Air Quality Assessment
Ninth Line Class EA

City of Mississauga

SLR Project No: 241.20066.00000

April 2021

Air Quality Assessment – Ninth Line
From Derry Road to Eglington Avenue
SLR Project No: 241.20066.00000

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April 2021

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TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Study Objectives 1
1.2 Contaminants of Interest 1
1.3 Applicable Guidelines 2
1.4 General Assessment Methodology 3

2. BACKGROUND AMBIENT DATA 4

2.1 Overview 4
2.2 Selection of Relevant Ambient Monitoring Stations 5
2.3 Detailed Analysis of Selected Worst-case Monitoring Stations 7

3. LOCAL AIR QUALITY ASSESSMENT 9

3.1 Location of Sensitive Receptors within the Modelled Area 9
3.2 Road Traffic Data 11
3.3 Mereological Data 14
3.4 Motor Vehicle Emission Rates 14
3.5 Re-suspended Particulate Matter Emission Rates 16
3.6 Air Dispersion Modelling Using CAL3QHCR 17
3.7 Modelling Results 17

3.7.1 Nitrogen Dioxide CAAQs 19
3.7.2 Nitrogen Dioxide 20
3.7.3 Carbon Monoxide 21
3.7.4 Fine Particulate Matter ($PM_{2.5}$) 22
3.7.5 Coarse Particulate Matter (PM_{10}) 23
3.7.6 Total Suspended Particulate Matter (TSP) 24
3.7.7 Acetaldehyde 25
3.7.8 Acrolein 26
3.7.9 Benzene 27
3.7.10 1,3-Butadiene 28
3.7.11 Formaldehyde 29

4. GREENHOUSE GAS ASSESSMENT 30

5. AIR QUALITY IMPACTS DURING CONSTRUCTION 32

6. CONCLUSIONS 33

7. REFERENCES 35

TABLES

Table 1: Contaminant of Interest 1

Table 2: Applicable Contaminant Guidelines 2

Table 3: Relevant MECP and NAPS Station Information 6

Table 4: Selection of Background Monitoring Stations 7

Table 5: Traffic Volumes (AADT – Vehicles/Day) Used in the Assessment 12

Table 6: Traffic Volumes (AADT – Vehicles/Day) Used in the Assessment 12

Table 7: Hourly Vehicle Distribution Used in the Assessment 13

Table 8: MOVES Input Parameters 15

Table 9: MOVES Output Emission Factors for Roadway Vehicles (g/VMT); Idle Emission Rates are grams per vehicle hour 16

Table 10: Re-suspended Particulate Matter Emission Factors 16

Table 11: CAL3QHCR Model Input Parameters 17

Table 12: Worst-Case Sensitive Receptors for 2041 Future Build Scenario 18

Table 13: Summary of Predicted NO_2 Concentrations 19

Table 14: Summary of Predicted NO_2 Concentrations 20

Table 15: Summary of Predicted CO Concentrations 21

Table 16: Summary of Predicted $PM_{2.5}$ Concentrations 22

Table 17: Summary of Predicted PM_{10} Concentrations 23

Table 18: Summary of Predicted TSP Concentrations 24

Table 19: Summary of Predicted Acetaldehyde Concentrations 25

Table 20: Summary of Predicted Acrolein Concentrations 26

Table 21: Summary of Predicted Benzene Concentrations 27

Table 22: Summary of Predicted 1,3-Butadiene Concentrations 28

Table 23: Summary of Predicted Formaldehyde Concentrations 29

Table 24: Summary of Ninth Line Traffic Volumes, Roadway Length and Emission Rates 30

Table 25: Changes in predicted GHG Emissions 31

Table 26: Predicted Future Build GHG Emissions compared to GHG targets 31

Table 27: Worst-Case Summary of Predicted Combined Contaminant Concentrations for the 2041 Future Build 34

CONTENTS (CONTINUED)

FIGURES

Figure 1: Study Area and Modelled Hotspot 1
Figure 2: Motor Vehicle Emission Sources 1
Figure 3: Effect of Trans-Boundary Air Pollution (MECP, 2005) 4
Figure 4: Typical Wind Direction during an Ontario Smog Episode 5
Figure 5: Location of Ambient Monitoring Stations, Relevant to the Study Area 6
Figure 6: Worst-Case Summary of Ambient Background Concentrations 8
Figure 7: Sensitive Receptor Locations Within Modelled Hotspot Area 10
Figure 8: Wind Frequency Diagram for Pearson International Airport (2013-2017) 14

APPENDICES

Appendix A Results for Each Receptor

1. 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 Ninth Line between Derry Road and Eglinton Avenue, a length of approximately 6.2 kilometres within Mississauga, Ontario. The project involves the widening of Ninth Line 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 Ninth Line widening from Derry Road to Eglinton Avenue. 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:

- 2018 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.
- 2041 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 alternatives 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 Ninth Line with Britannia Road was selected to be assessed for air quality impacts. This intersection was identified to have one of the highest future 2041 intersection volumes. The segment also has high concentrations of critical receptors and sensitive receptors in the form of parks and low-rise residential units respectively along Ninth Line. This section of the roadway was determined to be representative of worst-case impacts for the air quality study. The hot-spot approach and selected hot-spot was reviewed and accepted by the City of Mississauga prior to conducting the air quality study.

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

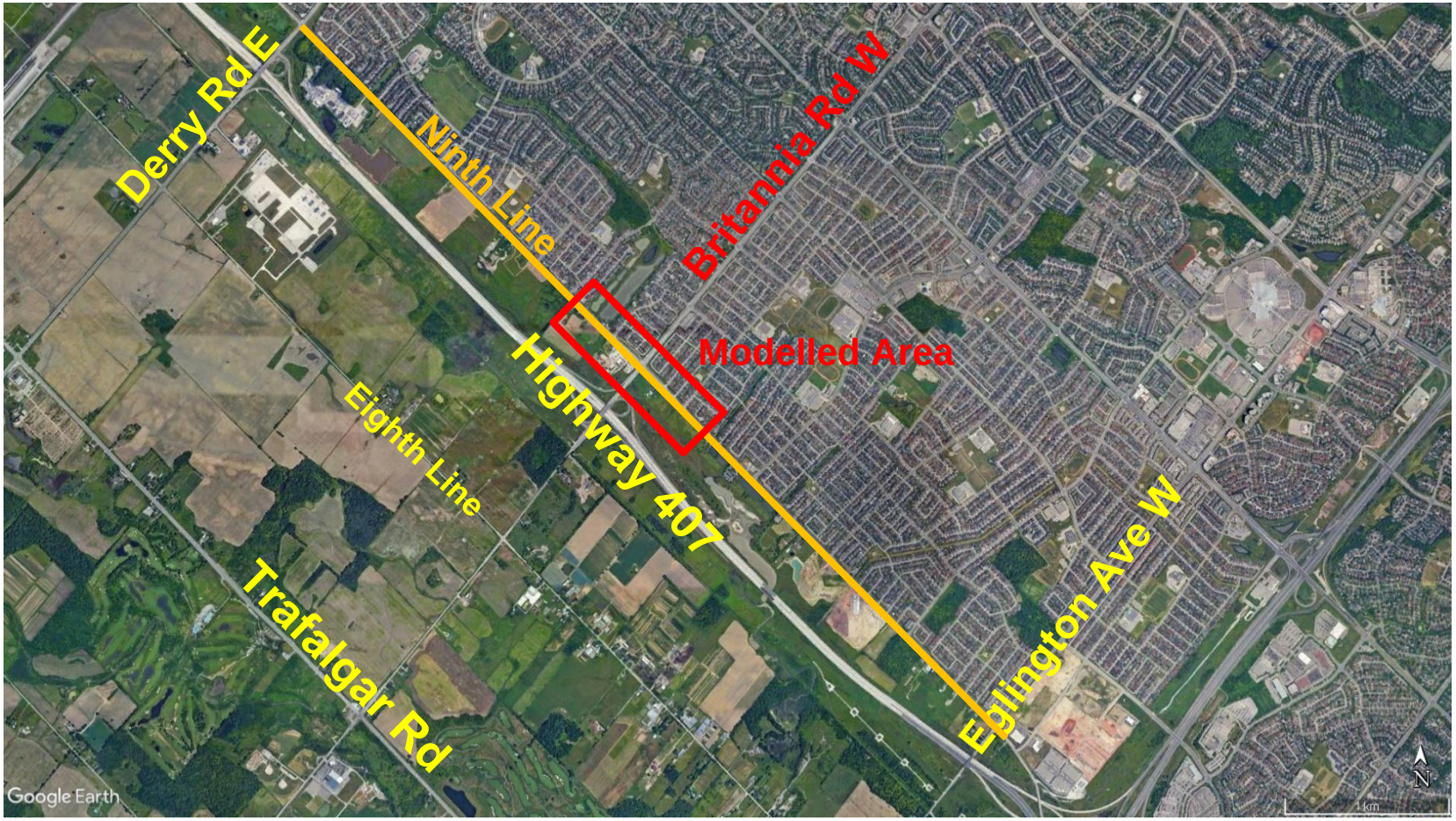


Figure 1: Study Area and Modelled Hotspot

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.

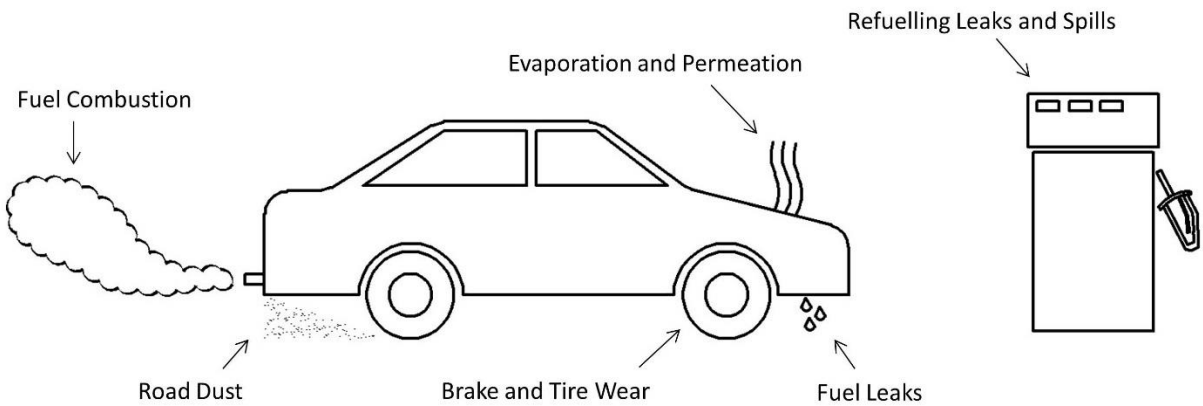


Figure 2: Motor Vehicle Emission Sources

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); and
- 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/m^3)	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 (to be phased-in in 2020)
	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

Contaminant	Averaging Period (hrs)	Threshold Value (µg/m^3)	Source
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. 2013-2017 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: 2018 No Build and 2041 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. 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.**

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

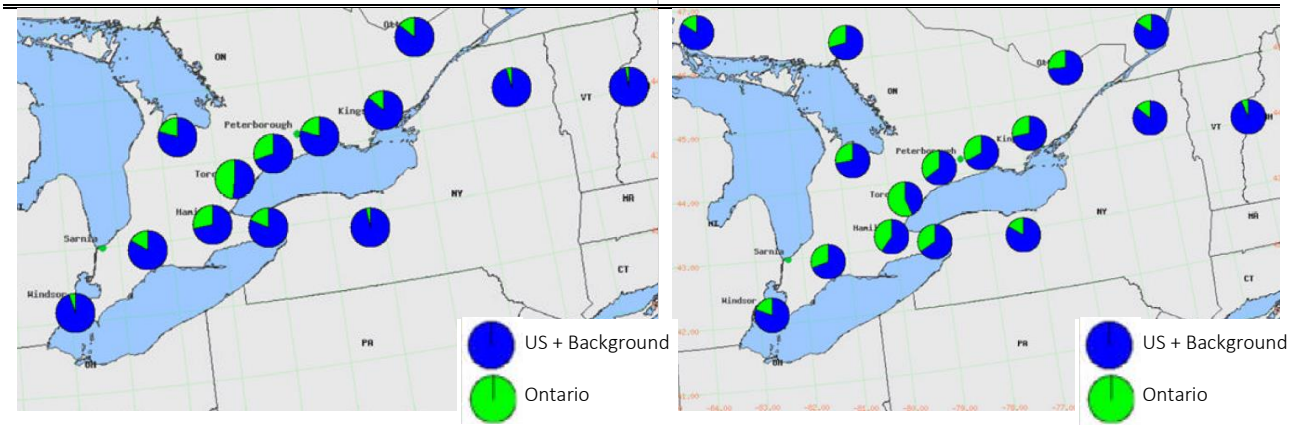


Figure 3: Effect of Trans-Boundary Air Pollution (MECP, 2005)

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.

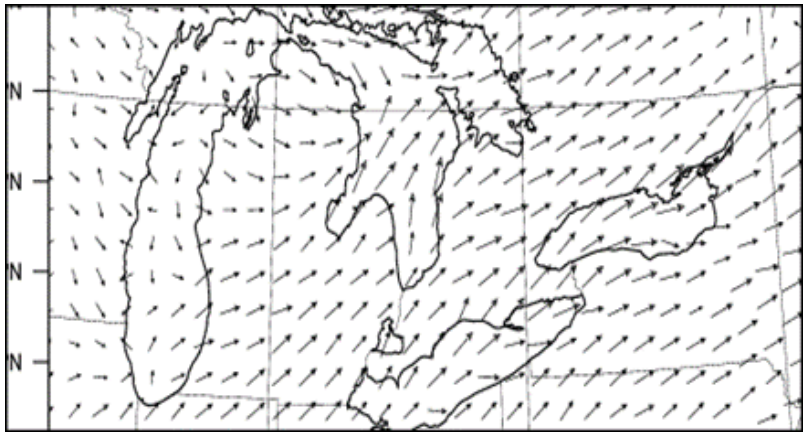


Figure 4: Typical Wind Direction during an Ontario Smog Episode

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. The closest MECP station is located 8.3km east of the site at University of Toronto Mississauga Campus, second closest being Oakville at 9km away. The closest NAPS (Etobicoke West) station is located within 17km of the site; therefore these monitoring stations and several others were used to summarize background concentrations in the modelled area. Note that 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.

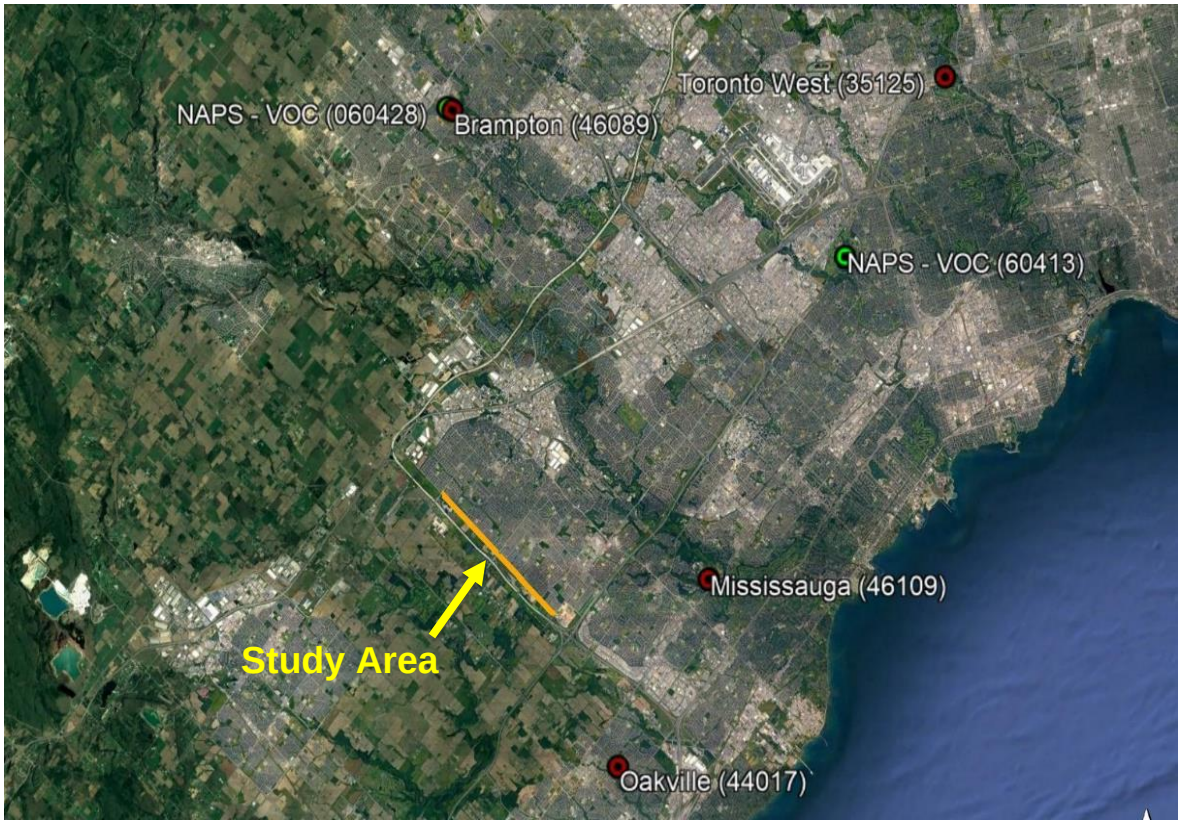


Figure 5: Location of Ambient Monitoring Stations, Relevant to the Study Area

Table 3: Relevant MECP and NAPS Station Information

City/Town	Station ID	Location	Operator	Contaminant
Mississauga	46109	3359 Mississauga Rd. N., U of T Campus.	MECP	NO_2|$PM_{2.5}$
Oakville	44017	Eighth Line/Glenashton Dr. Halton Res.	MECP	NO_2|$PM_{2.5}$
Brampton	46089	525 Main St. N., Peel Manor	MECP	NO_2|$PM_{2.5}$
Toronto West	35125	125 Resources Rd	MECP	CO
Etobicoke West	60413	Elmcrest Road	NAPS	1,3-Butadiene|Benzene
Brampton	60428	525 Main St. N., Peel Manor	NAPS	1,3-Butadiene|Benzene
Windsor West	60211	College St/Prince St	NAPS	Formaldehyde |Acetaldehyde | Acrolein

2.3 DETAILED ANALYSIS OF SELECTED WORST-CASE MONITORING STATIONS

Year 2013 to 2017 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.

Table 4: Selection of Background Monitoring Stations

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

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 2013-2017, background concentrations were generally below their respective guidelines. The exceptions are particulate matter and benzene, as well as the 1-hour 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 $PM_{2.5}$.

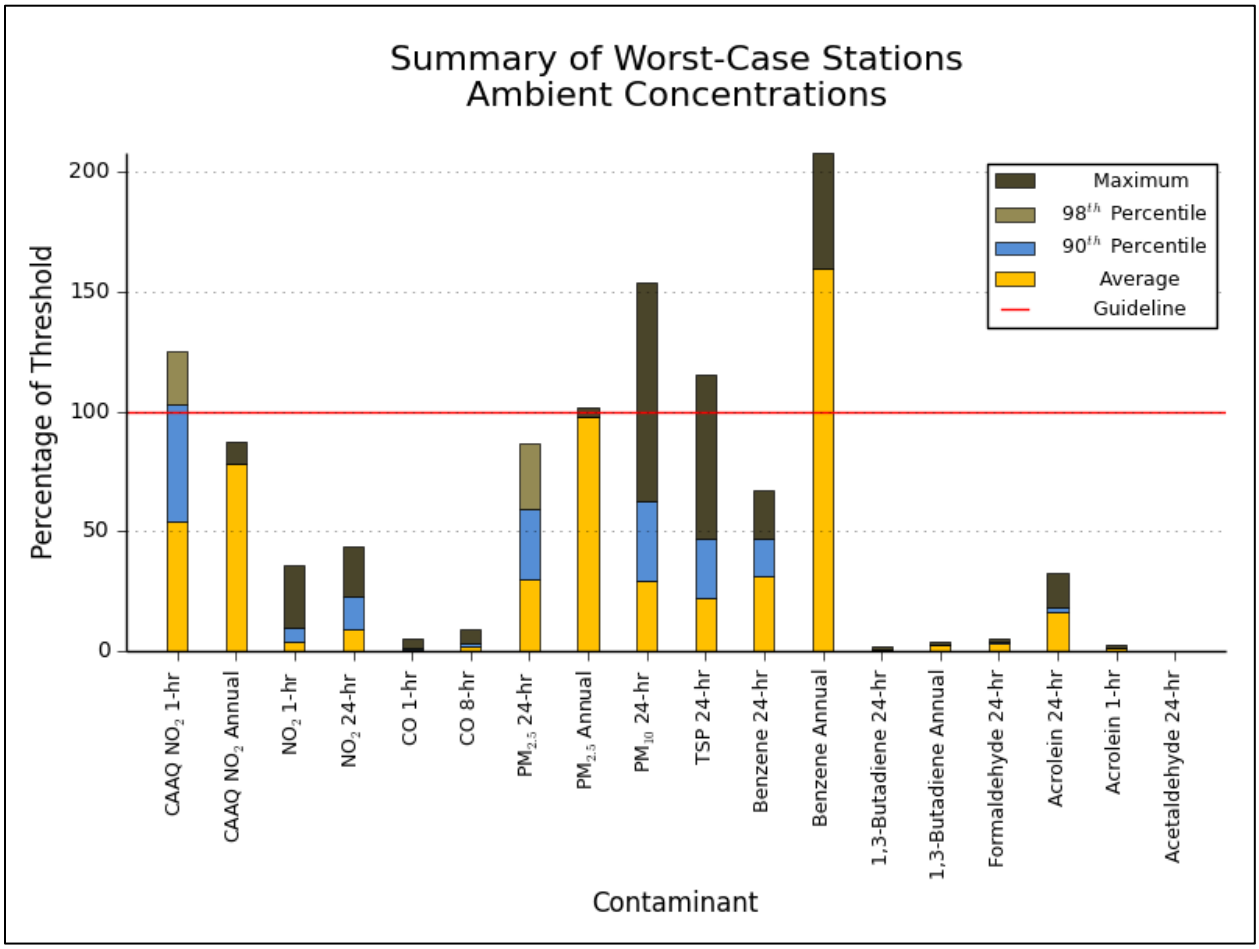


Figure 6: Worst-Case Summary of Ambient Background Concentrations

3. 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; and
- Residential dwellings.

Seven sensitive receptor locations were selected to be representative of potential impacts within the modelled area. They are all residential houses with the closest proximity to Ninth Line, and thus the most likely impacted by the lane expansion. The receptors are distributed between the residences east and west of Ninth Line 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 2018 No Build and 2041 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 Ninth Line and Britannia respectively.

Lastly, a heavy duty vehicle percentage was also provided by HDR for Ninth Line and arterial roads as shown in Table 5 and Table 6. Hourly traffic volumes for Ninth Line were provided. Hourly traffic volumes were not available for arterial road, 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 Ninth Line (Northbound and Southbound)					
Location	2018 No Build AADT	2041 Future Build AADT	% Trucks[1]	% Medium Trucks Split[2]	% Heavy Truck Splits[2]
Between Derry Rd E and Britannia Rd	14,900	29,300	1.75%	72%	28%
Between Britannia Rd and Freeman Terrance	18,400	39,800	1.05%	79%	21%

Note: [1] - Future truck % assumed to be same as No Build scenario
[2] - % Truck split from total truck volumes

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

Britannia Road (Eastbound and Westbound)							
Location	2018 No Build AADT West of Ninth Line	2018 No Build AADT East of Ninth Line	2041 Future Build AADT West of Ninth Line	2041 Future Build AADT East of Ninth Line	% Trucks[1]	% Medium Trucks Split[2]	% Heavy Truck Splits[2]
Britannia Rd	20,700	18,500	36,300	25,500	0.9%	76%	24%

Note: [1] - Future truck % assumed to be same as No Build scenario
[2] - % Truck split from total truck volumes

Table 7: Hourly Vehicle Distribution Used in the Assessment

Hour	Along Ninth Line	US EPA Weekday	US EPA Weekend
1	0.5%	1.0%	1.8%
2	0.3%	0.7%	1.1%
3	0.2%	0.6%	0.9%
4	0.4%	0.7%	0.8%
5	1.2%	0.9%	0.8%
6	3.2%	2.0%	1.0%
7	6.5%	4.1%	1.9%
8	7.6%	5.8%	2.7%
9	5.2%	5.4%	3.9%
10	4.4%	5.3%	5.2%
11	4.5%	5.5%	6.3%
12	4.9%	5.8%	7.0%
13	5.3%	5.9%	7.2%
14	5.5%	6.0%	7.2%
15	6.5%	6.6%	7.3%
16	7.9%	7.2%	7.4%
17	8.2%	7.8%	7.3%
18	6.8%	7.6%	7.0%
19	5.9%	5.9%	6.1%
20	5.3%	4.3%	5.1%
21	4.0%	3.6%	4.1%
22	2.8%	3.1%	3.3%
23	1.8%	2.4%	2.6%
24	1.2%	1.8%	2.0%

3.3 MEREOLOGICAL DATA

2013-2017 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**.

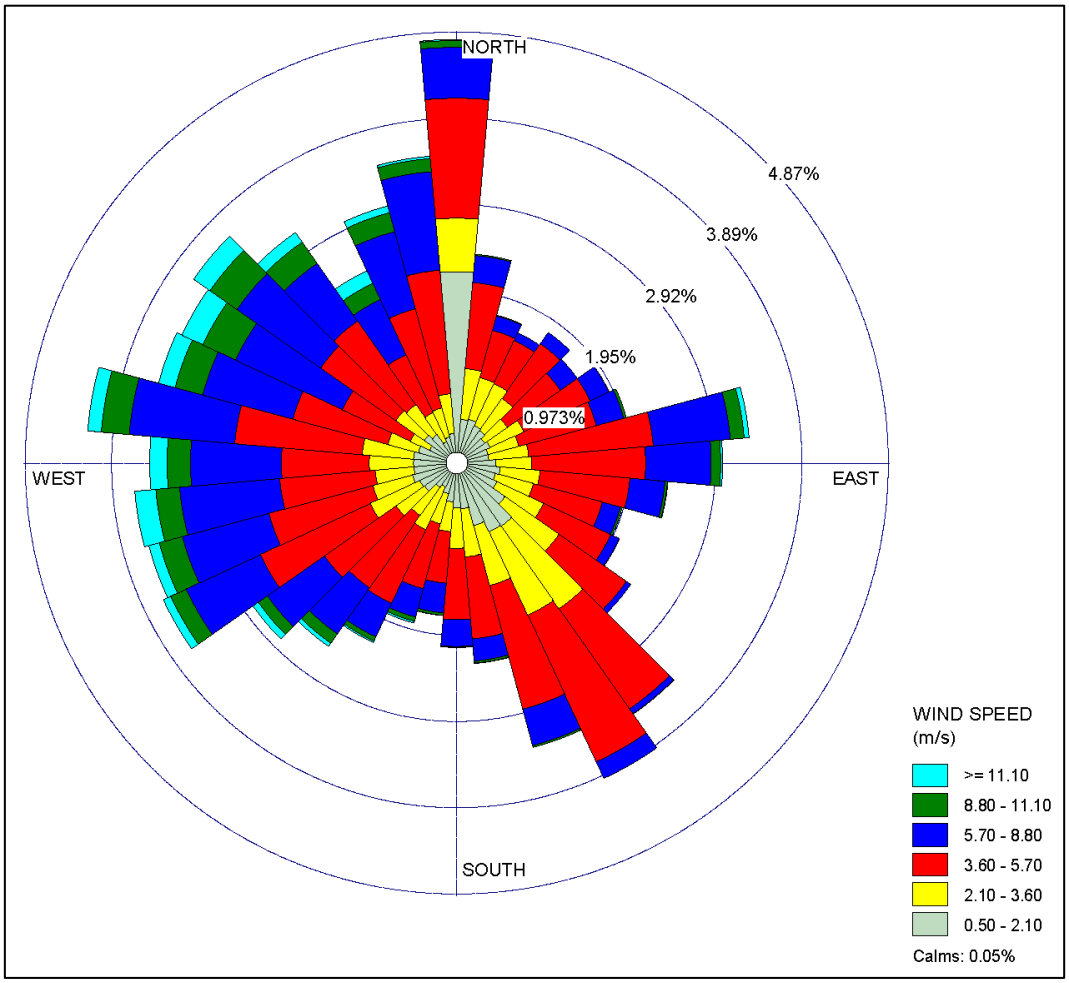


Figure 8: Wind Frequency Diagram for Pearson International Airport (2013-2017)

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 0.8 and 0.22%, 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 TORONTO INTL A station for the years 2013 to 2017.
Years	2018 (No Build) and 2041 (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 Principal Arterial
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

Year	Speed (Km/hr)	CO	NO_X	Benzene	1,3-Butadiene	Formald-ehyde	Acetalde-hyde	Acrolein	$PM_{2.5}$	PM_{10}	TSP[1]
2018	60	2.82	0.22	2.17E-03	1.29E-04	9.88E-04	5.61E-04	5.45E-05	4.91E-02	1.22E-02	1.22E-02
2018	70	2.49	0.22	1.92E-03	1.12E-04	8.68E-04	4.91E-04	4.78E-05	3.24E-02	9.98E-03	9.98E-03
2018	Idle	10.07	1.07	3.44E-02	3.47E-03	1.97E-02	1.26E-02	1.15E-03	1.10E-01	9.88E-02	9.88E-02
2041	60	0.87	0.04	7.80E-04	4.89E-07	3.40E-04	1.39E-04	1.69E-05	4.50E-02	8.07E-03	8.07E-03
2041	70	0.83	0.04	7.13E-04	4.16E-07	3.05E-04	1.25E-04	1.52E-05	2.79E-02	5.93E-03	5.93E-03
2041	Idle	2.08	0.20	9.70E-03	1.00E-05	5.04E-03	1.94E-03	2.45E-04	3.11E-02	2.77E-02	2.77E-02

[1] – Note that 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	2013-2017 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
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 2018 No Build and 2041 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 2041 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 2041 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
CAAQ NO_2	1-hour	5
	Annual	3
NO_2	1-hour	4
	24-hour	4
CO	1-hour	3
	8-hour	3
$PM_{2.5}$	24-hour	3
	Annual	3
PM_{10}	24-hour	2
TSP	24-hour	2
1,3-Butadiene	24-hour	1
	Annual	1
Formaldehyde	24-hour	4
Benzene	24-hour	2
	Annual	3
Acrolein	1-hour	3
	24-hour	2
Acetaldehyde	24-hour	3

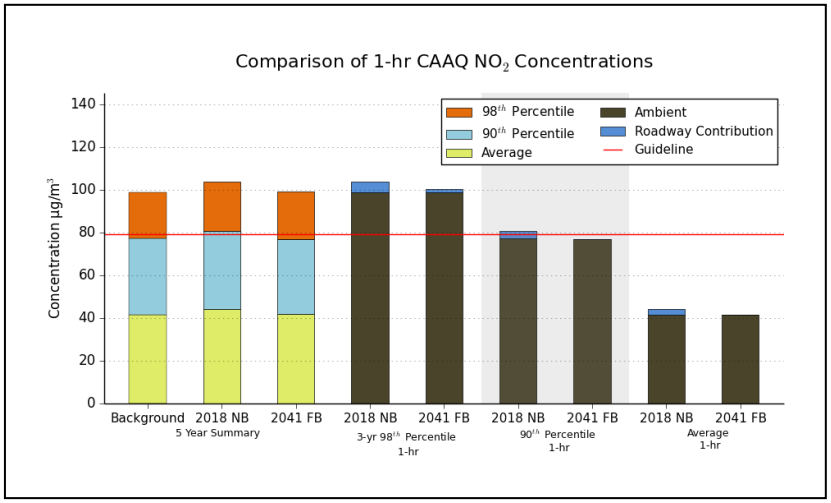
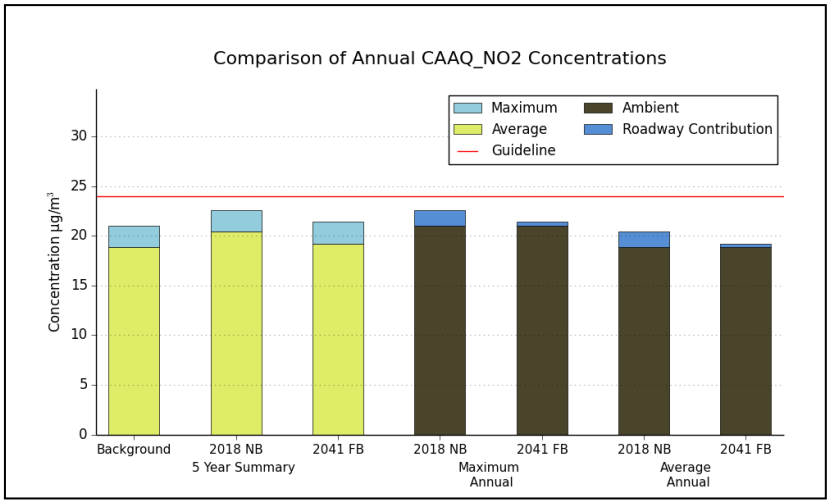
Coincidental hourly modelled roadway and background concentrations were added to derive the combined concentration for each hour over the 5-year period. Hourly combined concentrations were then used to determine contaminant concentrations based on the applicable averaging period. Statistical analysis 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 3% contribution from the roadway.*
- *The annual average concentration is within the guideline with a 2% contribution from the roadway.*

Table 13: Summary of Predicted NO_2 Concentrations

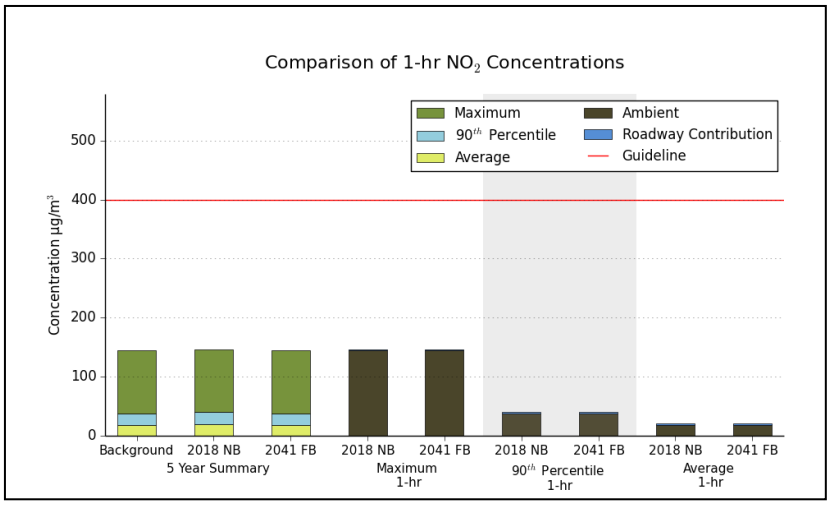
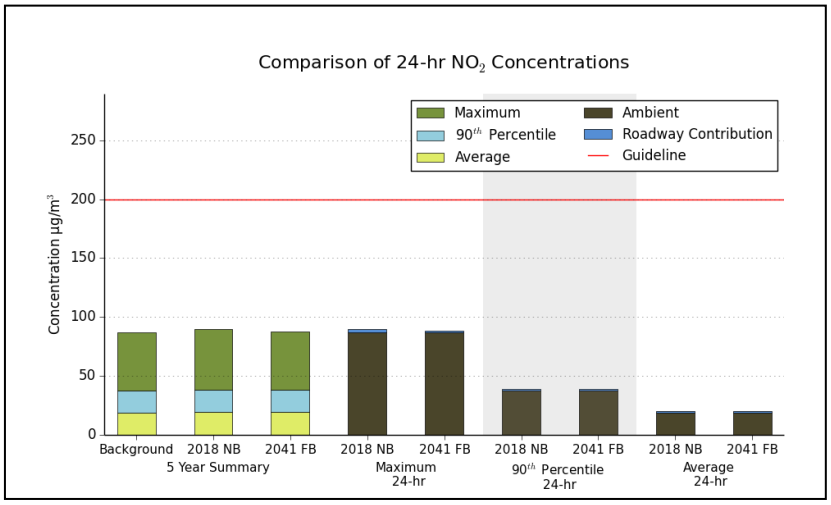
Statistical Analysis	2041 FB	
	**% of CAAQS Guideline:**	
	98th Percentile	125%
	90th Percentile	98%
	Average	53%
	Roadway Contribution:	
	98th Percentile	3%
	90th Percentile	1%
	Average	1%
	Maximum combined concentrations exceed the 1-hour CAAQ Guideline. Note that the maximum background concentrations alone exceed the CAAQ's 1-hr objective 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	89%
	Average	80%
	Roadway Contribution:	
	Maximum	1%
	Average	2%
	Maximum combined concentrations fall within the annual CAAQ Guideline of 24 µg/m³.	

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	2041 FB	
	**% of MECP Guideline:**	
	Maximum	36%
	90th Percentile	9%
	Average	4%
	Roadway Contribution:	
	Maximum	<1%
	90th Percentile	1%
	Average	1%
	**% of MECP Guideline:**	
	Maximum	44%
	90th Percentile	19%
	Average	10%
	Roadway Contribution:	
	Maximum	1%
	90th Percentile	1%
	Average	1%

Conclusions:

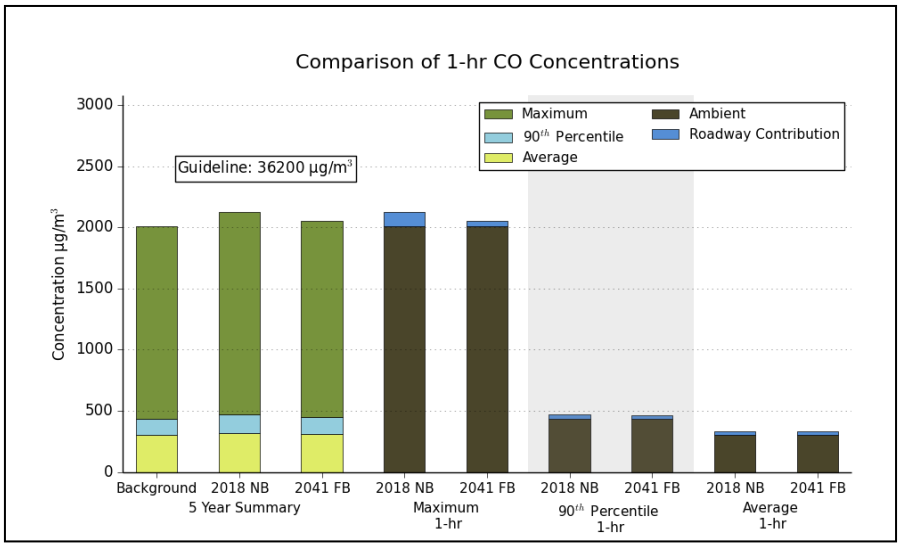
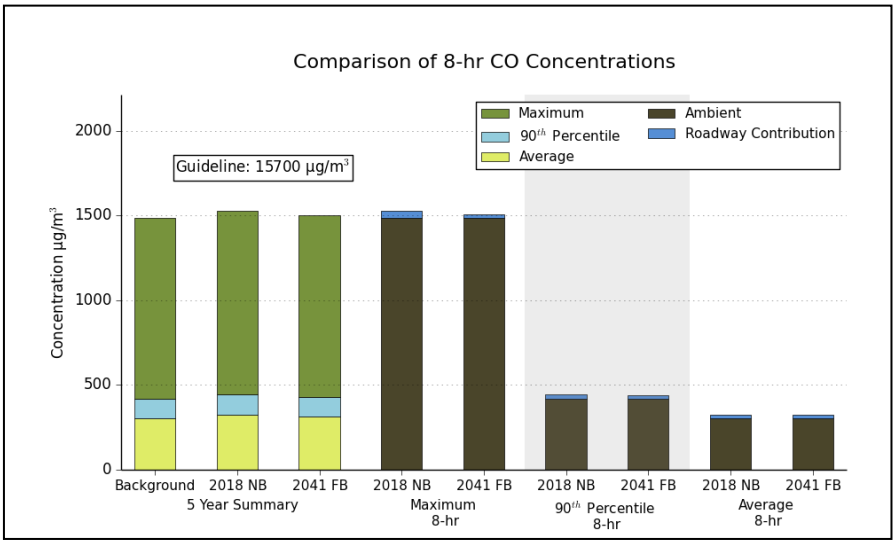
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 1% or less.

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	2041 FB	
	**% of MECP Guideline:**	
	Maximum	6%
	90th Percentile	1%
	Average	1%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	3%
	Average	3%
	**% of MECP Guideline:**	
	Maximum	10%
	90th Percentile	3%
	Average	2%
	Roadway Contribution:	
	Maximum	3%
	90th Percentile	3%
	Average	3%

Conclusions:

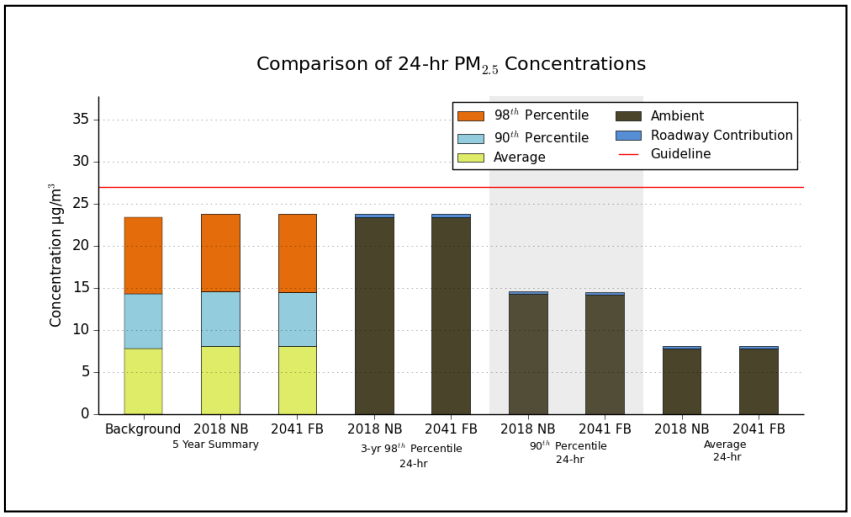
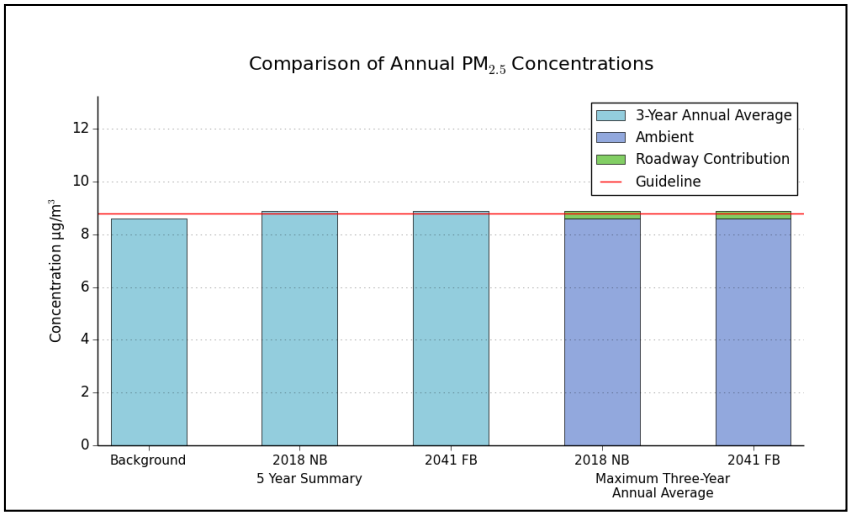
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 3%.

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 4% contribution from the roadway.*

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

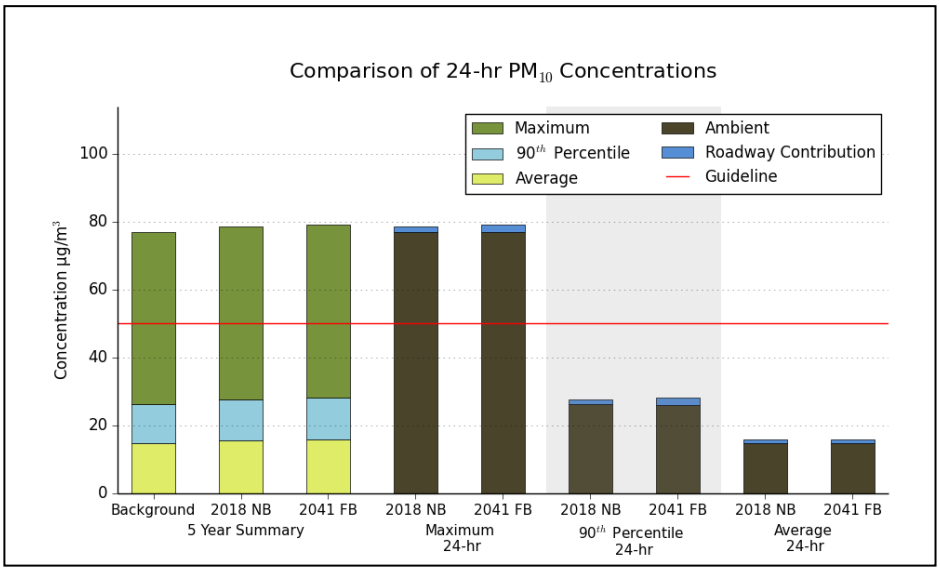
Statistical Analysis	2041 FB	
	**% of CAAQs Guideline:**	
	98th Percentile	88%
	90th Percentile	54%
	Average	30%
	Roadway Contribution:	
	98th Percentile	3%
	90th Percentile	2%
	Average	4%
	The $PM_{2.5}$ results were below the 3-year CAAQS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 23.80 µg/m³ or 88% of the CAAQS.	
	**% of CAAQs Guideline:**	
	Maximum 3-Year Annual Average	101%
	Roadway Contribution:	
	Maximum 3-Year Annual Average	4%
	The $PM_{2.5}$ results were above the 3-year CAAQS. The maximum 3-year annual average concentration was 101% of the guideline. Note that the background concentration alone is at 97% of the CAAQ 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	2041 FB	
	**% of MECP Guideline:**	
	Maximum	158%
	90th Percentile	56%
	Average	32%
	Roadway Contribution:	
	Maximum	3%
	90th Percentile	7%
	Average	10%

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 3% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- A total of 13 days exceeded the guideline in the five-year period for No Build and 14 days for the 2041 Future Build scenario, which equate to less than 1% of the time.

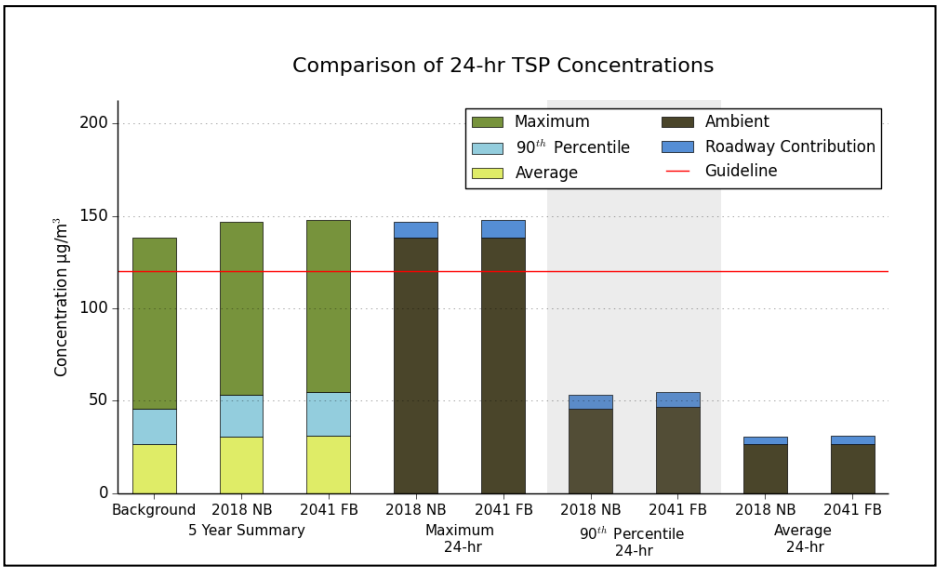
3.7.6 TOTAL SUSPENDED PARTICULATE MATTER (TSP)

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	2041 FB



% of MECP Guideline:	
Maximum	123%
90th Percentile	46%
Average	26%
roadway Contribution:	
Maximum	6%
90th Percentile	15%
Average	16%

Conclusions:

- The TSP results show that the combined concentrations exceed the guideline. It should be noted, however, that background concentrations alone account for 117% of the guideline and that the roadway contribution is 6% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- A total of 4 days 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. Note that there are no additional exceedances between the No Build and Future Build scenarios.

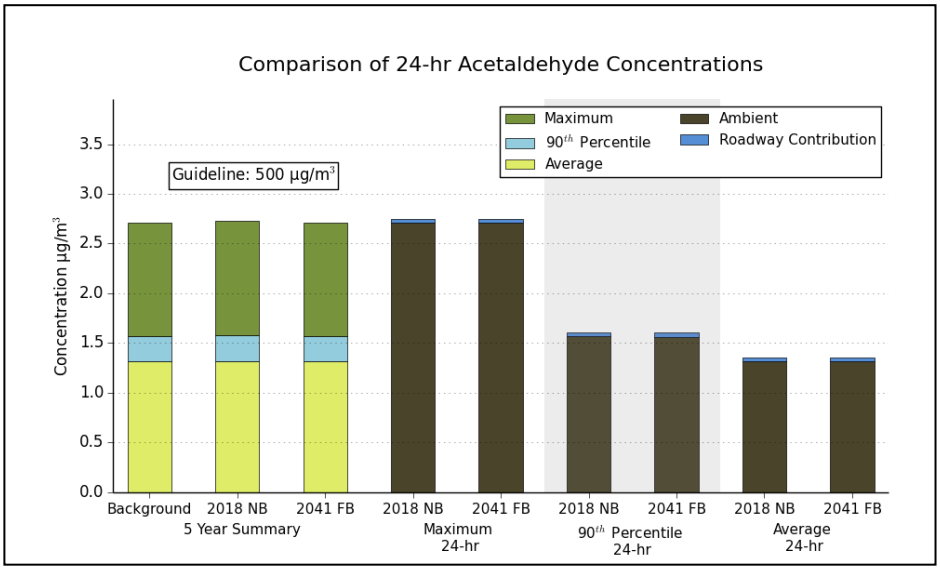
Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to combine the ambient data to the modelled results, the measured concentrations were applied to the following 6 days when measurements were 6 days apart. When measurements were further than 6 days apart, the 90th percentile 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	2041 FB	
	**% of MECP Guideline:**	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Roadway Contribution:	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%

Conclusions:

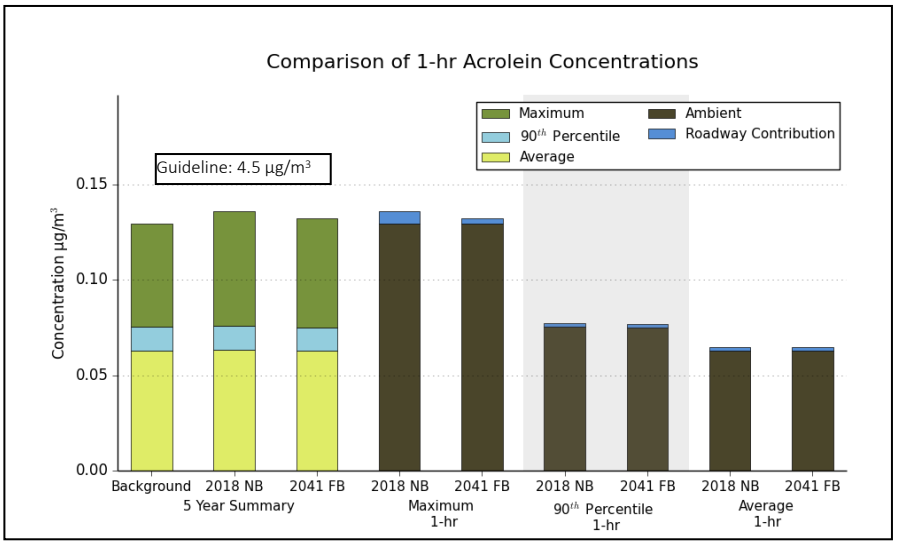
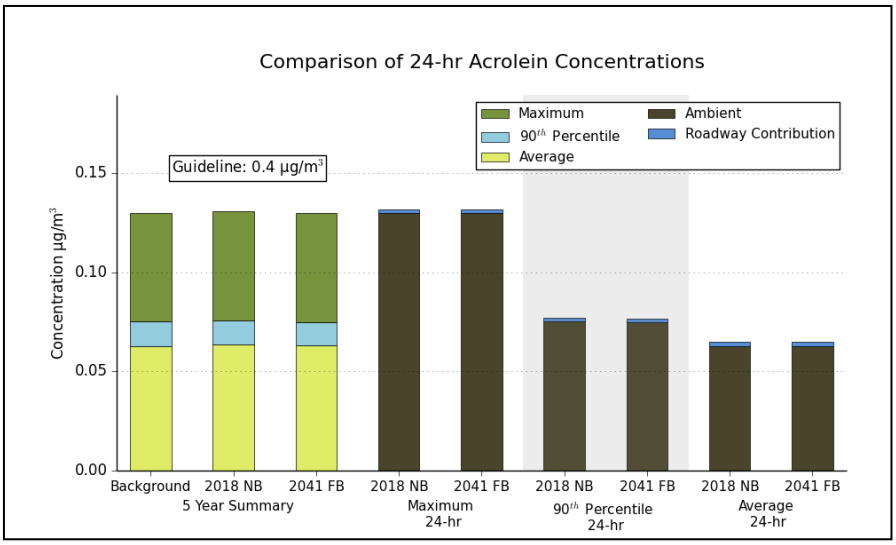
- All combined concentrations were below the respective MECP guideline.
- The contribution from the roadway to the combined concentrations was <1%.

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

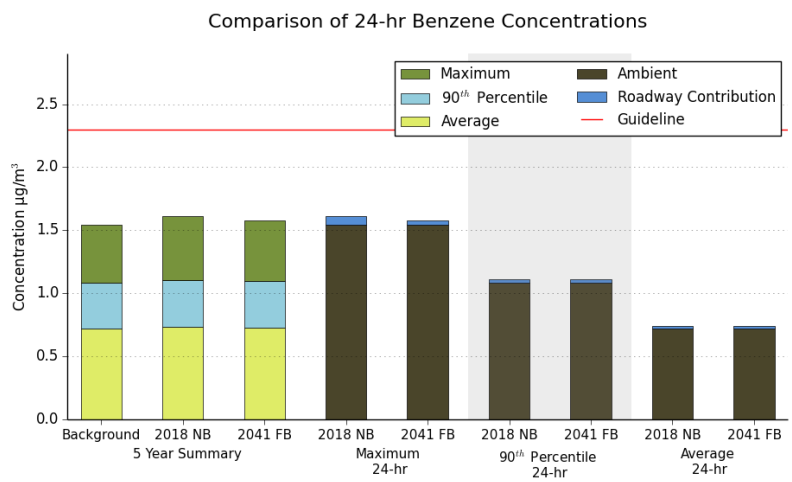
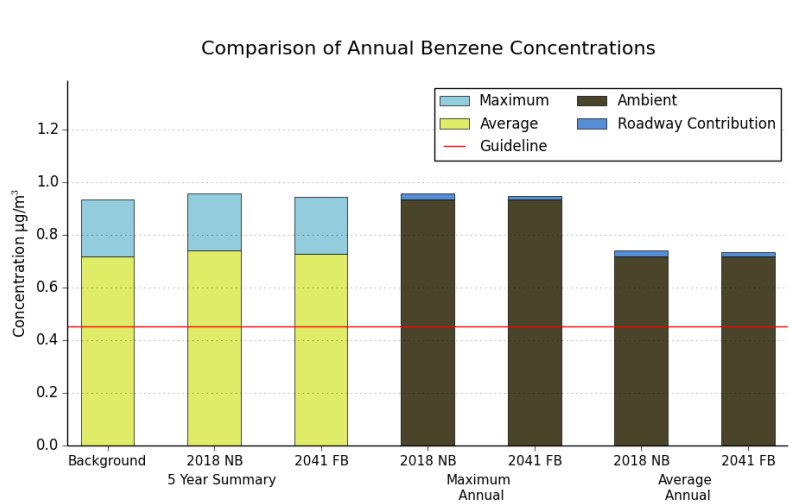
Statistical Analysis	2041 FB	
	**% of MECP Guideline:**	
	Maximum	3%
	90th Percentile	2%
	Average	1%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MECP 1-hr guideline. The contribution from the roadway was 2% or less.	
	**% 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 2%.*
- *The annual benzene concentration exceeded the guidline. The* roadway *contribution to the maximum annual average was 1%.*

Table 21: Summary of Predicted Benzene Concentrations

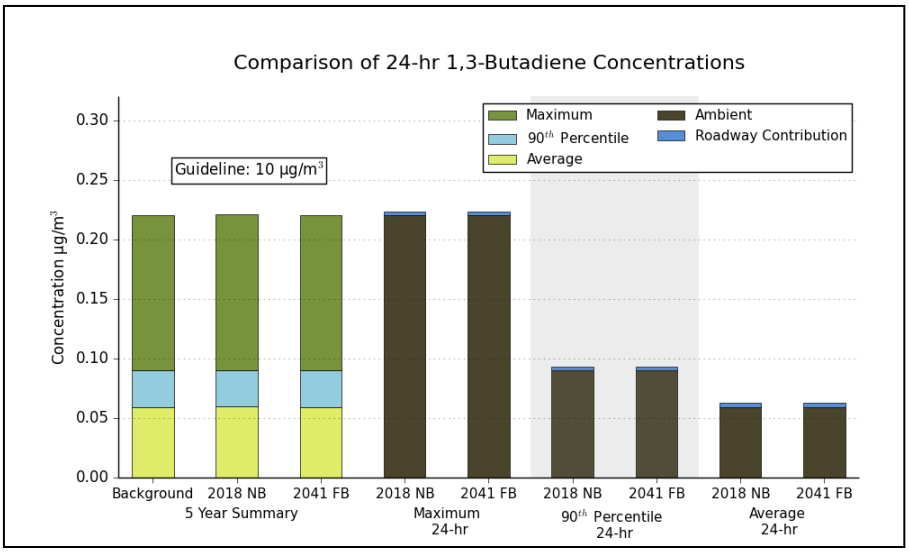
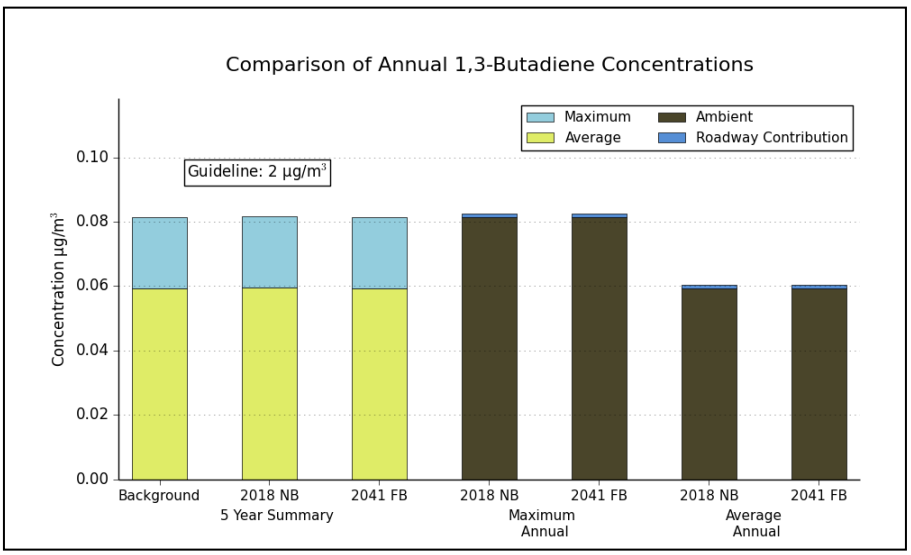
Statistical Analysis	2041 FB	
	**% of MECP Guideline:**	
	Maximum	69%
	90th Percentile	48%
	Average	32%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	1%
	Average	2%
	Conclusions: The combined concentrations were below the respective MECP 24-hr guideline. The roadway contribution to the maximum was 2%.	
	**% of MECP Guideline:**	
	Maximum	210%
	Average	162%
	Roadway Contribution:	
	Maximum	1%
	Average	1%
	Conclusions: The combined concentration exceeded the MECP annual guideline. It should be noted that ambient concentrations were 209% 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

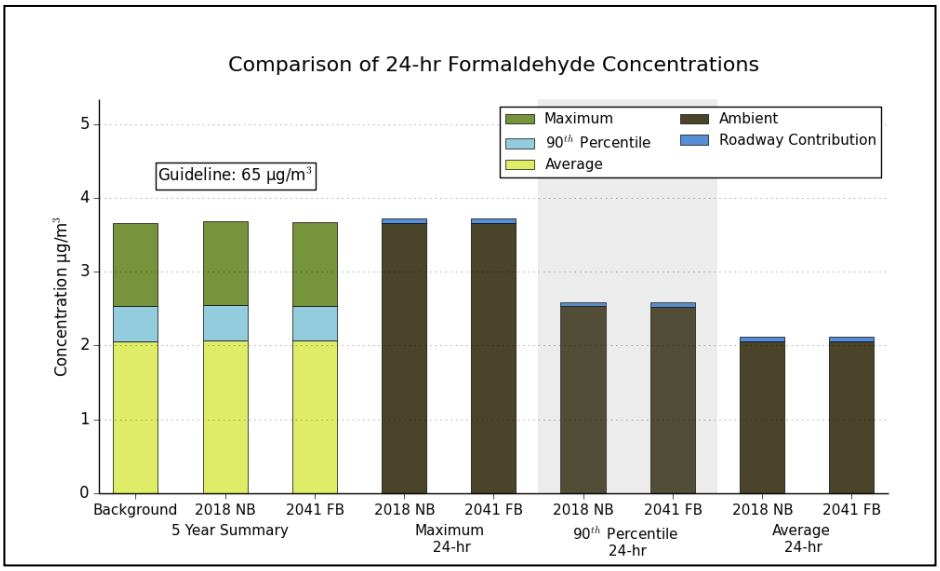
Statistical Analysis	2041 FB	
	**% of MECP Guideline:**	
	Maximum	2%
	90th Percentile	1%
	Average	<1%
	Roadway Contribution:	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MECP 24-hr guideline. The contribution from the roadway was 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	2041 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. 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 2018 No Build and 2041 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 6.2km 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 Ninth Line. Table 24 summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions on Ninth Line in the 2018 No Build and 2041 Future Build scenario.

Table 24: Summary of Ninth Line Traffic Volumes, Roadway Length and Emission Rates

Roadway	2018 Two-Way AADT	2041 Two-Way AADT	Length of Roadway (Miles)	Heavy/Medium Duty Vehicle Percentage (%)	Posted Speed (km/hr)	2018 CO_2 Equivalent Emission Rate (g/VMT)	2041 CO_2 Equivalent Emission Rate (g/VMT)
Ninth Line South of Derry	14,900	29,300	1.86	0.5/1.3	60	366	277
Ninth Line Britannia to Freeman	18,400	39,800	0.12	0.8/0.2	60	371	232
Ninth Line Freeman to Stardust[1]	18,500	40,000	1,80	0.8/0.2	60	4,512	6,100
Ninth Line Stardust to Eglington	18,500	40,000	0.12	0.6/1.6	60	384	245

Note: [1] – AADT estimated using the worst case of Freeman and Stardust

The total predicted annual GHG emissions for the 2018 No Build and 2041 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 existing routes and decrease in future vehicle emissions levels, the total GHG emissions will increase by 8%.

Table 26 shows the GHG emissions on Ninth Line represent 0.0093% of the provincial target and 0.0019% 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	2018 CO_2 Equivalent Emission Rate (g/VMT)	2041 CO_2 Equivalent Emission Rate (g/VMT)	Changes in Emission (%)
Ninth Line	8,820	9,567	8%

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

Roadway	Total CO_2 Equivalent (tonnes/year)
Ninth Line from Derry to Eglington	9,560
Comparison to Canada-wide Target	0.0019%
Comparison to Ontario-wide Target	0.0093%
Comparison to Transportation Target	0.0058%
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. 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. CONCLUSIONS

Presented in Table 27 is a summary of the worst-case modelling results for the 2041 Future Build based on 5-years of meteorological data. For each contaminant, combined concentrations are presented as a percentage of the applicable guideline.

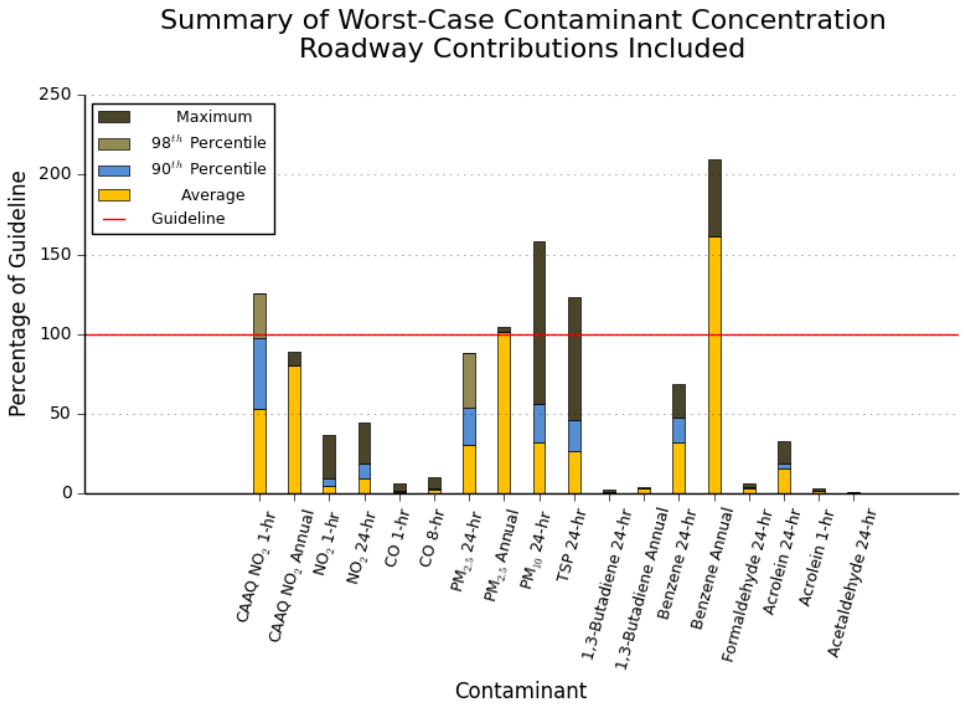
The maximum combined concentrations for the Future Build were all below their respective MECP guidelines or CAAQS, with the exception of the 1-hr and annual NO2 CAAQ, annual $PM_{2.5}$, 24-hr PM_{10}, 24-hr TSP, 24-hour benzene and annual benzene. Note that background concentrations exceeded the guideline for all of these contaminant averaging periods as well. The contribution from the roadway emissions to the combined concentrations was small.

Mitigation measures are not warranted, due to the small number of days which are expected to exceed the guideline.

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 2041 Future Build

5 Year Statistical Summary



% of Guideline

	2041 FB
CAAQ NO_2 (1-hr)	125%
CAAQ NO_2 (Annual)	89%
NO_2 (1-hr)	36%
NO_2 (24-hr)	44%
CO (1-hr)	6%
CO (8-hr)	10%
$PM_{2.5}$ (24-hr See Note)	88%
$PM_{2.5}$ (Annual)	101%
PM_{10}	158%
TSP	123%
Acetaldehyde	<1%
Acrolein (1-hr)	3%
Acrolein (24-hr)	33%
Benzene (24-hr)	69%
Benzene (Annual)	210%
1,3-Butadiene (24-hr)	2%
1,3-Butadiene (Annual)	4%
Formaldehyde	6%

7. REFERENCES

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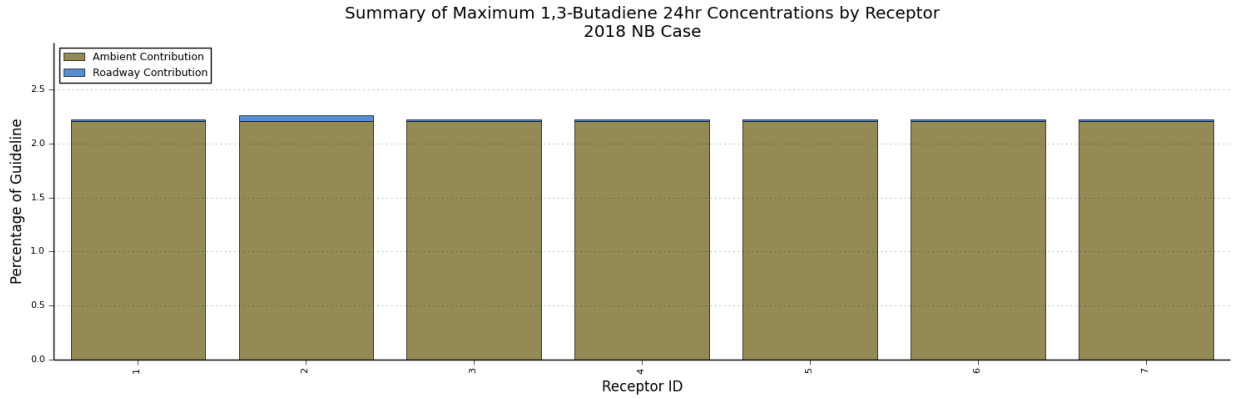
Appendix A
Results For Each Receptor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Roadway Contribution
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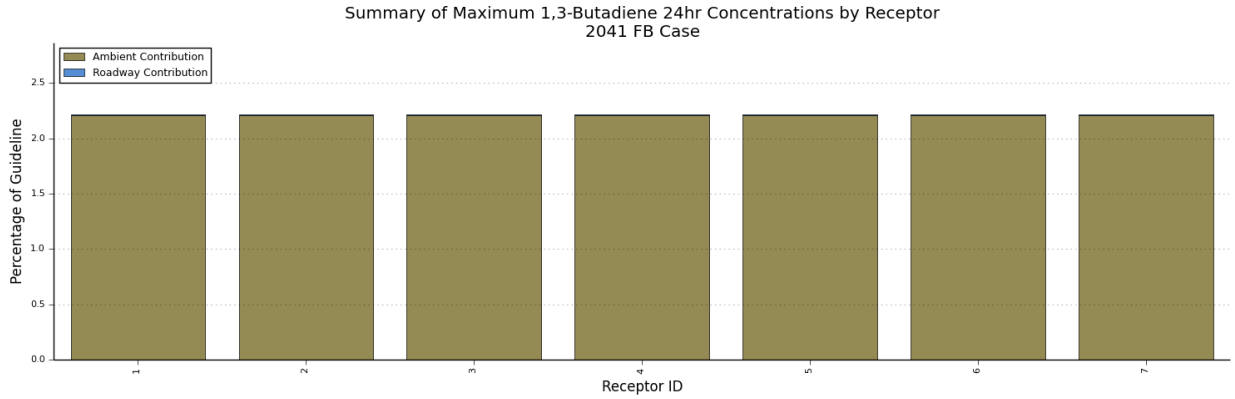
Receptor ID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Ambient Contribution
Roadway Contribution
Percentage of Guideline
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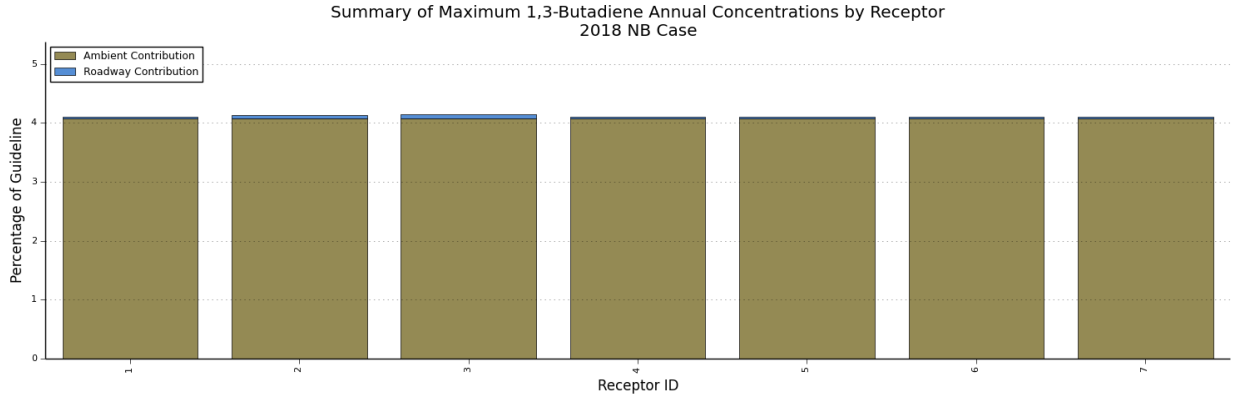
Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
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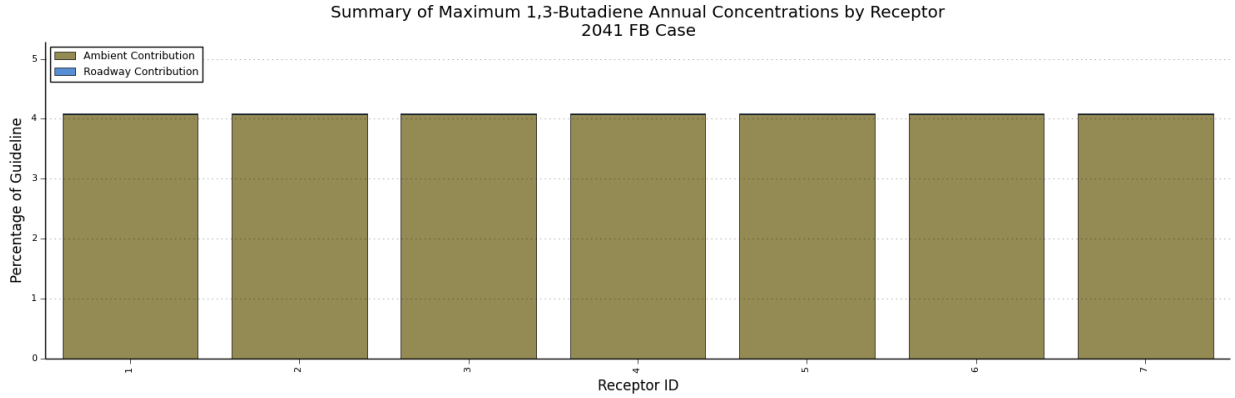
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Roadway Contribution
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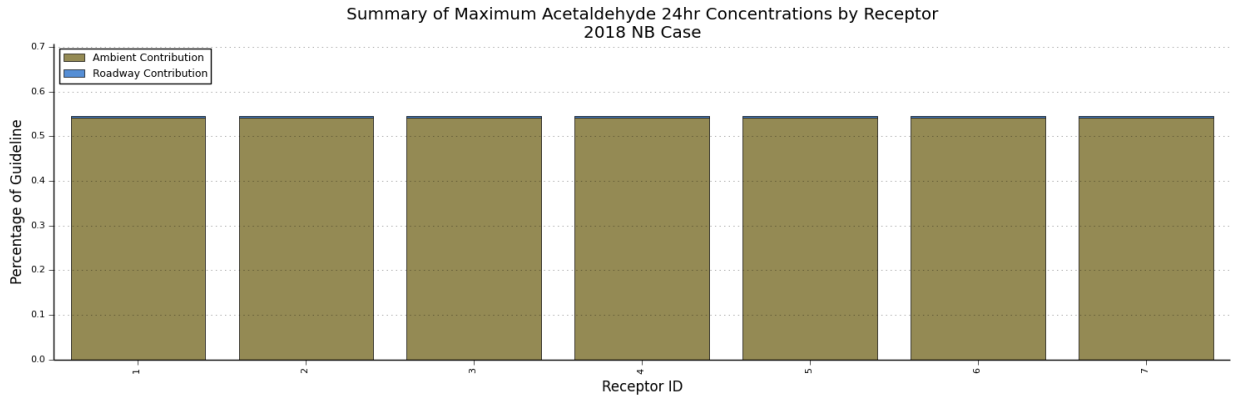
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Roadway Contribution
Percentage of Guideline
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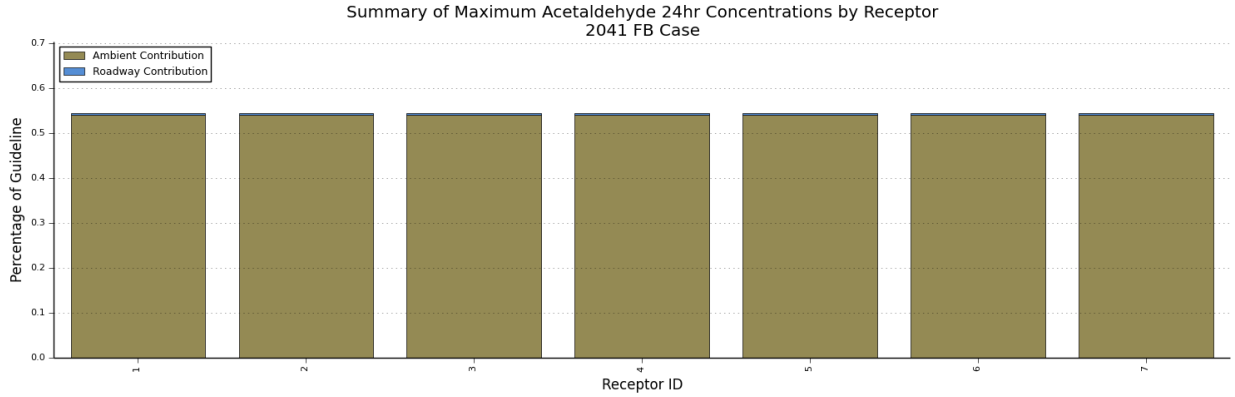
Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
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Roadway Contribution
Percentage of Guideline
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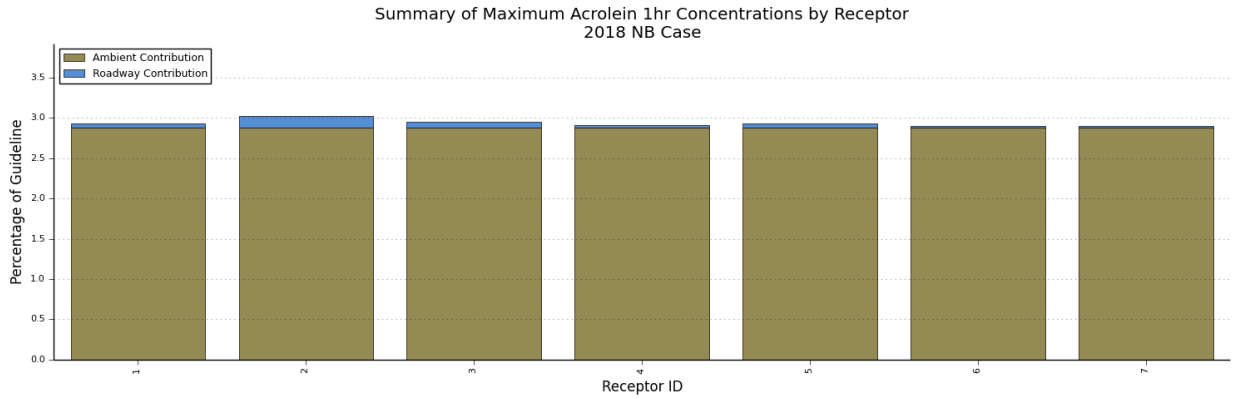
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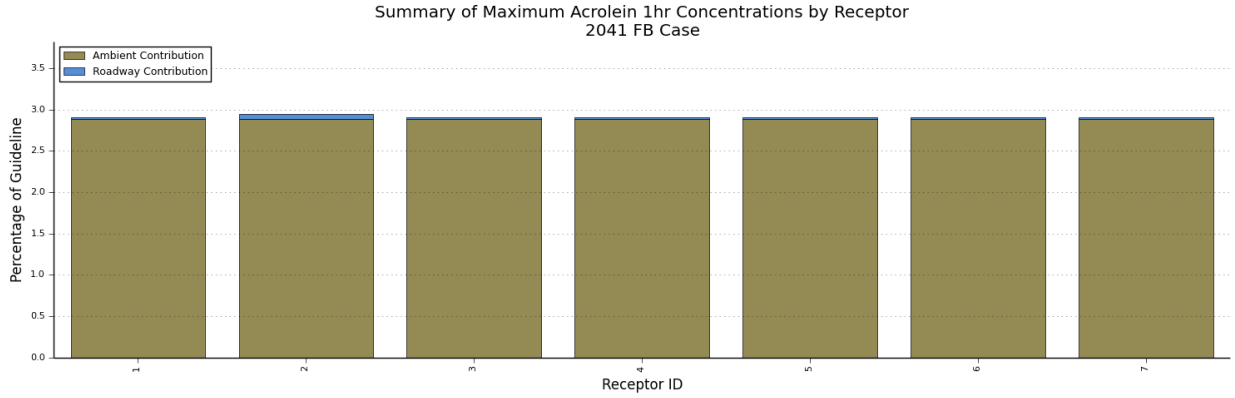
Roadway Contribution
Percentage of Guideline
Receptor ID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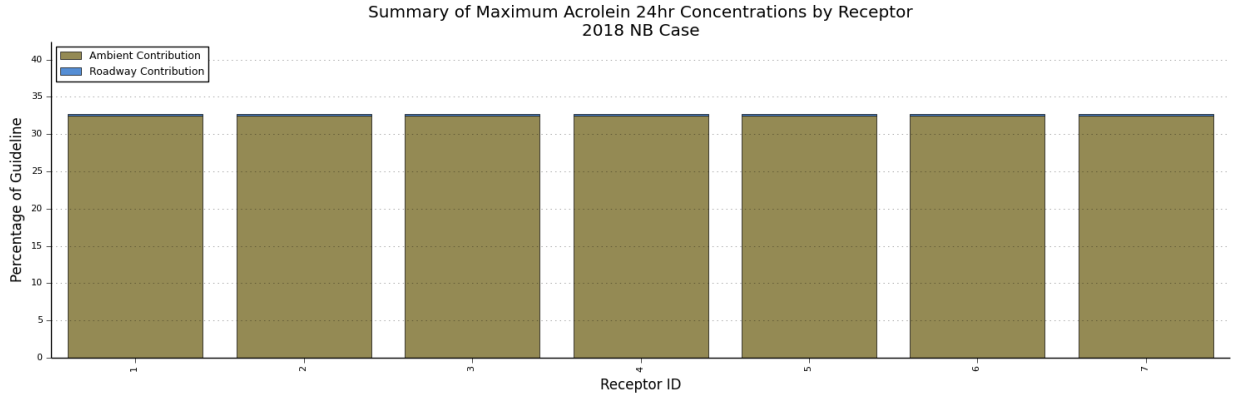
Roadway Contribution
Percentage of Guideline
Receptor ID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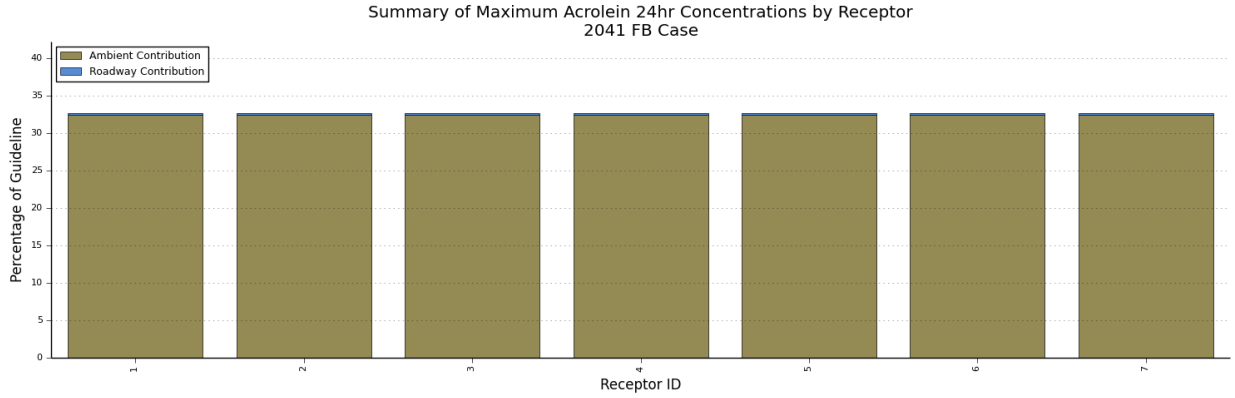
Roadway Contribution
Percentage of Guideline
Receptor ID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Percentage of Guideline
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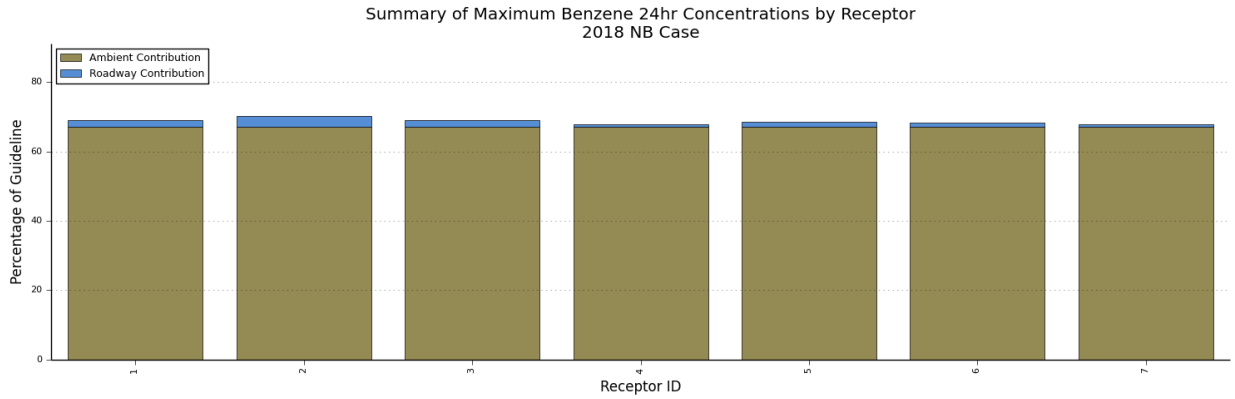
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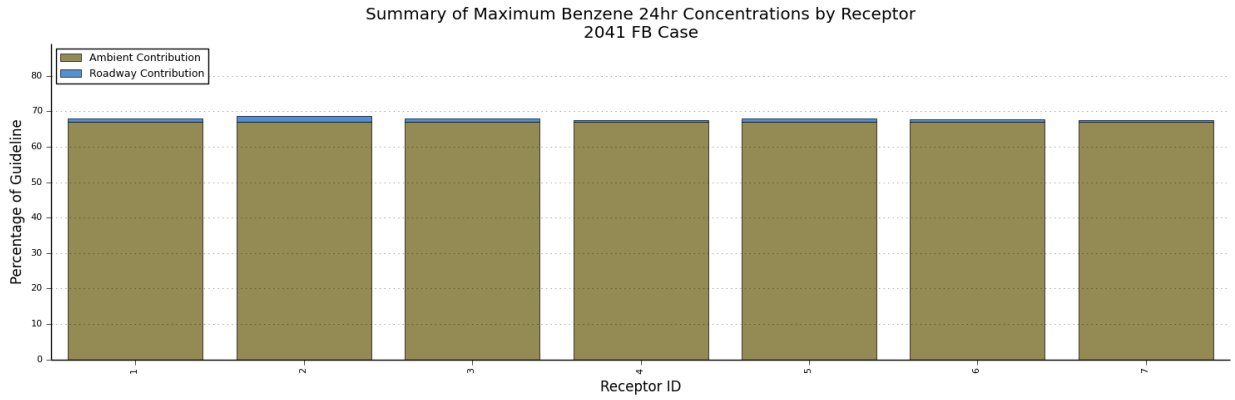
Roadway Contribution
Percentage of Guideline
Receptor ID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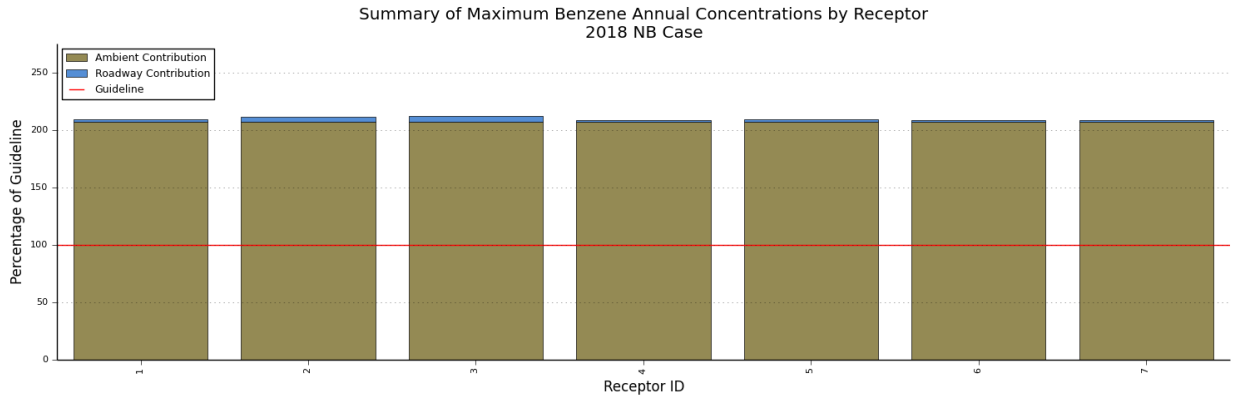
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Roadway Contribution
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Percentage of Guideline
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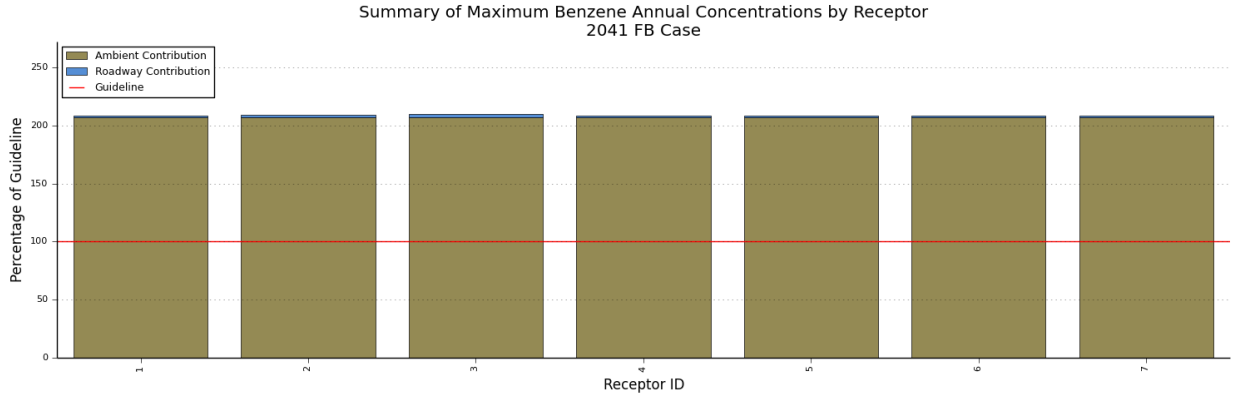
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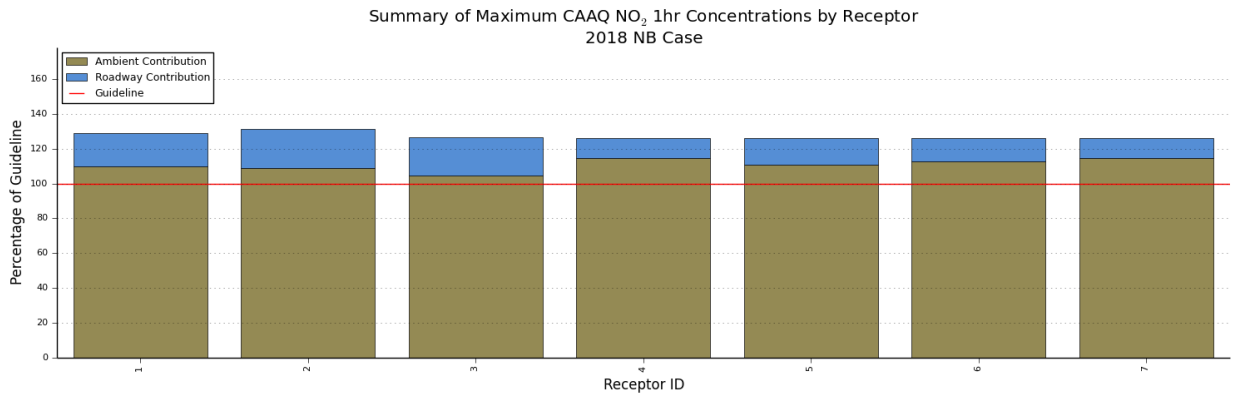
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Percentage of Guideline
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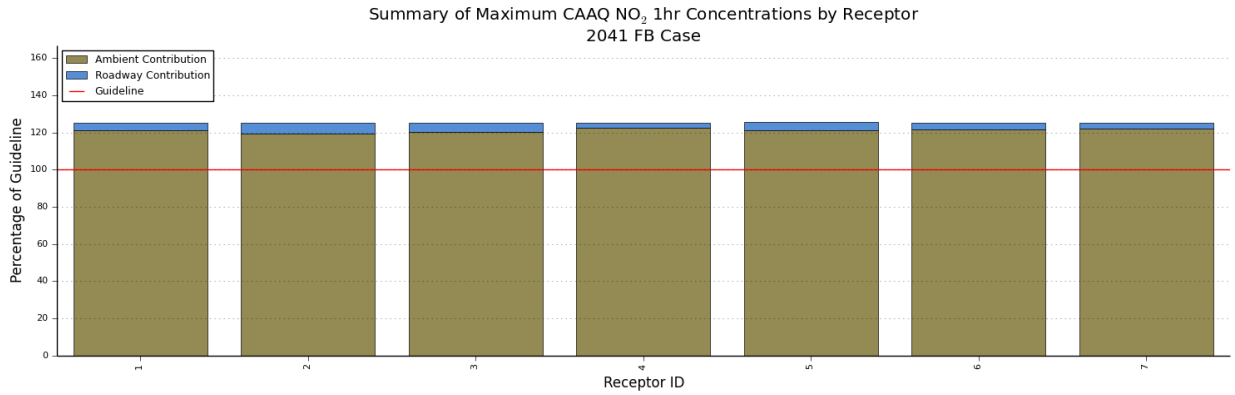
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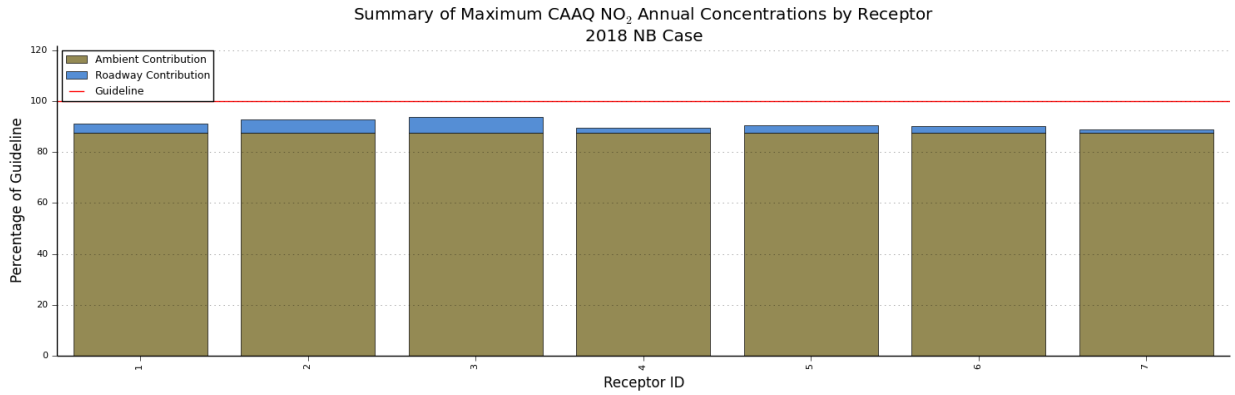
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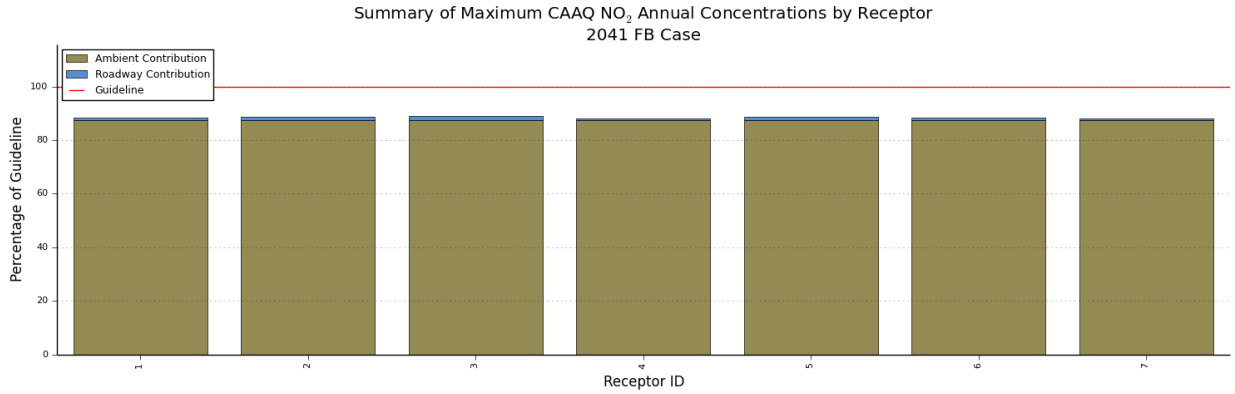
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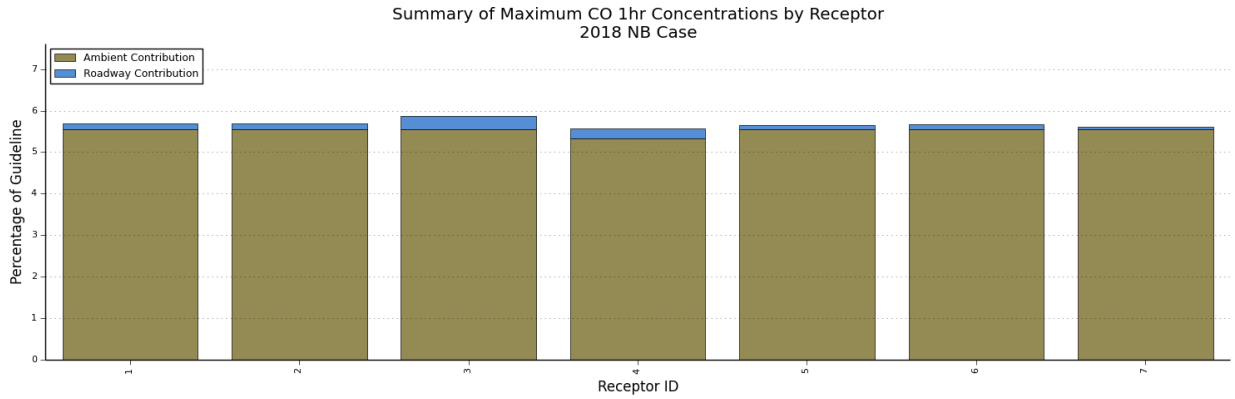
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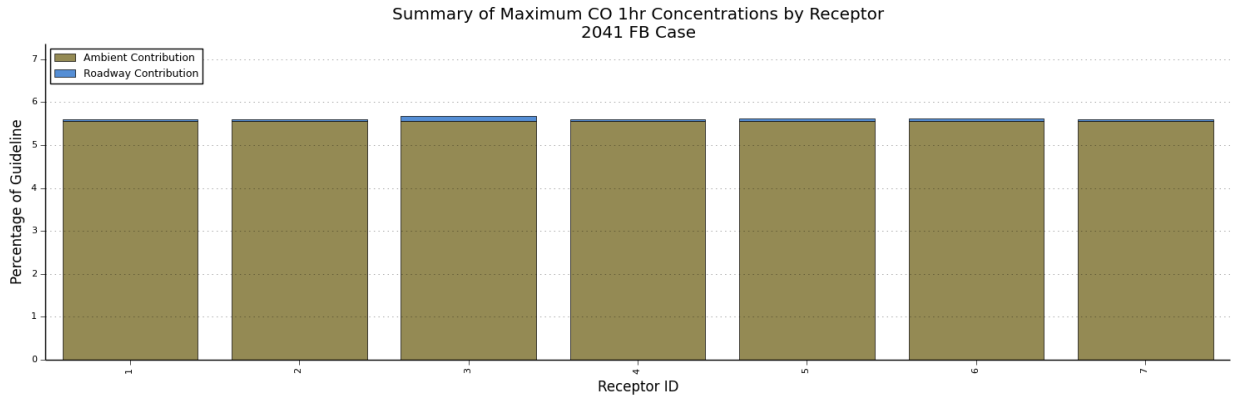
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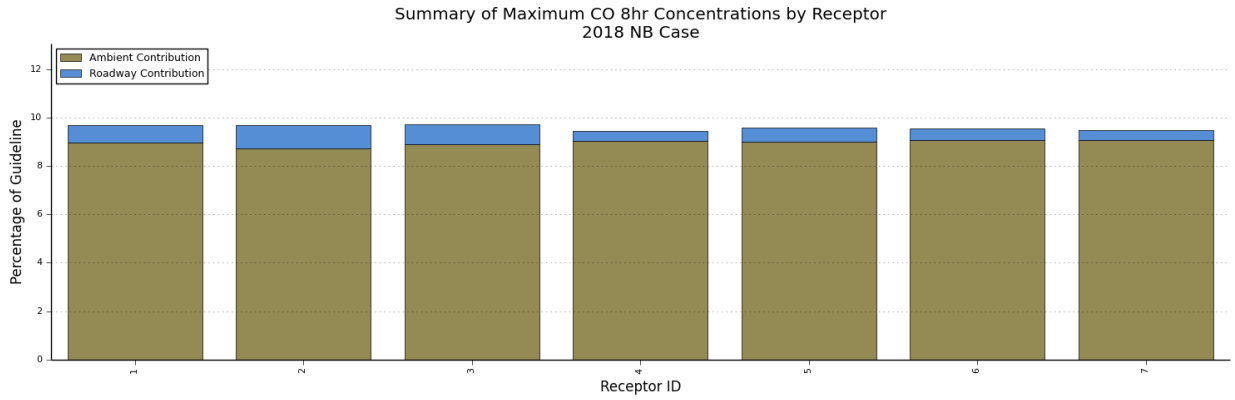
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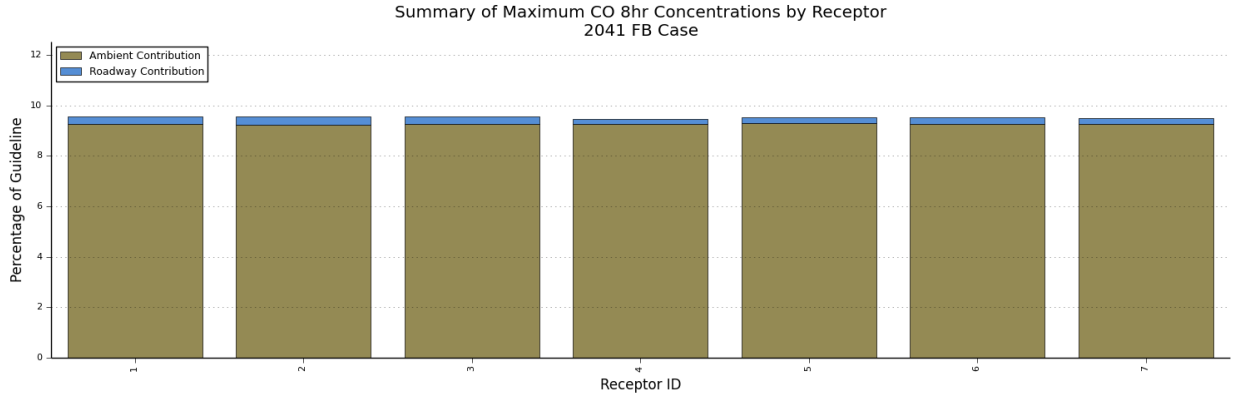
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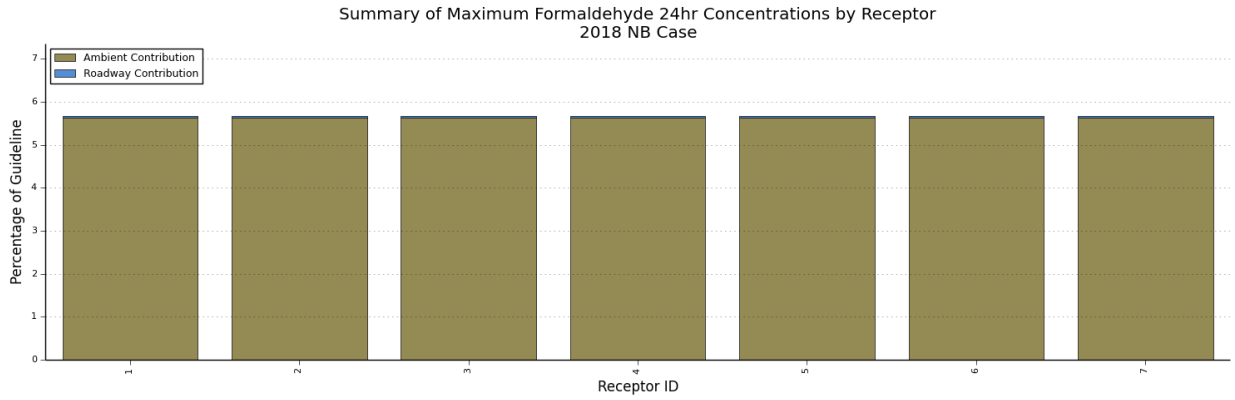
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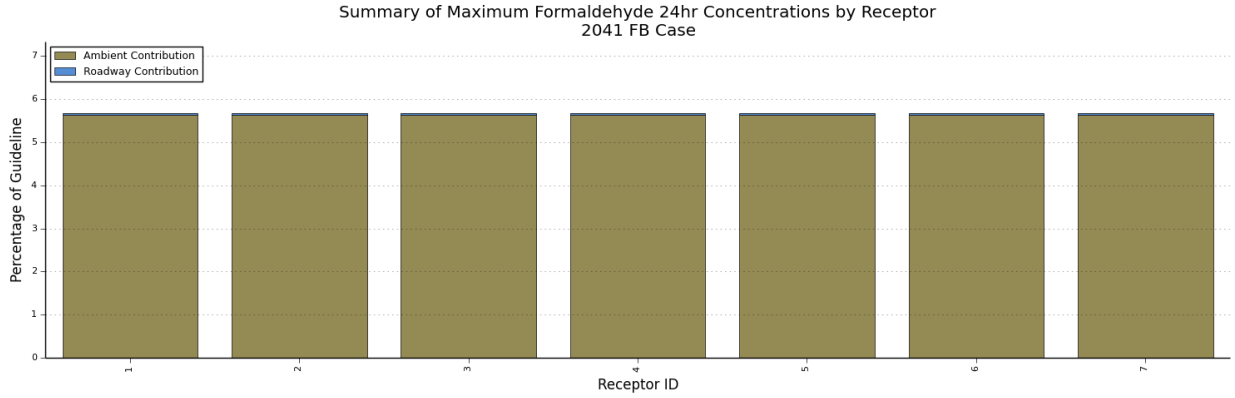
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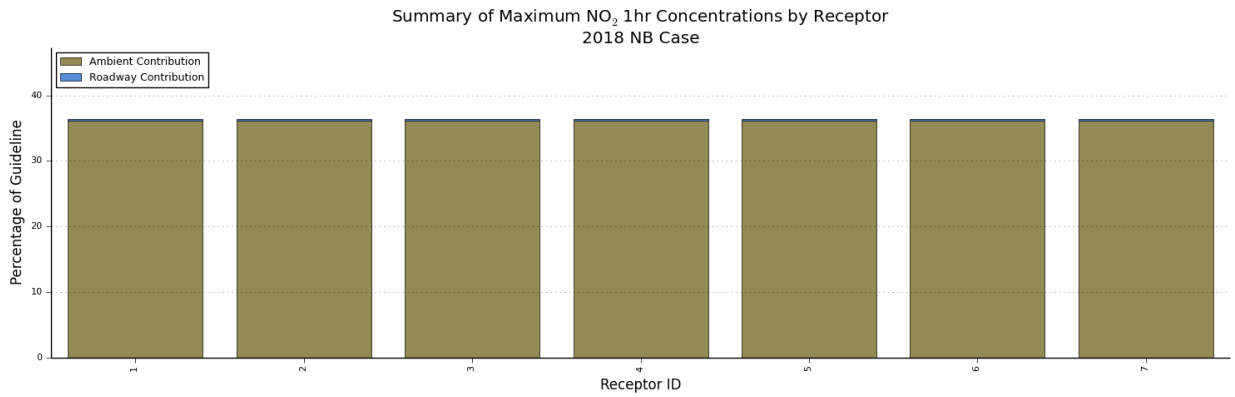
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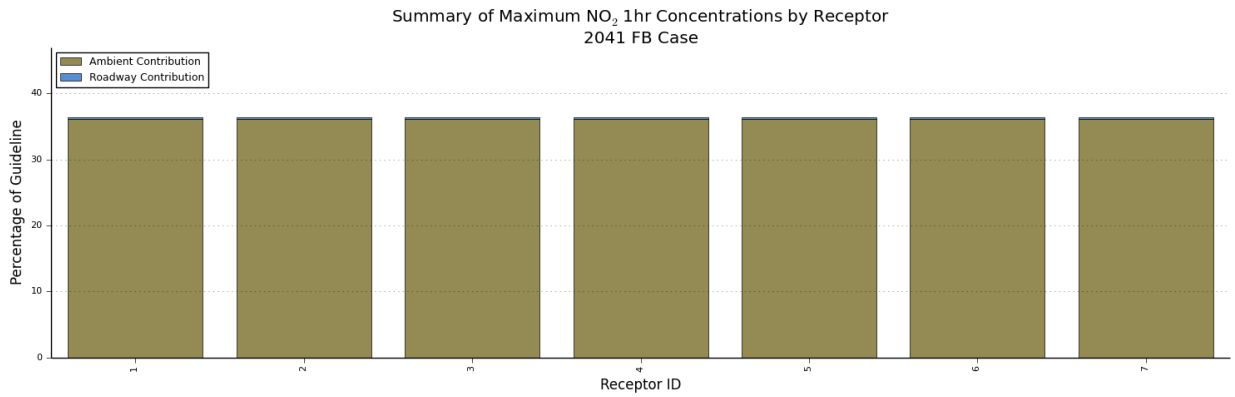
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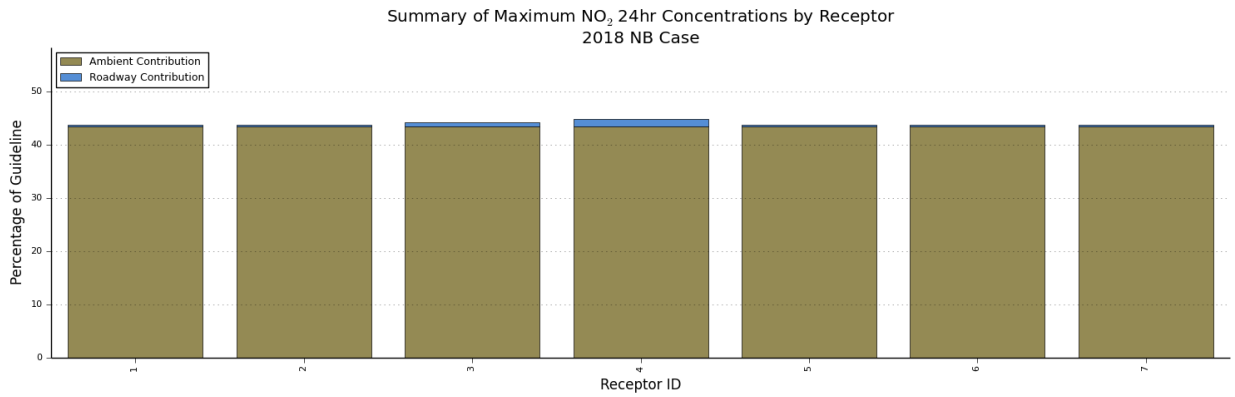
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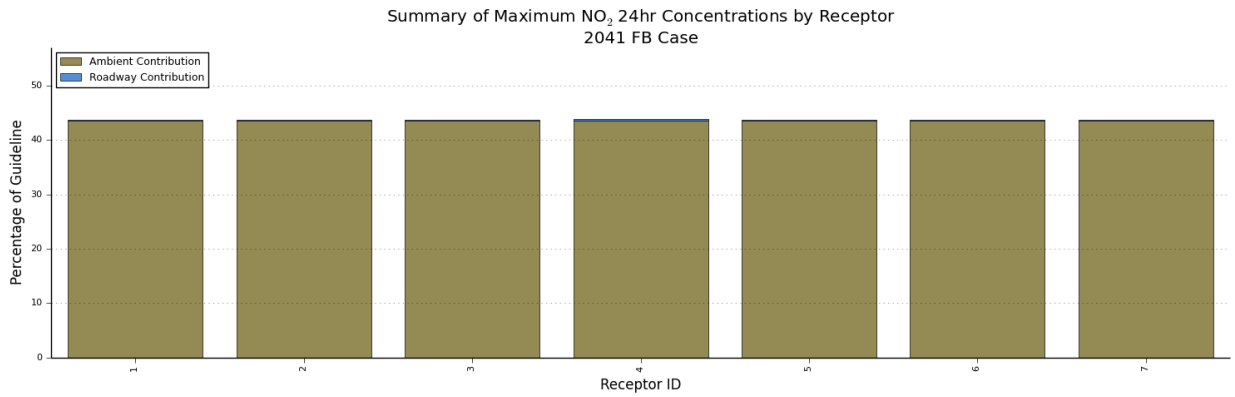
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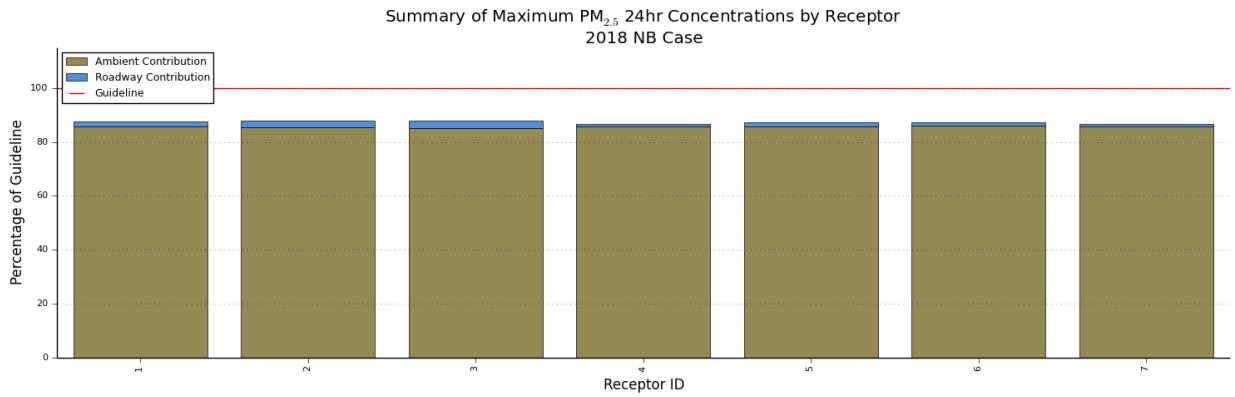
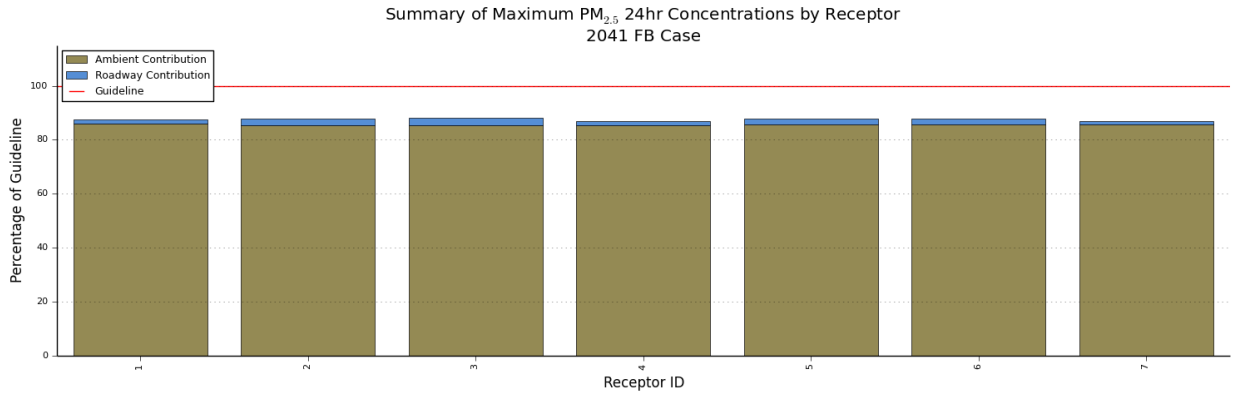
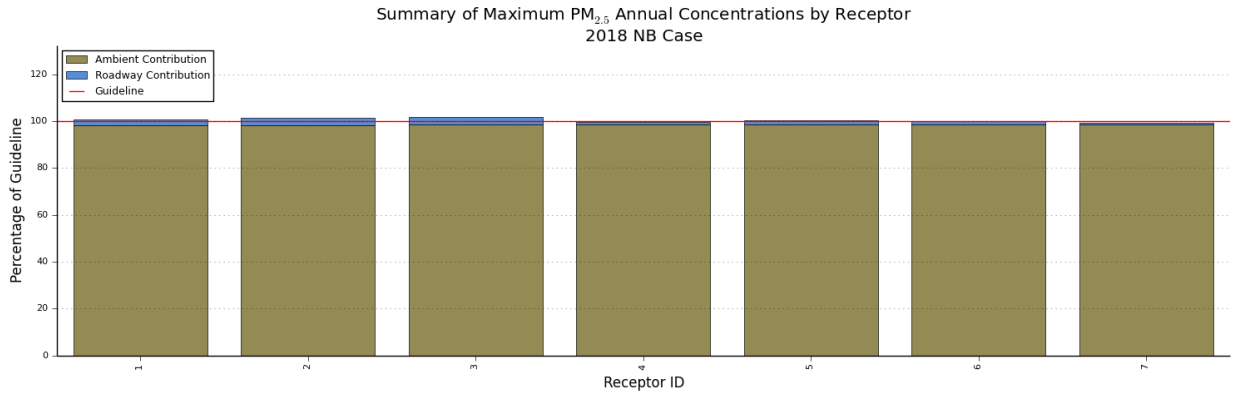
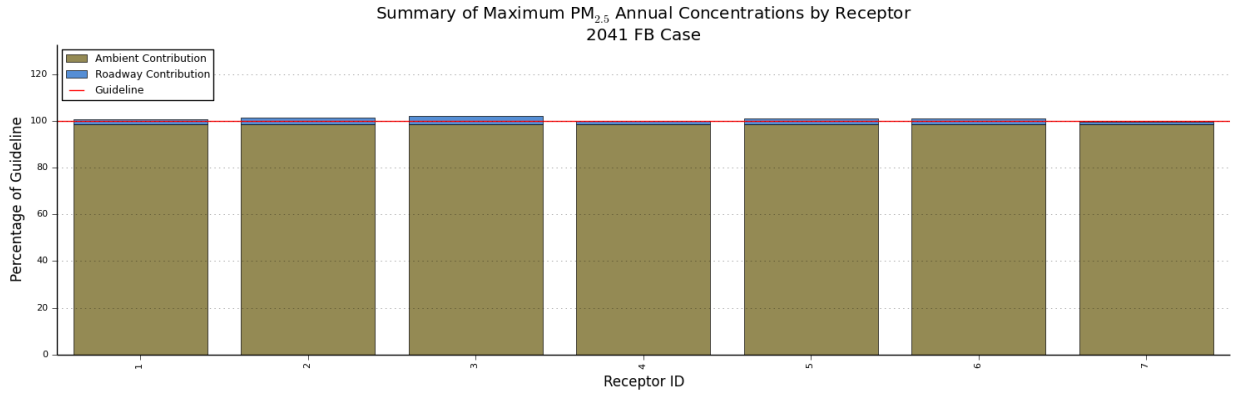
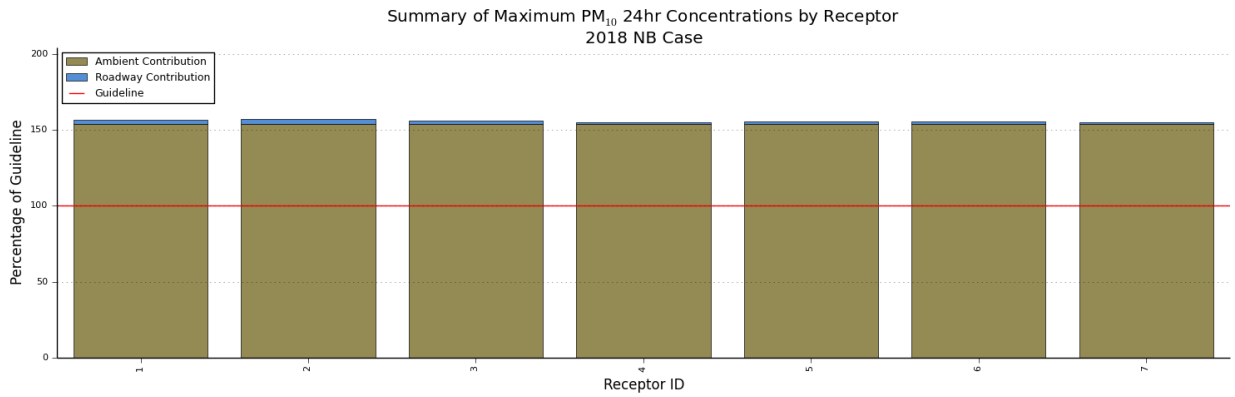
50
1
2
3
4
5
6
7
Receptor ID

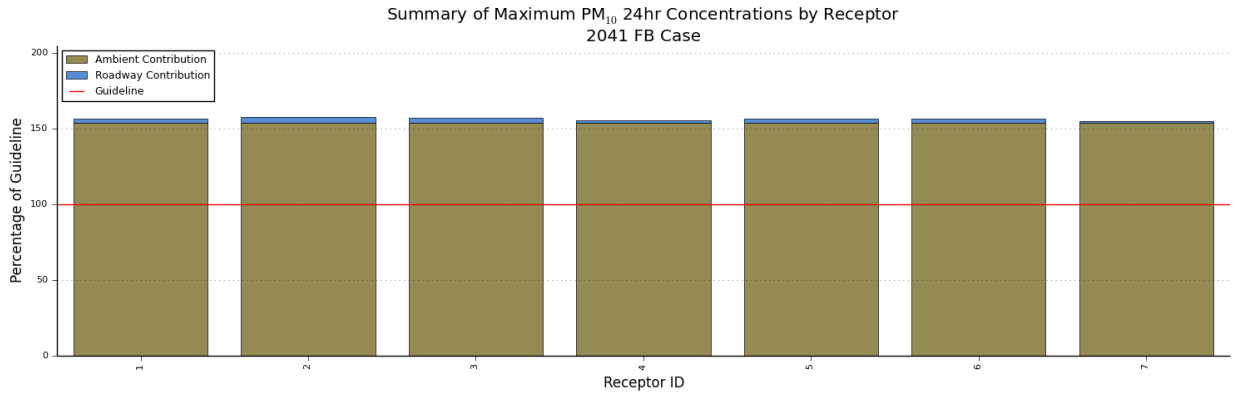

Summary of Maximum PM2.5 24hr Concentrations by Receptor
2018 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

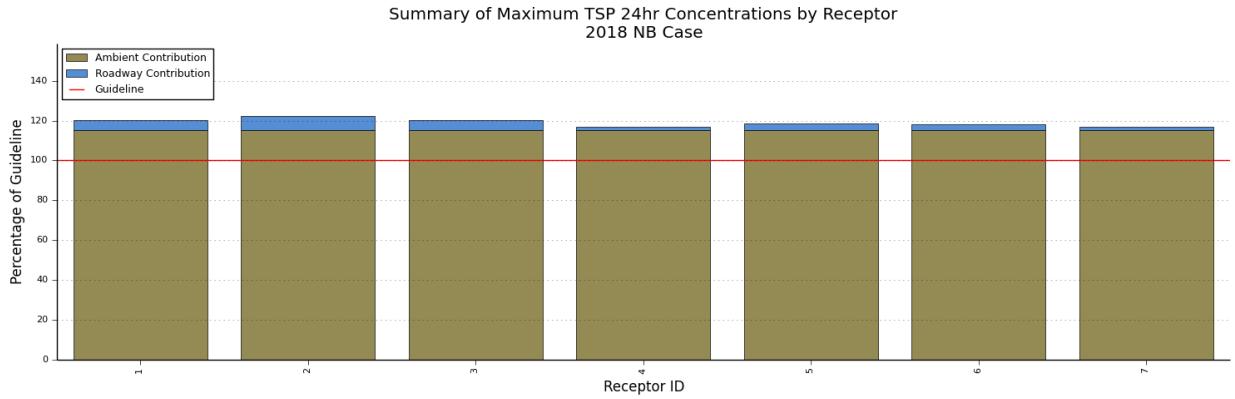

Summary of Maximum PM2.5 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID

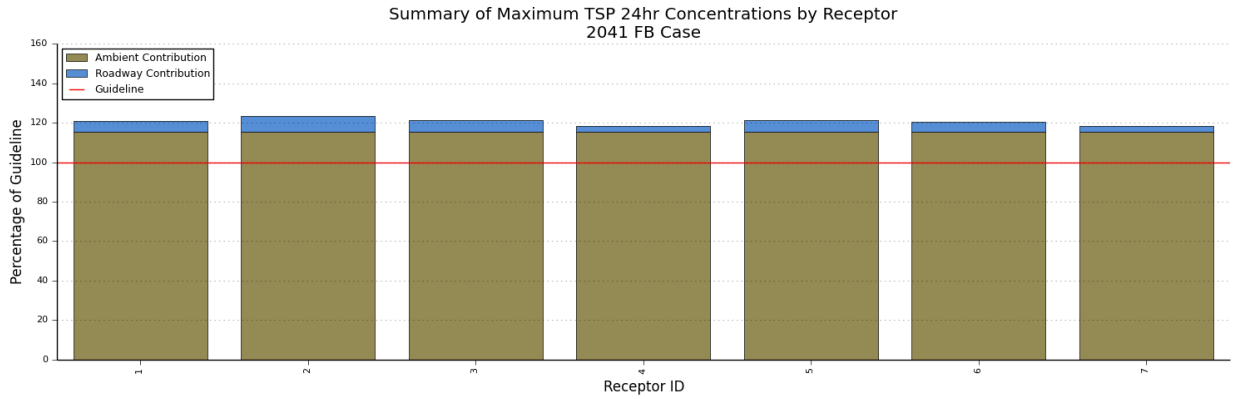

Summary of Maximum PM2.5 Annual Concentrations by Receptor
2018 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum PM2.5 Annual Concentrations by Receptor
2041 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum PM10 24hr Concentrations by Receptor
2018 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum PM10 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum TSP 24hr Concentrations by Receptor
2018 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum TSP 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID