guideline:**	
	Maximum	10%
	90th Percentile	3%
	Average	2%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	2%
	Average	2%

Conclusions:

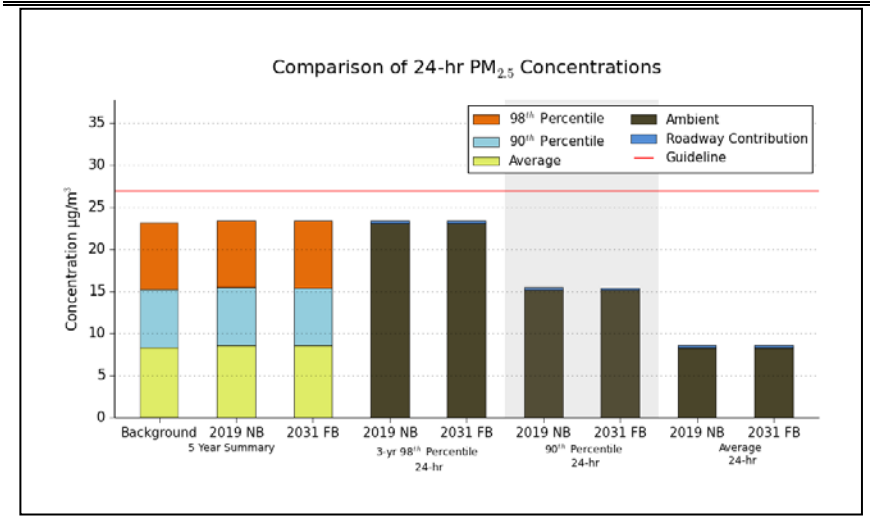
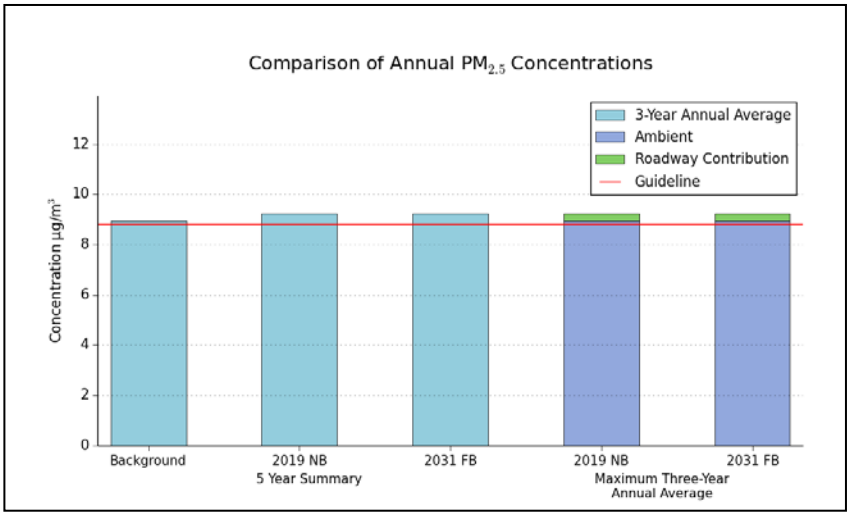
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 2%.

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

Table 16 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual $PM_{2.5}$ based on 5 years of meteorological data. The results conclude that:

- The average annual 98th percentile of 24-hour $PM_{2.5}$ combined concentrations, averaged over three consecutive years was below the CAAQs.
- The three-year annual average concentration exceeded the guideline with a 3% contribution from the roadway.

Table 16: Summary of Predicted $PM_{2.5}$ Concentrations

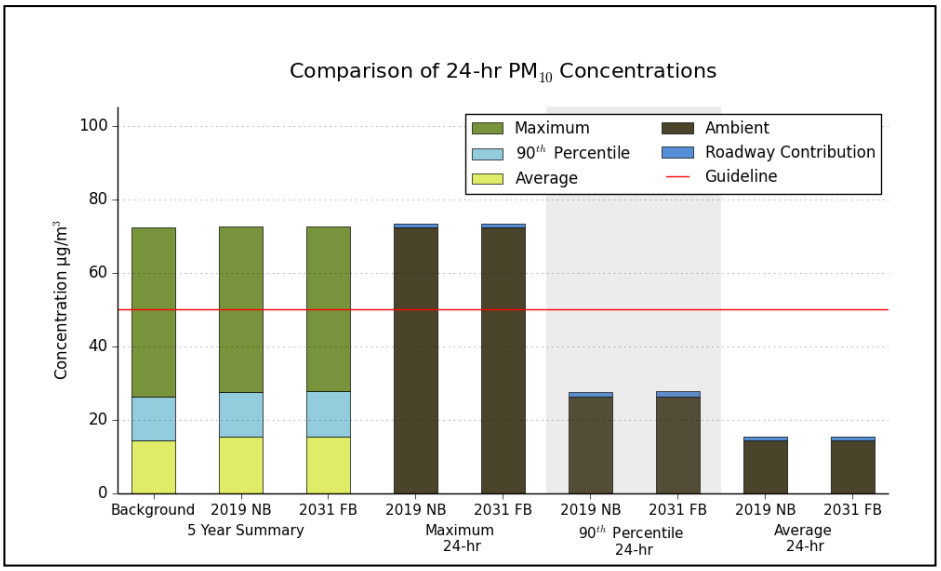
Statistical Analysis	2031 FB	
	**% of CAAQs Guideline:**	
	98th Percentile	87%
	90th Percentile	57%
	Average	32%
	Roadway Contribution:	
	98th Percentile	3%
	90th Percentile	2%
	Average	5%
	The $PM_{2.5}$ results were below the 3-year CAAQs. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 23.4 µg/m³ or 87% of the CAAQs.	
	**% of CAAQs Guideline:**	
	Maximum 3-Year Annual Average	109%
	Roadway Contribution:	
	Maximum 3-Year Annual Average	3%
	The $PM_{2.5}$ results were above the 3-year CAAQs. The maximum 3-year annual average concentration was 109% of the guideline. Note that the background concentration alone is at 106% of the CAAQs guideline.	

3.7.5 Coarse Particulate Matter (PM_{10})

Table 17 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour PM_{10} based on 5 years of meteorological data. The results conclude that:

- The maximum 24-hr PM_{10} combined concentration exceeded the MECP guideline.

Table 17: Summary of Predicted PM_{10} Concentrations

Statistical Analysis	2031 FB
	**% of MECP Guideline:**
	Maximum: 146%
	90th Percentile: 55%
	Average: 31%
	Roadway Contribution:
	Maximum: 1%
	90th Percentile: 5%
	Average: 7%

Conclusions:

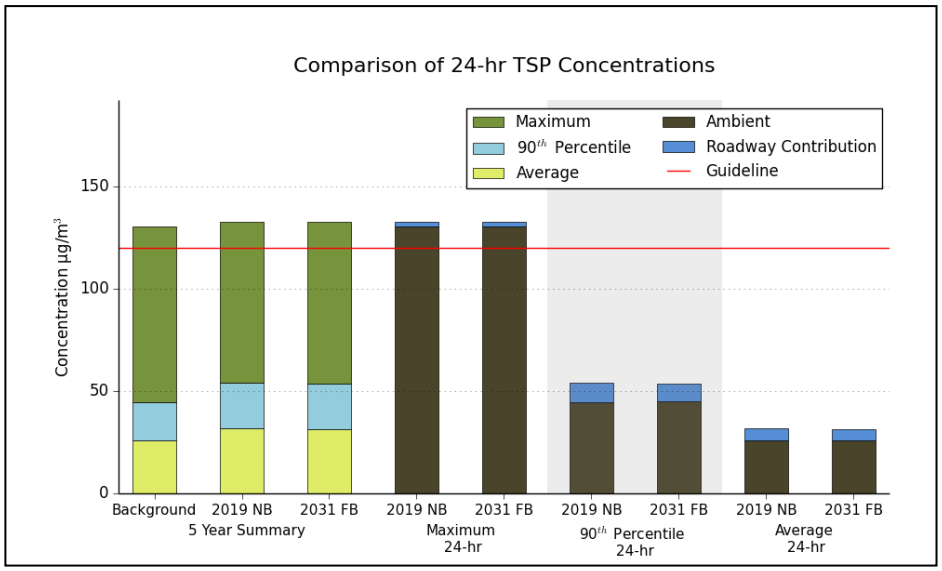
- The maximum combined concentration of PM_{10} was found to exceed the guideline of 50 µg/m^3. It should be noted, however, that background concentrations alone exceeded the guideline and that the roadway contribution is 1% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- A total of 14 days exceeded the guideline in the five-year period for No Build and 14 days for the Future Build scenario, which equate to less than 1% of the time.

3.7.6 Total Suspended Particulate Matter (TSP)

Table 18 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour TSP based on 5 years of meteorological data. The results conclude that:

- The maximum 24-hr TSP combined concentration exceeded the MECP guideline.

Table 18: Summary of Predicted TSP Concentrations

Statistical Analysis	2031 FB
	**% of MECP Guideline:**
	Maximum: 111%
	90th Percentile: 45%
	Average: 26%
	Roadway Contribution:
	Maximum: 2%
	90th Percentile: 16%
	Average: 19%

Conclusions:

- The TSP results show that the combined concentrations exceed the guideline. It should be noted, however, that background concentrations alone account for 109% of the guideline and that the roadway contribution is 2% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period. A total of 1 day exceeded the guideline in the five-year period in both the No Build and Future Build scenarios, which equates to less than 1% of the time.

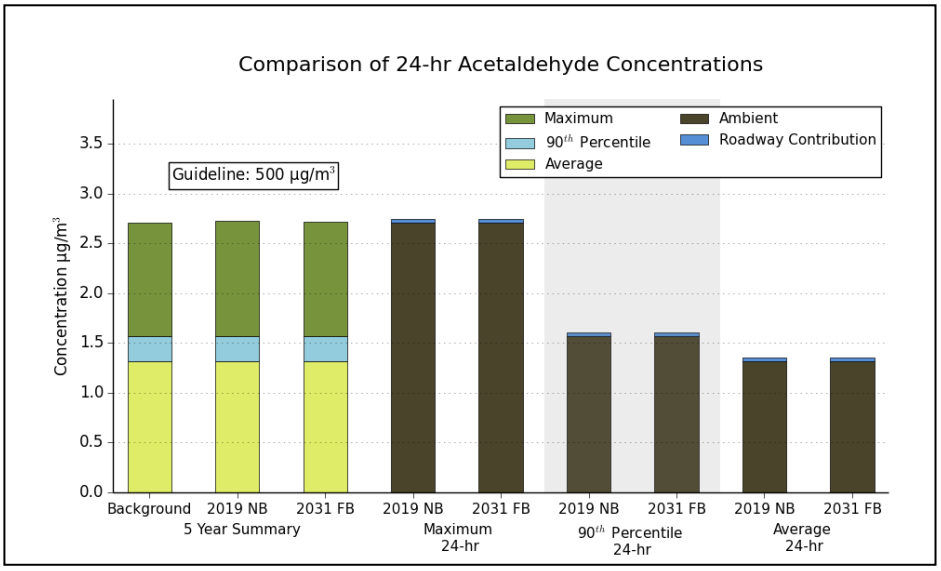
Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to combine the ambient data to the modelled results, the measured concentrations were applied to the following 6 days when measurements were 6 days apart. When measurements were further than 6 days apart, the 90th percentile annual value was used to represent the missing data. This background data was added to the predicted hourly roadway concentrations at each receptor to obtain results for the VOCs.

3.7.7 Acetaldehyde

Table 19 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour acetaldehyde based on 5 years of meteorological data. The results conclude that:

- The maximum 24-hour acetaldehyde combined concentration was well below the respective MECP guideline.

Table 19: Summary of Predicted Acetaldehyde Concentrations

Statistical Analysis	2031 FB
	**% of MECP Guideline:**
	Maximum: <1%
	90th Percentile: <1%
	Average: <1%
	Roadway Contribution:
	Maximum: <1%
	90th Percentile: <1%
	Average: <1%

Conclusions:

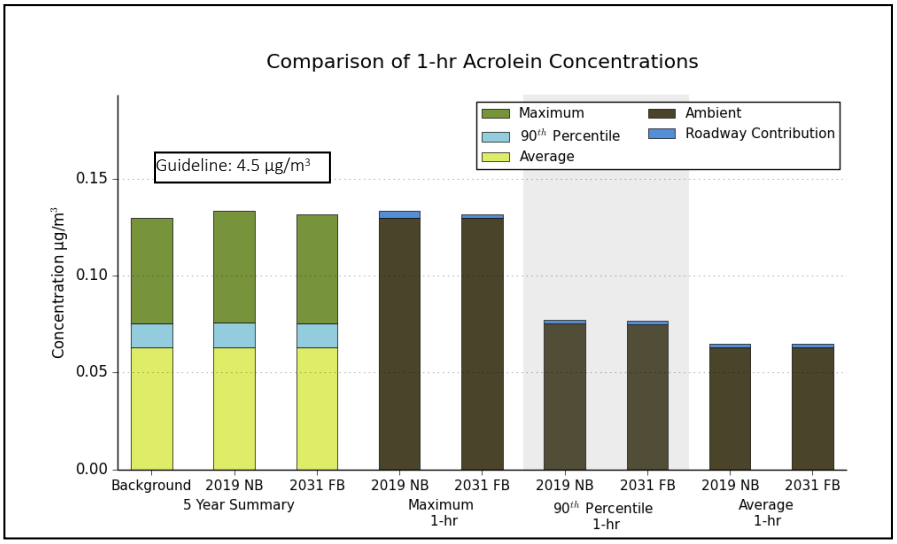
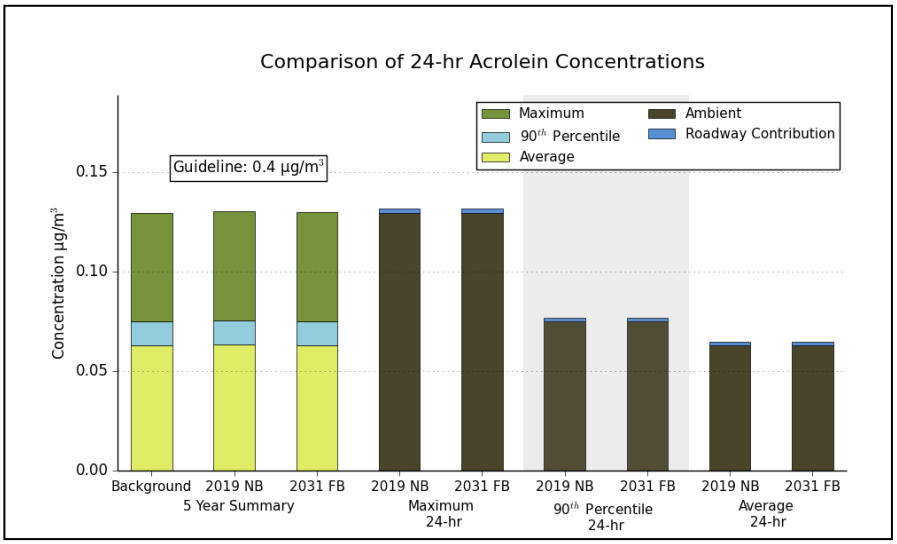
- All combined concentrations were below the respective MECP guideline.
- The contribution from the roadway to the combined concentrations was <1%.

3.7.8 Acrolein

Table 20 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 24-hour acrolein based on 5 years of meteorological data. The results conclude that:

- The maximum 1-hour and 24-hour acrolein combined concentrations were below the respective MECP guidelines.

Table 20: Summary of Predicted Acrolein Concentrations

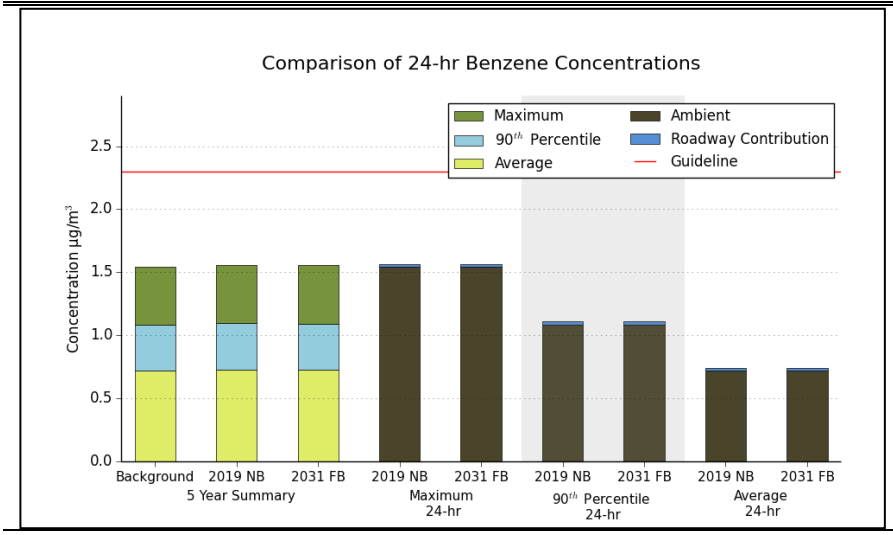
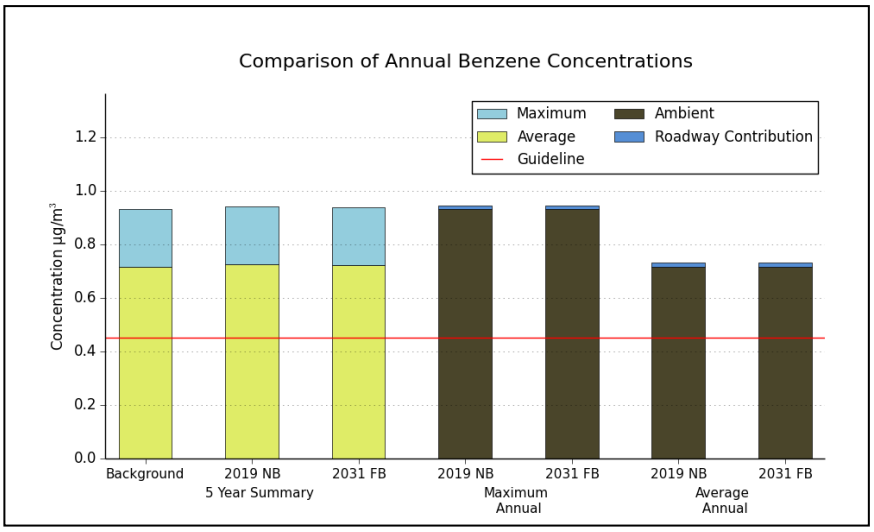
Statistical Analysis	2031 FB	
	**% of MECP Guideline:**	
	Maximum	3%
	90th Percentile	2%
	Average	<1%
	Roadway Contribution:	
	Maximum	1%
	90th Percentile	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MECP 1-hr guideline. The contribution from the roadway was less than 1%.	
	**% of MECP Guideline:**	
	Maximum	33%
	90th Percentile	19%
	Average	16%
	Roadway Contribution	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MECP 24-hr guideline. The contribution from the roadway was 1% or less.	

3.7.9 Benzene

Table 21 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual benzene based on 5 years of meteorological data. The results conclude that:

- The maximum 24-hour benzene combined concentration was below the respective MECP guideline. The roadway contribution to the maximum concentration was 1%.
- The annual benzene concentration exceeded the guidline. The roadway contribution to the maximum annual average was 1%.

Table 21: Summary of Predicted Benzene Concentrations

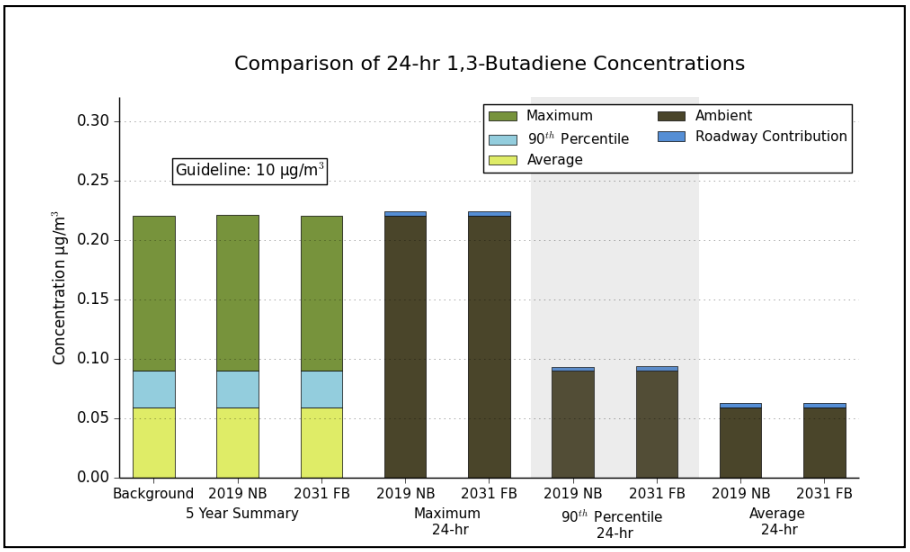
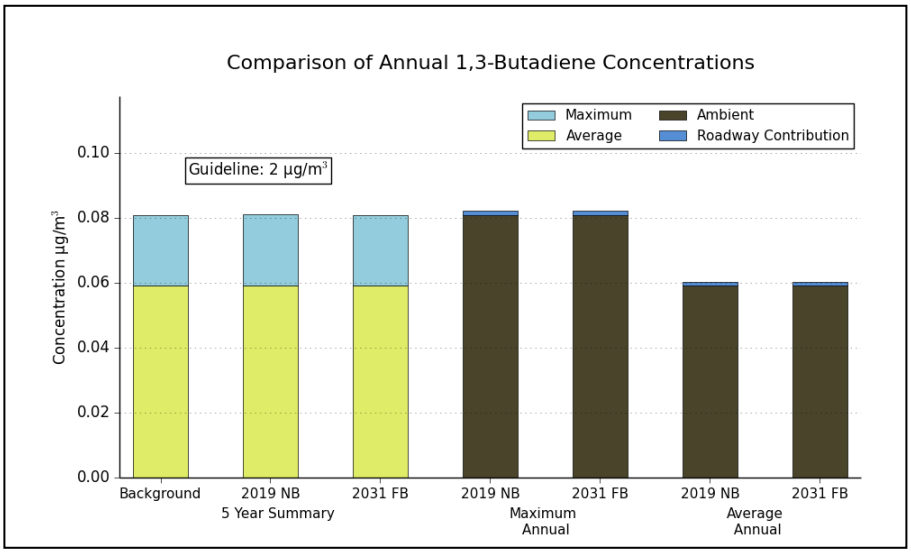
Statistical Analysis	2031 FB
	**% of MECP Guideline:** Maximum: 68% 90th Percentile: 48% Average: 31% **Roadway Contribution:** Maximum: 1% 90th Percentile: 1% Average: 1% **Conclusions:** The combined concentrations were below the respective MECP 24-hr guideline. The roadway contribution to the maximum was 1%.
	**% of MECP Guideline:** Maximum: 209% Average: 161% **Roadway Contribution:** Maximum: 1% Average: 1% **Conclusions:** The combined concentration exceeded the MECP annual guideline. It should be noted that ambient concentrations were 208% of the guideline and the roadway contribution to the maximum was 1%.

3.7.10 1,3-Butadiene

Table 22 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual 1,3-butadiene based on 5 years of meteorological data. The results conclude that:

- The maximum 24-hour and annual 1,3-butadiene combined concentrations were well below the respective MECP guidelines.

Table 22: Summary of Predicted 1,3-Butadiene Concentrations

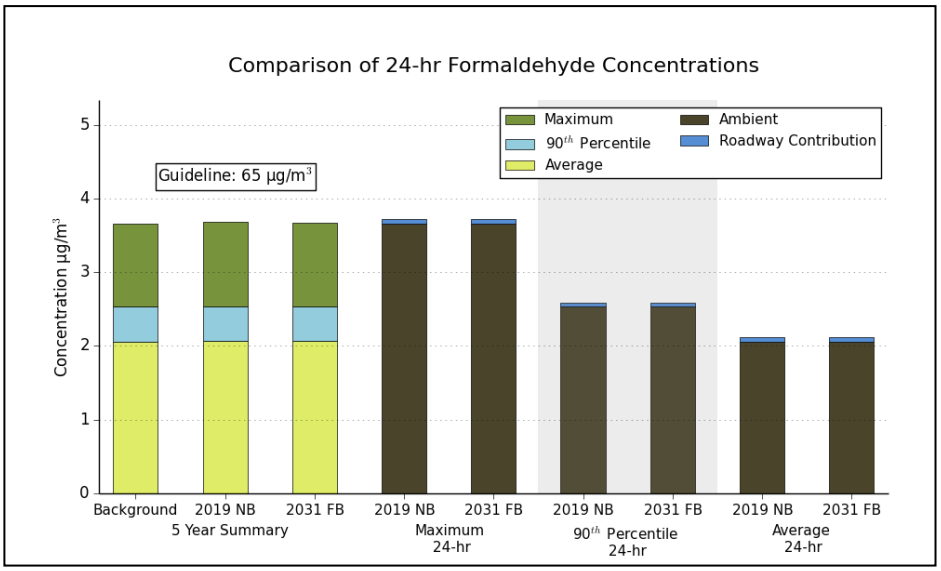
Statistical Analysis	2031 FB	
	**% of MECP Guideline:**	
	Maximum	2%
	90th Percentile	1%
	Average	1%
	Roadway Contribution:	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MECP 24-hr guideline. The contribution from the roadway was less than 1%.	
	**% of MECP Guideline:**	
	Maximum	4%
	Average	3%
	Roadway Contribution:	
	Maximum	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MECP annual guideline. The contribution from the roadway was less than 1%.	

3.7.11 Formaldehyde

Table 23 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour formaldehyde based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hour formaldehyde combined concentration was below the respective MECP guideline.*

Table 23: Summary of Predicted Formaldehyde Concentrations

Statistical Analysis	2031 FB
	**% of MECP Guideline:**
	Maximum: 6%
	90th Percentile: 4%
	Average: 3%
	Roadway Contribution:
	Maximum: <1%
	90th Percentile: <1%
	Average: <1%

Conclusions:

- All combined concentrations were below the respective MECP guideline.
- The contribution from the roadway to the combined concentration was <1%.

4.0 GREENHOUSE GAS ASSESSMENT

In addition to the contaminants of interest assessed in the local air quality assessment, greenhouse gas (GHG) emissions were predicted from the project. Potential impacts were assessed by calculating the relative change in total emissions between the 2019 No Build and 2031 Future Build scenarios as well comparing the total emission to the 2030 provincial and Canada-wide GHG targets. Total GHG emissions from the roadway were determined based on the total 4.1km length of the study roadway, traffic volumes, and predicted emission rates.

From a GHG perspective, the contaminants of concern from motor vehicle emissions are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These GHGs can be further classified according to their Global Warming Potential. The Global Warming Potential is a multiplier developed for each GHG, which allows comparison of the ability of each GHG to trap heat in the atmosphere, relative to carbon dioxide. Using these multipliers, total GHG emissions can be classified as CO_2 equivalent emissions. For this assessment, the MOVES model was used to determine total CO_2 equivalent emission rates for the posted speed and heavy/medium-duty vehicle percentage on Kirby Road. Table 24 summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions on Kirby Road in the 2019 No Build and 2031 Future Build scenario.

Table 24: Summary of Kirby Road Traffic Volumes, Roadway Length and Emission Rates

Roadway	Two-Way AADT		Length of Roadway (Miles)	Heavy/Medium Duty Vehicle Percentage (%)		Posted Speed (km/hr)	Total CO_2 Equivalent (tonnes)	
	2019	2031		2019	2031		2019	2031
Kirby from Jane to Keele	6,300	15,400	1.26	3.20/4.90	5.0/5.0	60	1195	2,348
Kirby from Keele to Dufferin	8,600	18,200	1.30	0.34/3.67	5.0/5.0	60	1499	2,852
Jane Street	11,900	11,698	0.37	1.60/2.90		80	583	438
Keele Street	18,300	19,754	0.37	2.30/4.40		70	931	739
Dufferin Street	13,100	11,168	0.37	0.90/2.00		70	622	378

The total predicted annual GHG emissions for the 2019 No Build and 2031 Future Build scenarios are shown in Table 25. Also shown is the percent change in total GHG emissions between the scenarios. The results show that due to the increases in traffic volumes on future Kirby road, the total GHG emissions will increase by 40%.

Table 26 shows the GHG emissions on Kirby Road project represent 0.0066% of the provincial target and 0.0013% of the Canada-wide target. The contribution of GHG emissions from the project is small in comparison to these provincial and national targets.

Table 25: Changes in predicted GHG Emissions

Roadway	2019 Total CO_2 Equivalent (tonnes)	2031 Total CO_2 Equivalent (tonnes)	Changes in Emission (%)
All Roads	4,829	6,755	+40%

Table 26: Predicted Future Build GHG Emissions compared to GHG targets

	Total CO_2 Equivalent (tonnes/year)
All Roads	6,755
Comparison to Canada-wide Target	0.0013%
Comparison to Ontario-wide Target	0.0066%
Comparison to Transportation Target	0.0041%
Canada-Wide 2030 GHG Target[1]	517,000,000
Ontario-Wide 2030 GHG Target[2]	102,350,000
Transportation Sector GHG 2030 Target[3]	164,000,000

[1] Environment and Climate Change Canada (2018) Canadian Environmental Sustainability Indicators: Progress towards Canada's greenhouse gas emissions reduction target. Available at: www.canada.ca/en/environment-climate-change/services/environmentalindicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html.

[2] Ontario Climate Change Strategy. Available at: https://www.ontario.ca/page/climate-change-strategy

[3] CANADA'S SECOND BIENNIAL REPORT ON CLIMATE CHANGE. Available at https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/second-biennial-report.html

5.0 AIR QUALITY IMPACTS DURING CONSTRUCTION

During construction of the roadway, dust is the primary contaminant of concern. Other contaminants including NO_x and VOC's may be emitted from equipment used during construction activities. Due to the temporary nature of construction activities, there are no air quality criteria specific to construction activities. However, the Environment Canada "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" document provides several mitigation measures for reducing emissions during construction activities. Mitigation techniques discussed in the document include material wetting or use of chemical suppressants to reduce dust, use of wind barriers, and limiting exposed areas which may be a source of dust and equipment washing. In addition, planting of additional vegetation (for example coniferous species) and use of non-chloride dust suppressants for dust control are recommended by the MECP. It is recommended that these best management practices be followed during construction of the roadway to reduce any air quality impacts that may occur.

6.0 CONCLUSIONS

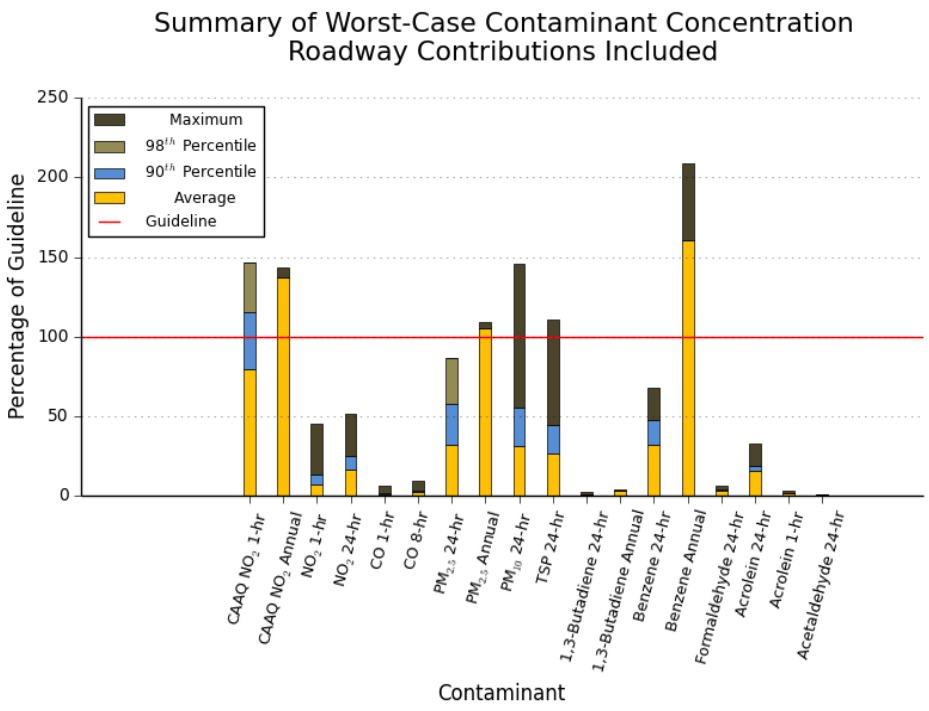
Presented in **Table 27** is a summary of the worst-case modelling results for the 2031 Future Build based on 5-years of meteorological data. For each contaminant, combined concentrations are presented as a percentage of the applicable guideline.

The maximum combined concentrations for the Future Build were all below their respective MECP guidelines or CAAQS, with the exception of the 1-hr and annual NO_2 CAAQ, annual $PM_{2.5}$, 24-hr PM_{10}, 24-hr TSP and annual benzene. Note that background concentrations alone exceeded the guideline for all of these contaminant averaging periods as well. The contribution from the roadway emissions to the combined concentrations was small.

As shown in **Table 12**, Receptor 18 will be the worst-case sensitive receptor for most of the contaminants of interest, including NO_2 CAAQ standards, $PM_{2.5}$, PM_{10}, and TSP, in the 2031 future build scenario. Therefore, additional dust mitigation measures are recommended to be conducted in the vicinity of this receptor.

Greenhouse gas assessment and air quality impacts during construction are discussed in **Section 4** and **Section 5**.

Table 27: Worst-Case Summary of Predicted Combined Contaminant Concentrations for the 2031 Future Build

5 Year Statistical Summary	% of Guideline	
	2031 FB	
	CAAQ NO_2 (1-hr)	146%
	CAAQ NO_2 (Annual)	143%
	NO_2 (1-hr)	45%
	NO_2 (24-hr)	51%
	CO (1-hr)	6%
	CO (8-hr)	10%
	$PM_{2.5}$ (24-hr See Note)	87%
	$PM_{2.5}$ (Annual)	109%
	PM_{10}	146%
	TSP	110%
	Acetaldehyde	<1%
	Acrolein (1-hr)	3%
	Acrolein (24-hr)	33%
	Benzene (24-hr)	68%
	Benzene (Annual)	209%
	1,3-Butadiene (24-hr)	2%
	1,3-Butadiene (Annual)	4%
	Formaldehyde	6%

7.0 REFERENCES

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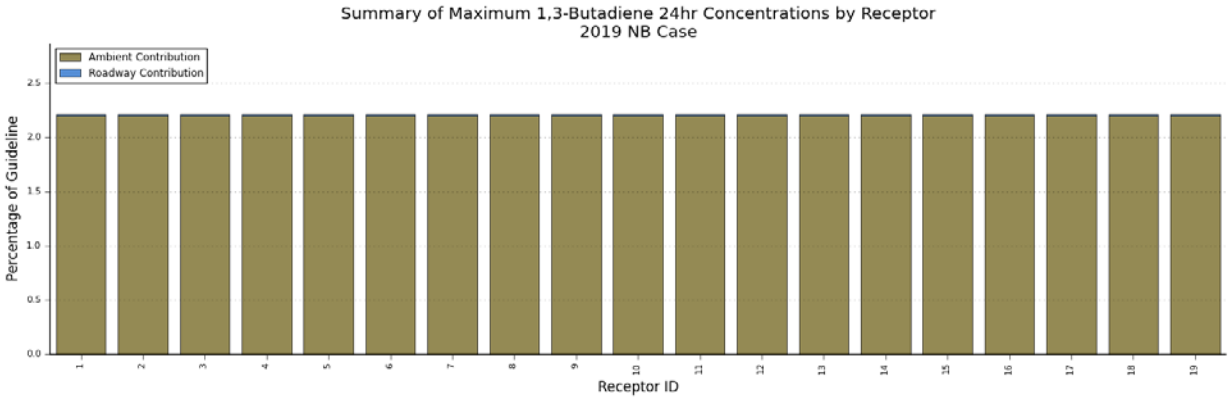
APPENDIX A
RESULTS FOR EACH RECEPTOR

Air Quality Assessment Kirby Road Widening

City of Vaughan

SLR Project No.: 241.20105.00000


Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
0.0
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1.5
2.0
2.5
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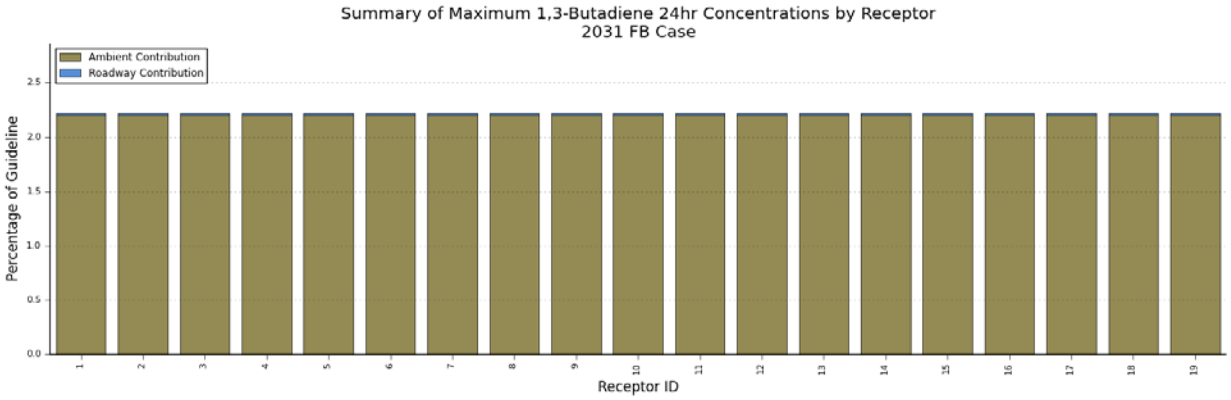
Receptor ID


Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
0.0
0.5
1.0
1.5
2.0
2.5
1
2
3
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7
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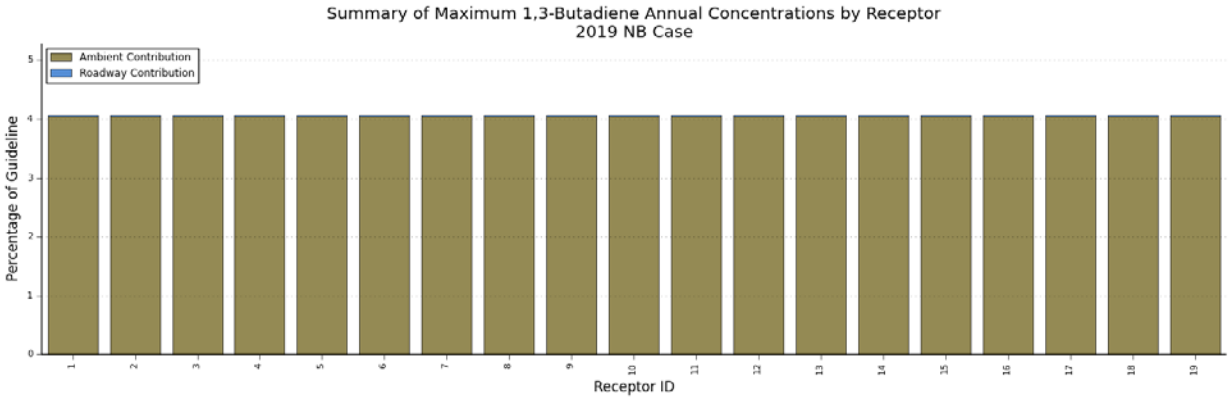
Receptor ID


Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
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3
4
5
1
2
3
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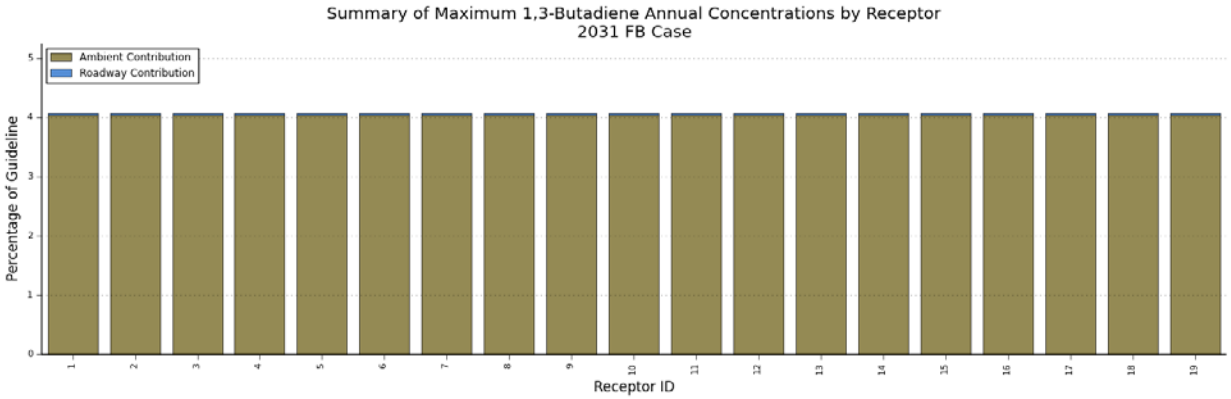
Receptor ID


Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
0
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2
3
4
5
1
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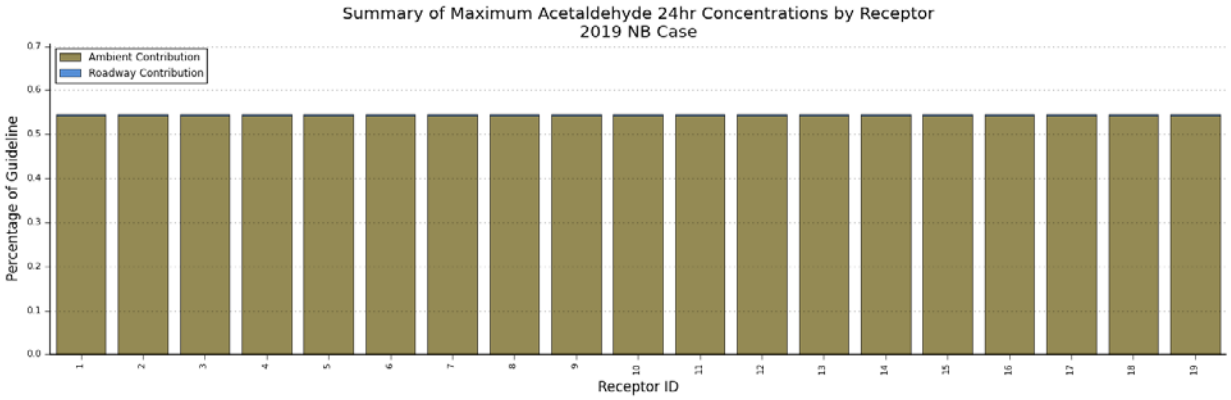
Receptor ID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2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
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0.3
0.4
0.5
0.6
0.7
1
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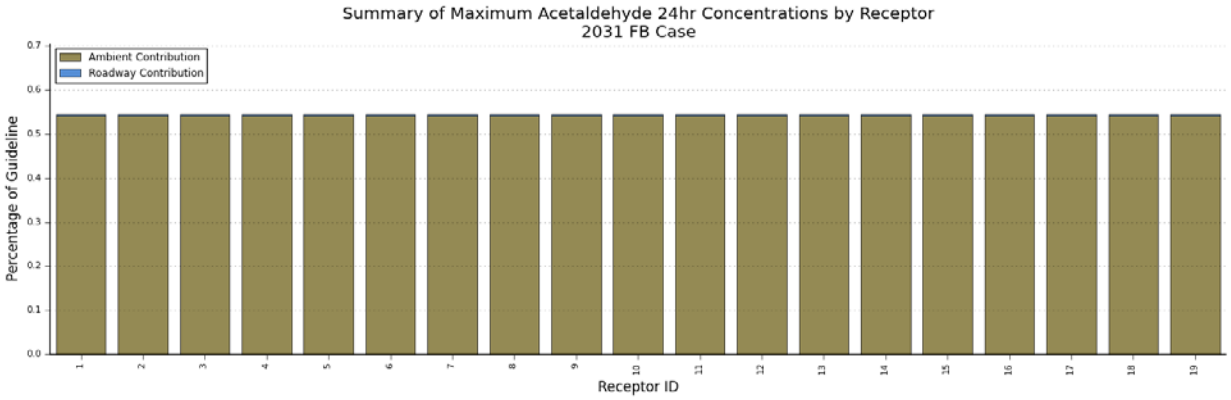
Receptor ID


Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1
2
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6
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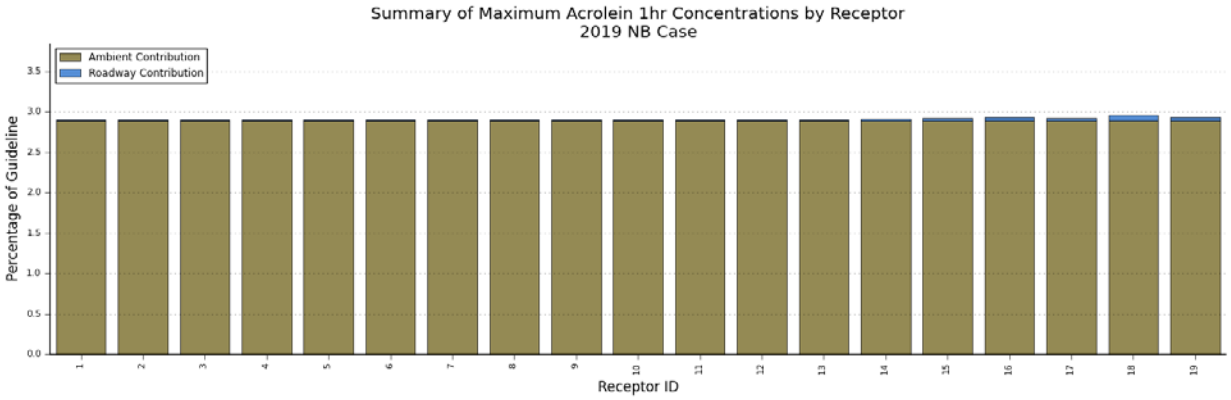
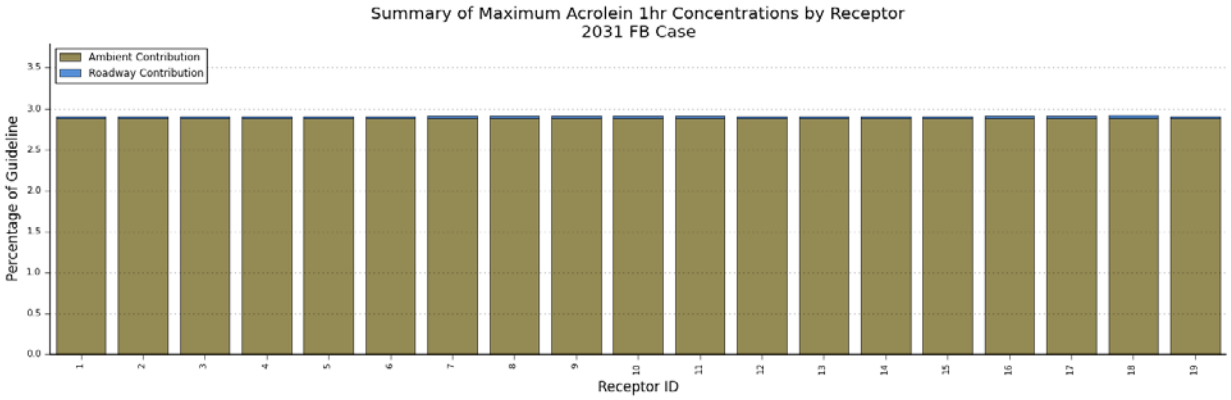
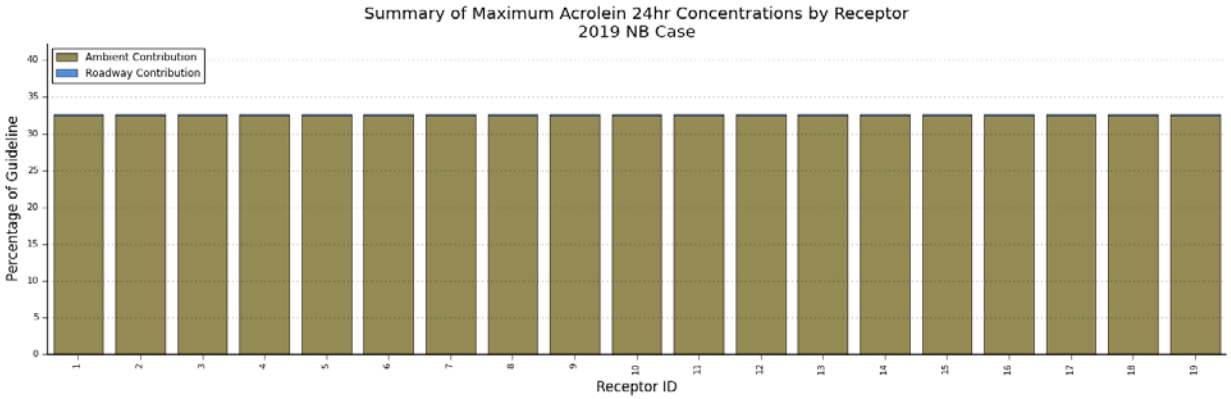
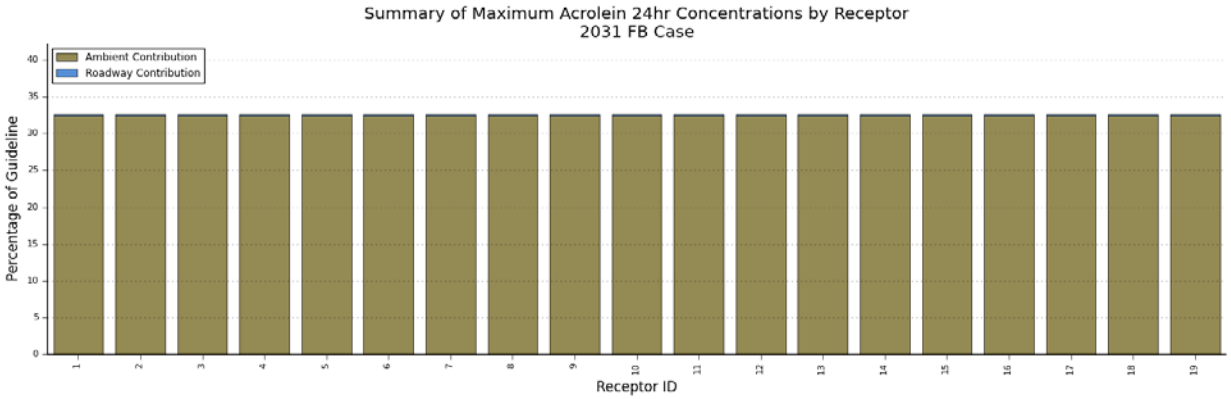
19
Receptor ID


Summary of Maximum Acrolein 1hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 1hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 24hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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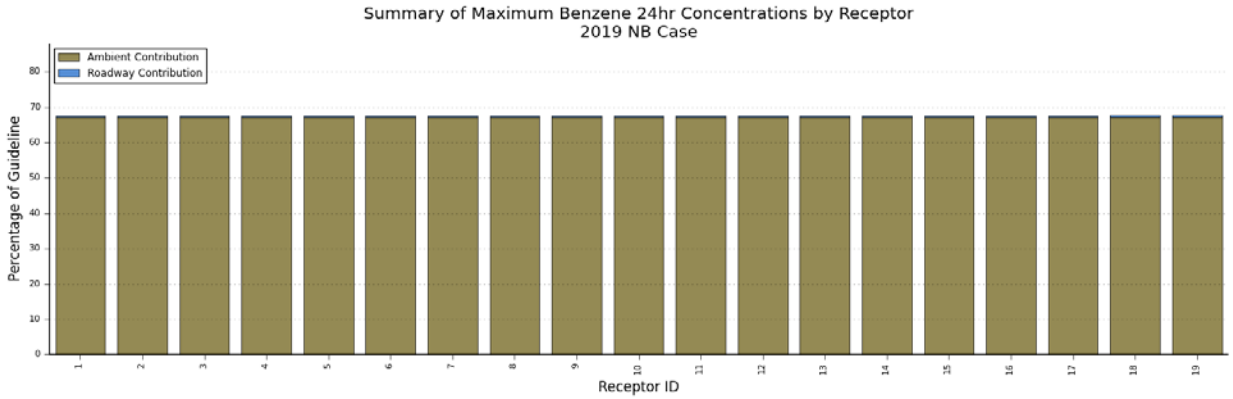
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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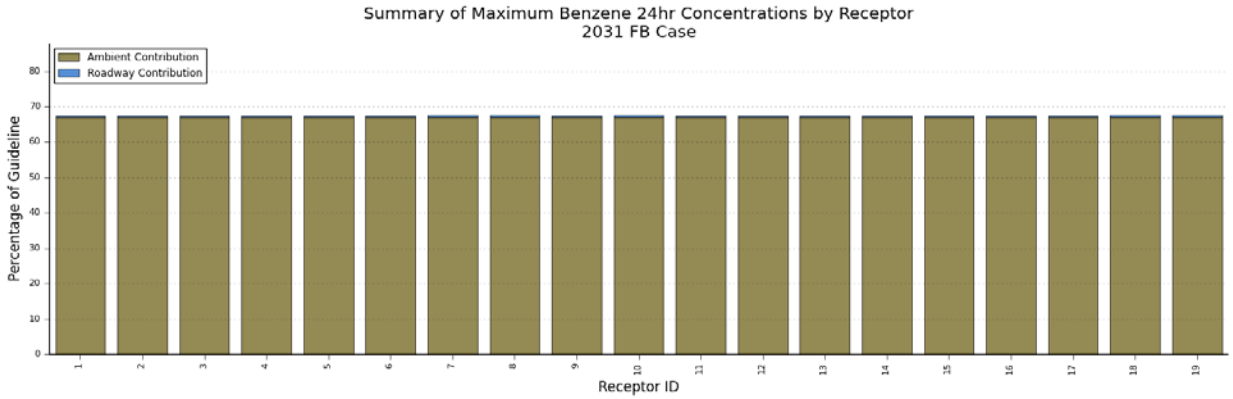
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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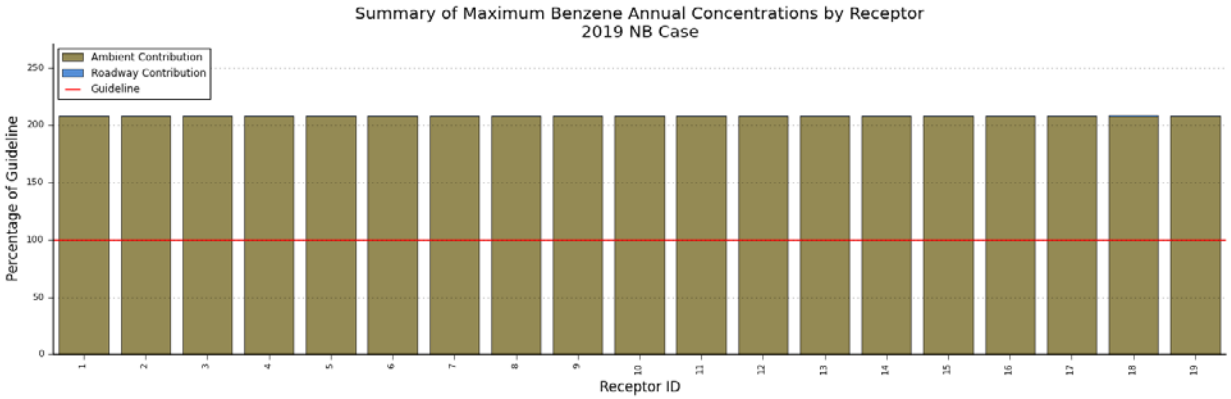
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Benzene Annual Concentrations by Receptor
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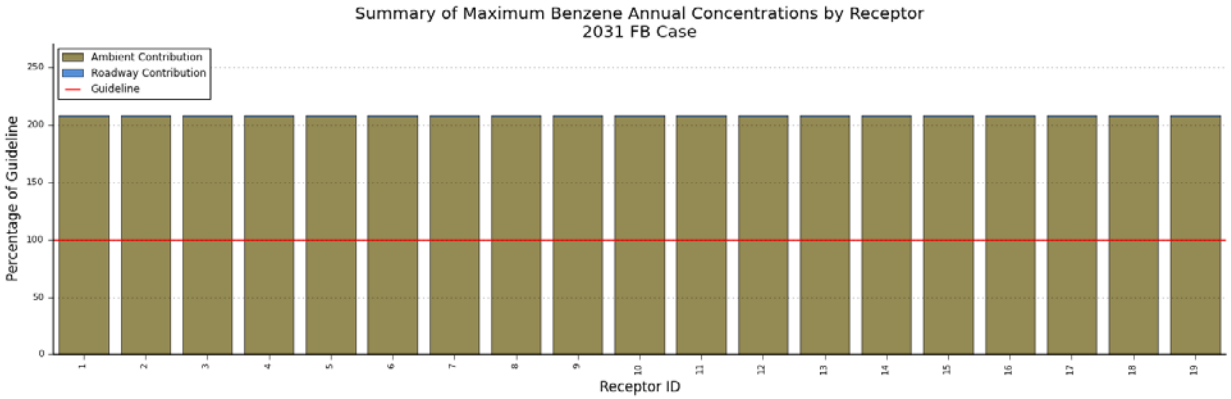
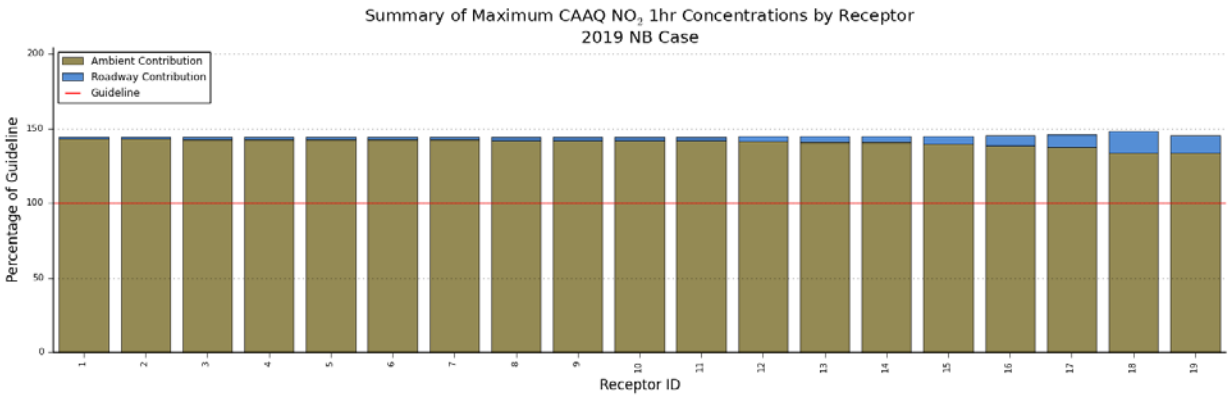
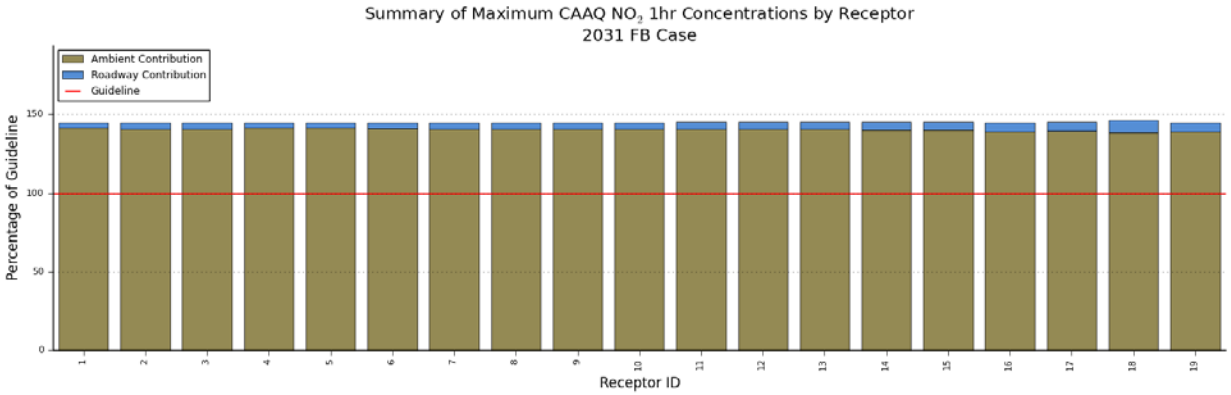
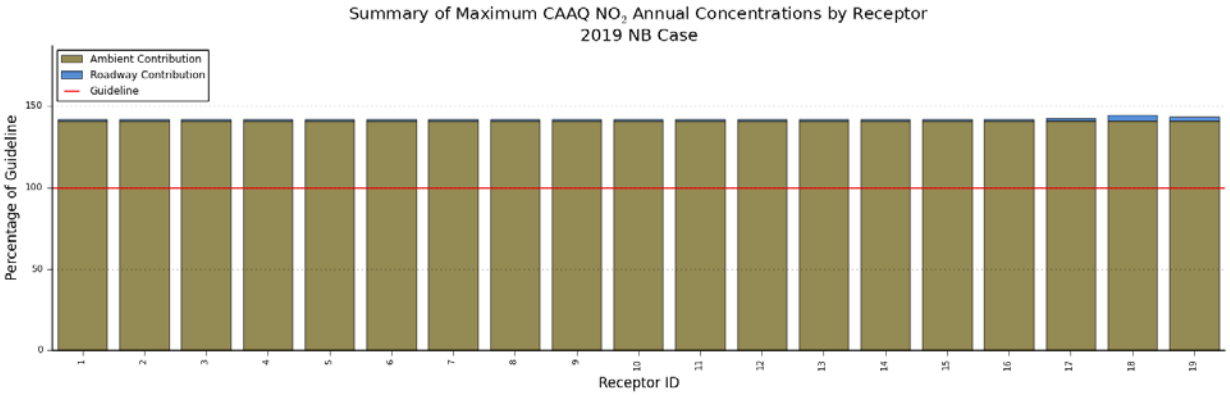
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

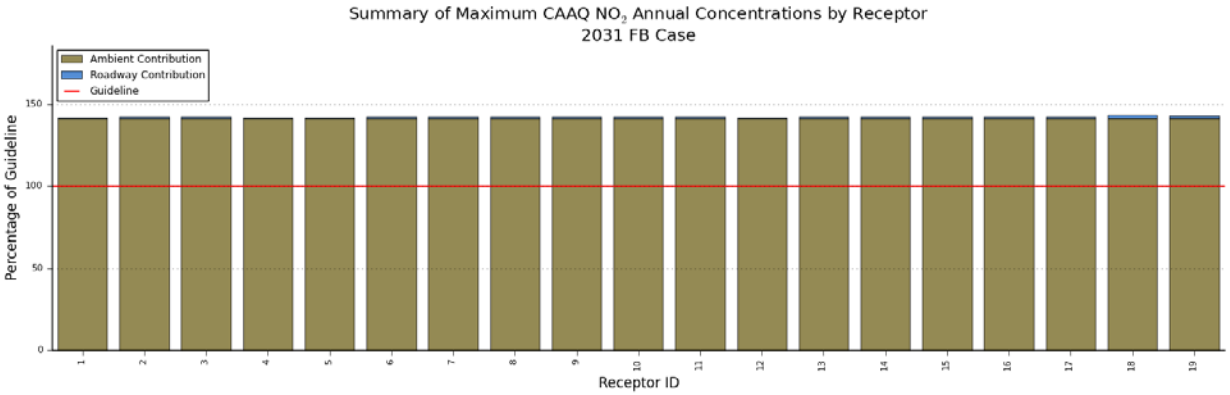

Summary of Maximum Benzene Annual Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

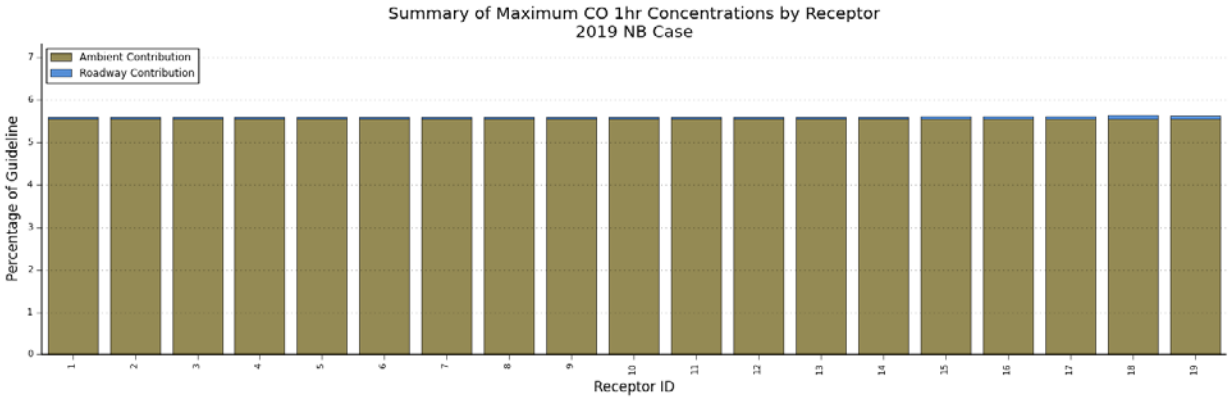

Summary of Maximum CAAQ NO_2 1hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

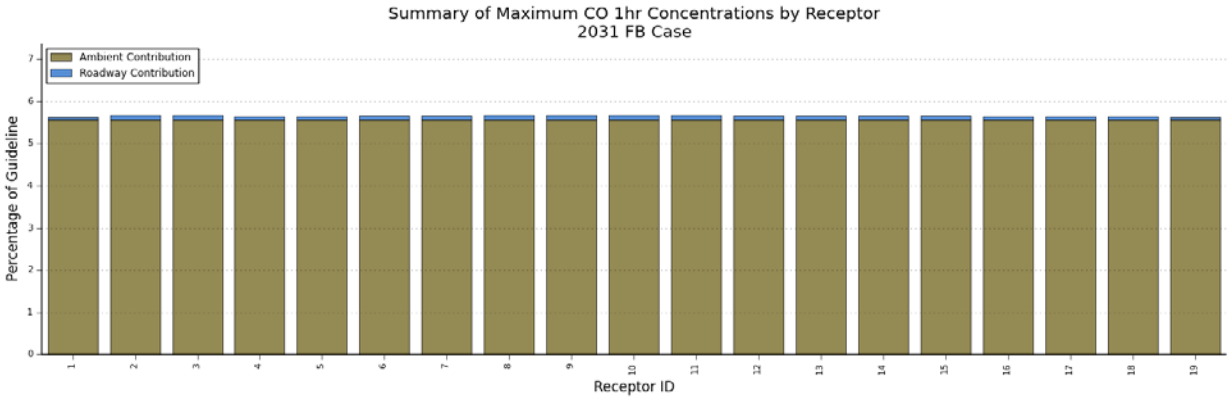

Summary of Maximum CAAQ NO_2 1hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

APPENDIX A - RESULTS FOR EACH RECEPTOR






Summary of Maximum CO 1hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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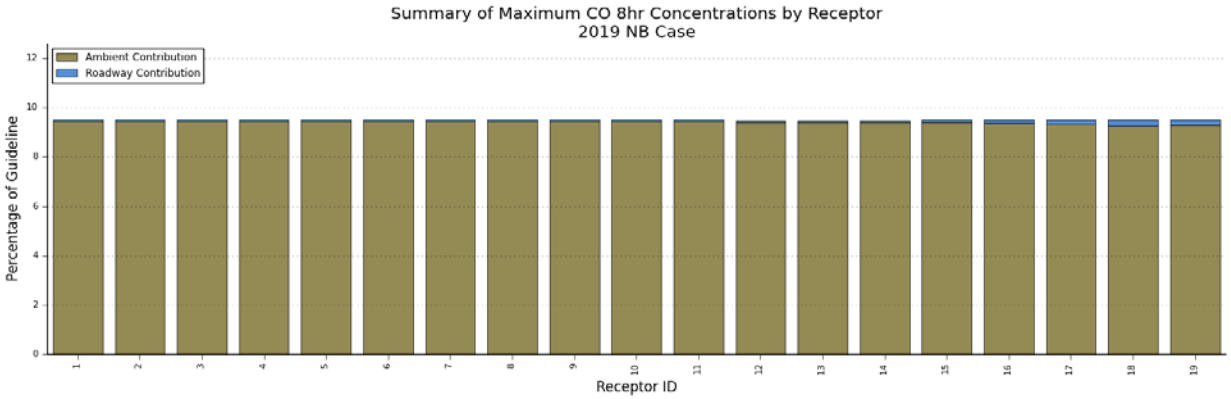
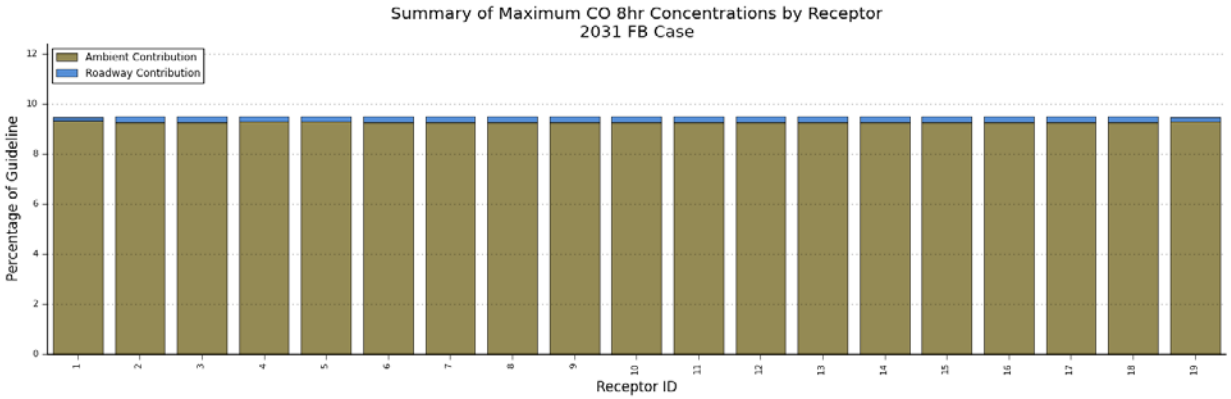
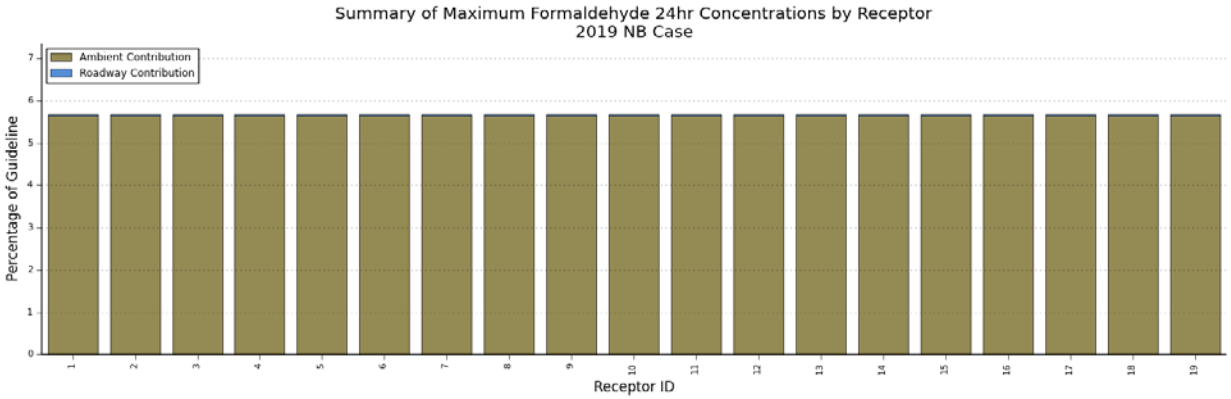
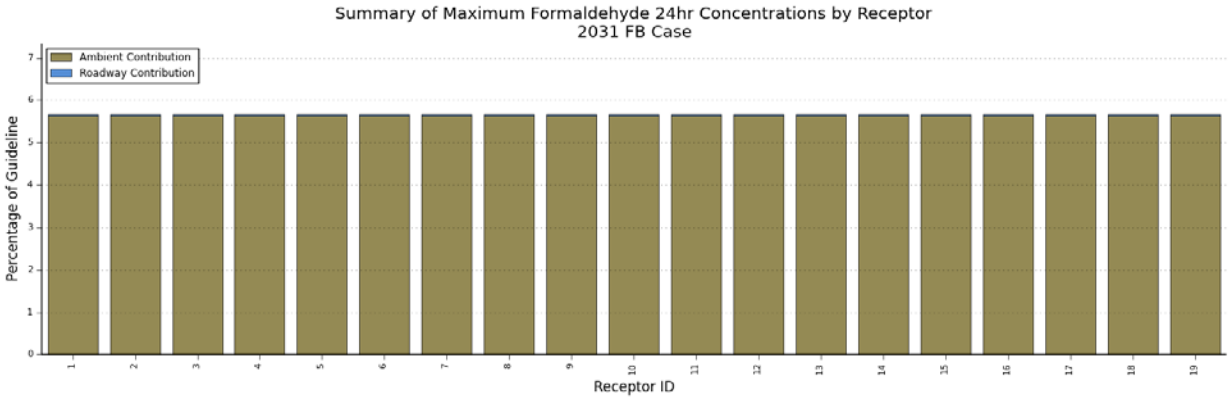
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

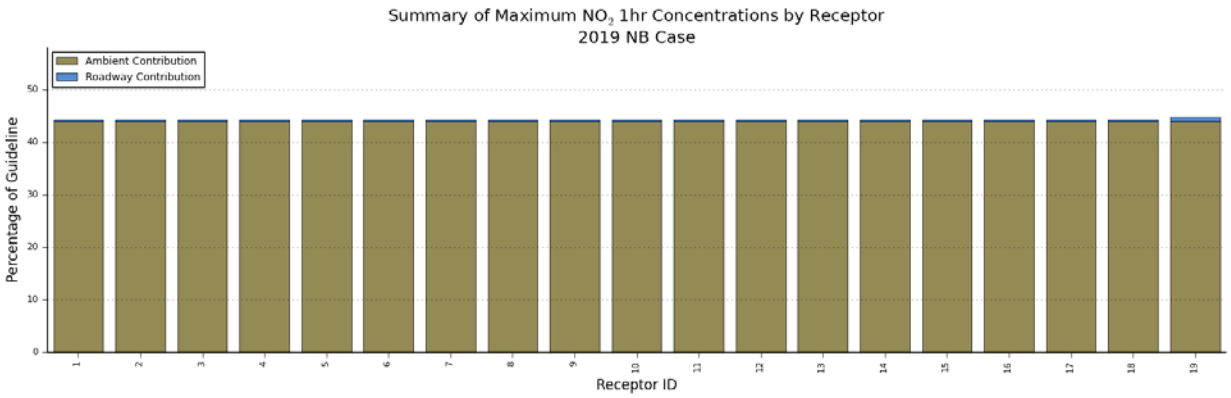

Summary of Maximum CO 8hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

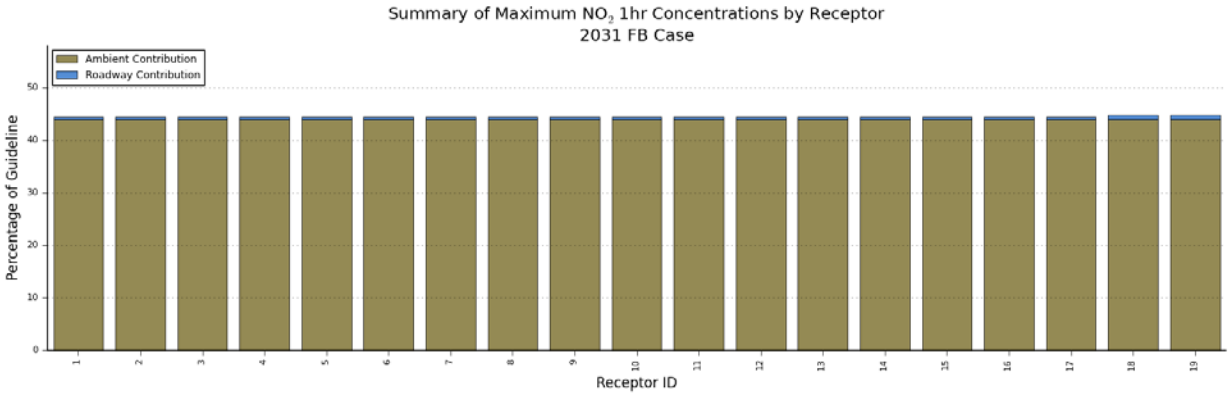

Summary of Maximum CO 8hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

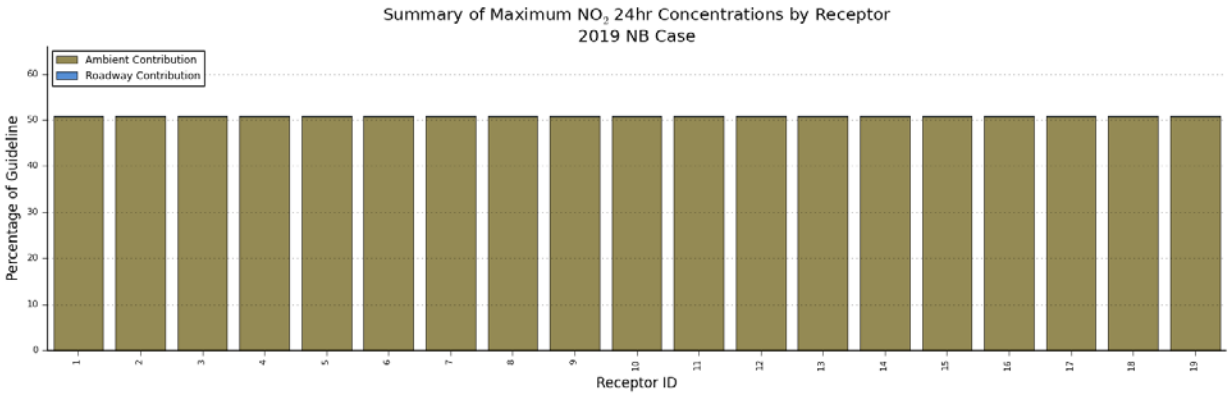
APPENDIX A - RESULTS FOR EACH RECEPTOR

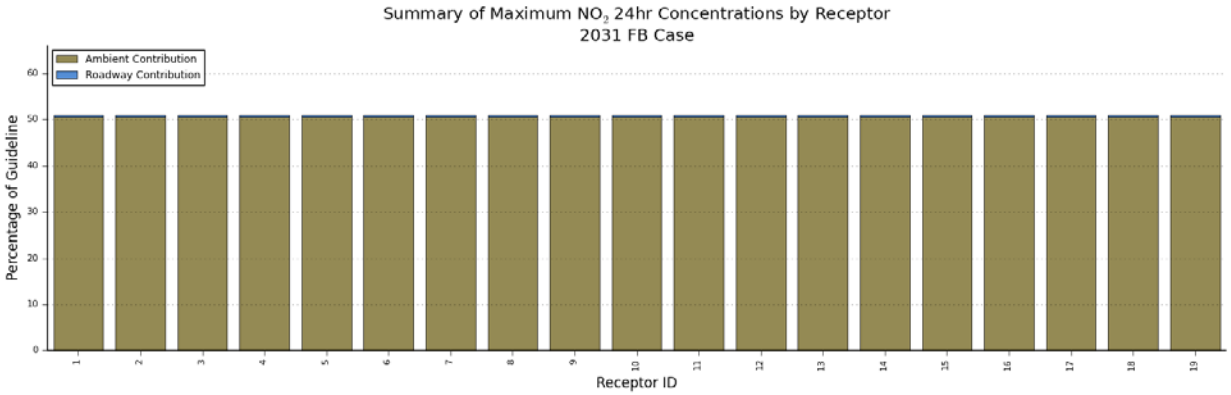


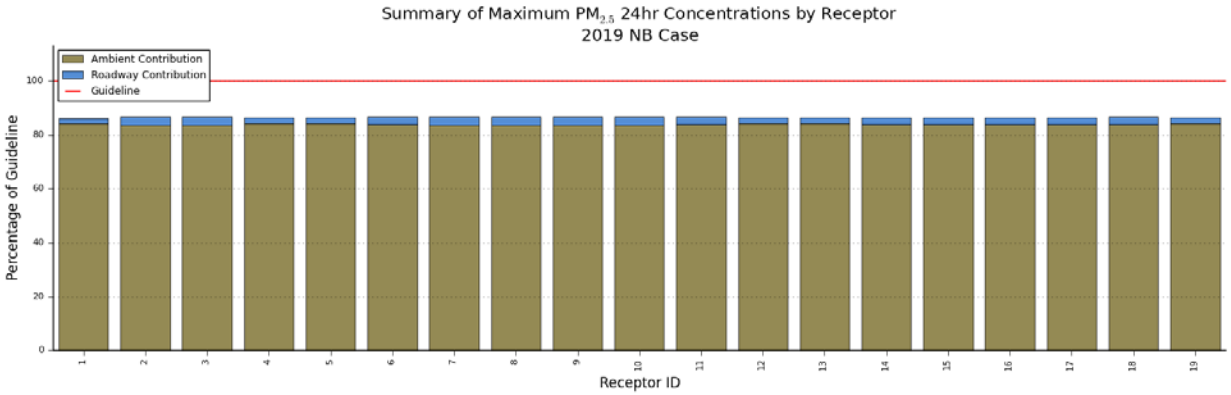


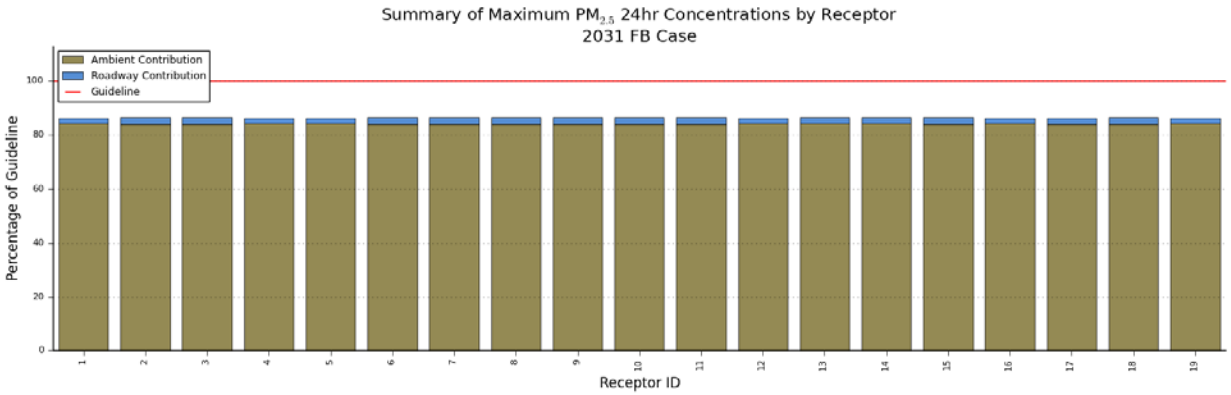

Summary of Maximum NO2 1hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO2 1hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

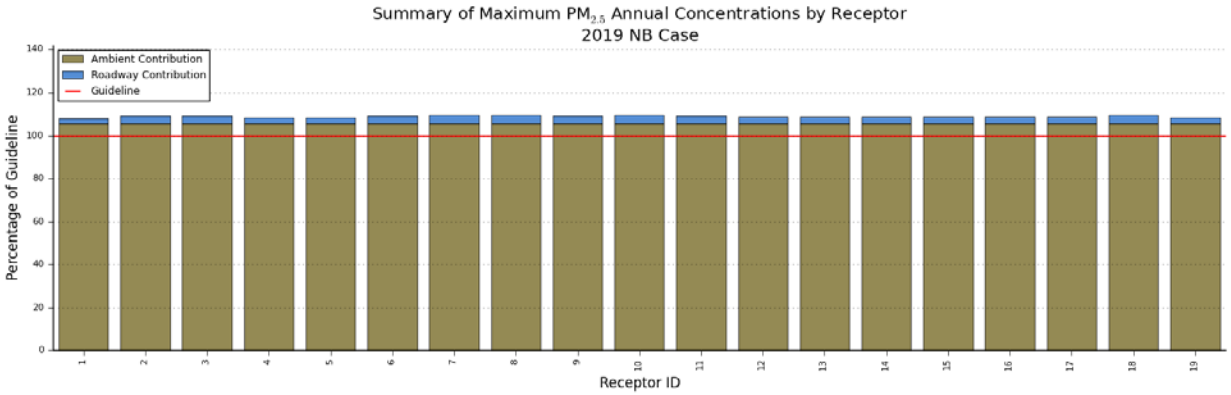

Summary of Maximum NO2 24hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

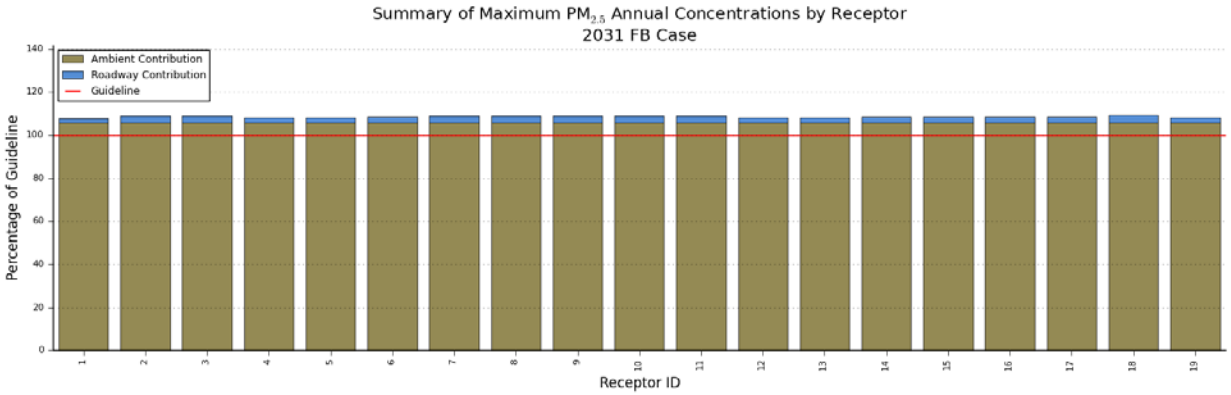

Summary of Maximum NO2 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum PM2.5 24hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

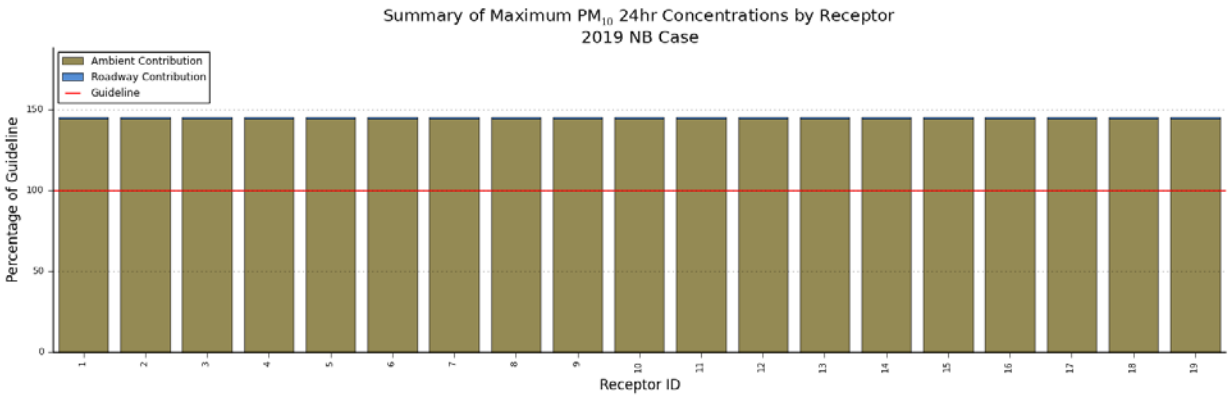

Summary of Maximum PM2.5 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

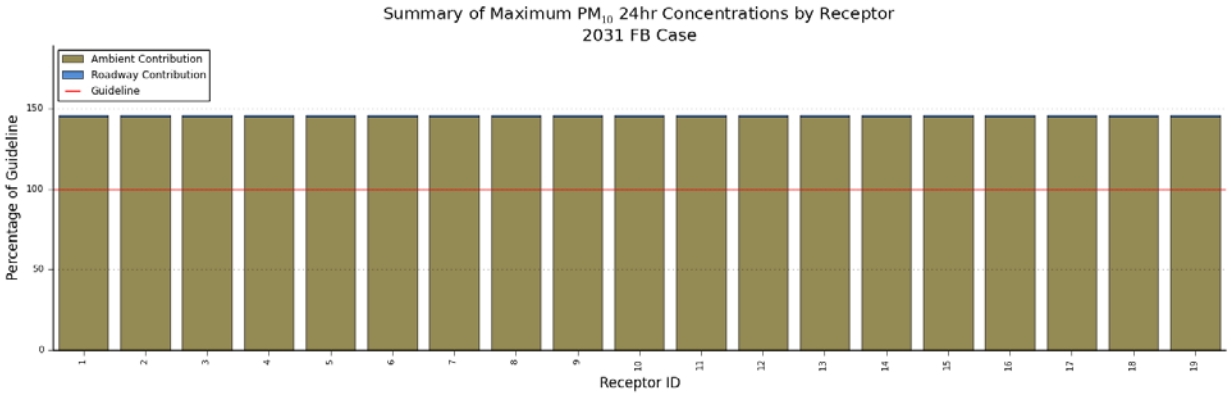
APPENDIX A - RESULTS FOR EACH RECEPTOR

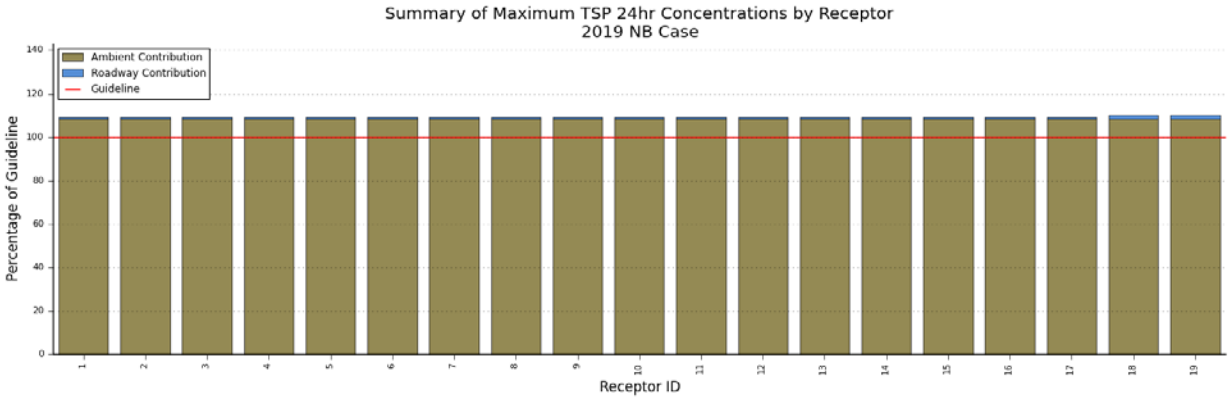


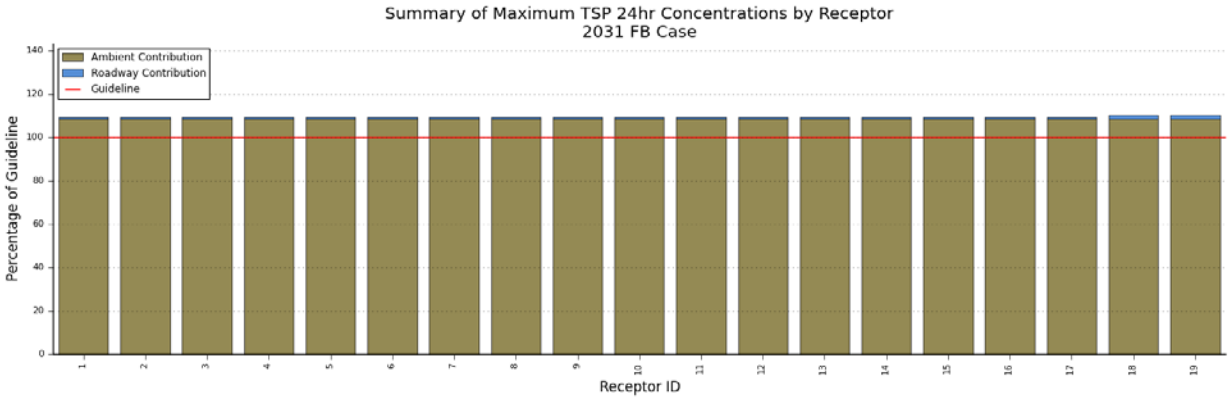


APPENDIX A - RESULTS FOR EACH RECEPTOR






Summary of Maximum TSP 24hr Concentrations by Receptor
2019 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum TSP 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID