Local Air Quality Assessment
Class Environmental Assessment for 404 North Collector Roads, City of Markham

Novus Reference No. 17-0271 | Version No. 1 (FINAL) | October 24, 2019

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Table of Contents

List of Tables

List of Figures

1.0 Introduction

Novus Environmental Inc. (Novus) was retained by CIMA+ to conduct an air quality assessment as part of the Municipal Class Environmental Assessment for the Highway 404 North Collector Roads located in the City of Markham. The project includes four new segments of collector roadways to be constructed between Highway 404 and Woodbine Avenue, south of 19th Avenue and near Honda Boulevard. The segments include:

- Road A: approximately 470 meters of new roadway connecting Woodbine Avenue and 19th Avenue to the north
- Road C1: approximately 480 meter extension of Honda Boulevard northbound up to 19th Avenue
- Road D: approximately 730 meters new roadway connecting Woodbine Avenue with Honda Boulevard
- Road E1: approximately 650 meter extension of Victoria Square Boulevard connecting north to Road D.

This report assesses the impacts of the new roadways at nearby sensitive receptors. The study area is approximately 2 kilometers in length and is shown in orange in **Figure 1**.

Figure 1: Study Area Showing the Proposed New Road (In Orange)

1.1 Study Objectives

The main objective of the study was to assess the local air quality impacts due to the proposed new collector roadways. The study also included an assessment of total greenhouse (GHG) emissions due to the project, and an overview of construction impacts. To meet these objectives, the following scenarios were considered:

- **2017 Existing** – Assess the existing air quality conditions at representative receptors. Predicted contaminant concentrations from the existing roadway were combined with hourly measured ambient concentrations to determine the combined impact.
- **2037 Future Build** – Assess the future air quality conditions with the proposed new roadways in place. Predicted contaminant concentrations from the proposed roadway improvements were combined with hourly measured ambient concentrations to determine the combined impact.

1.2 Contaminants of Interest

The contaminants of interest for this study have been chosen 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 the 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**.

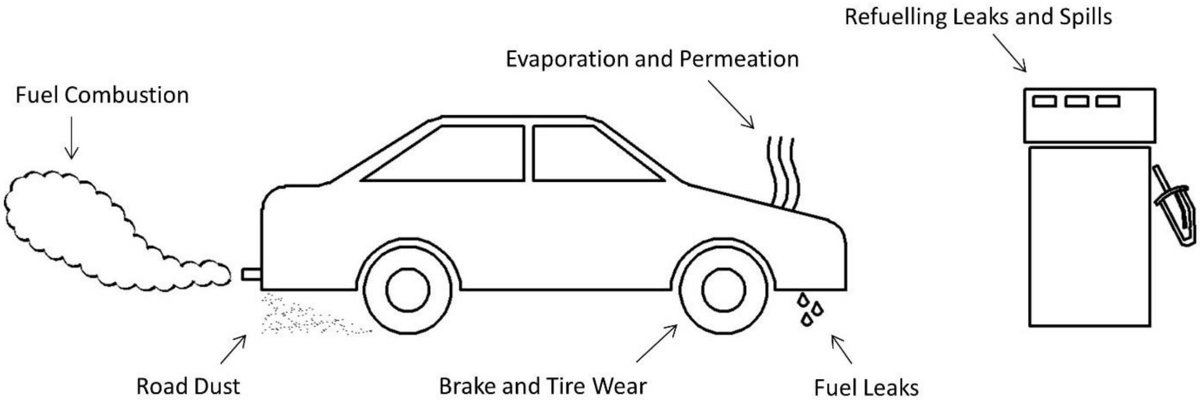


Figure 2: Motor Vehicle Emission Sources

Table 1: Contaminants 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 assess the impact of the project, the predicted effects at sensitive receptors were compared to guidelines established by government agencies and organizations. Relevant agencies and organizations in Canada and their applicable contaminant guidelines are:

- MECP Ambient Air Quality Criteria (AAQC);
- 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 98^{th} percentile value, averaged over 3 consecutive years.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value ($\mu g/m^3$)	Source
NO_2	1	400	AAQC
	24	200	AAQC
	1	79 (42 ppb)[1]	CAAQS (standard is to be phased-in in 2025)
	Annual	23 (12 ppb)[2]	CAAQS (standard is to be phased-in in 2025)
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	27[3]	CAAQS (standard is 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
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 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 annual 98th percentile concentration, averaged over three consecutive years

[2] 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 Toronto Pearson Airport was used. Five years were modelled in order to capture the worst-case meteorological conditions. Two emission scenarios were assessed: 2017 Existing and 2037 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 study 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.

Local background concentrations are presented in **Section 2.0**. Impacts due to the roadway for the 2017 Existing and 2037 Future Build scenarios are presented in **Section 3.8**.

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**.

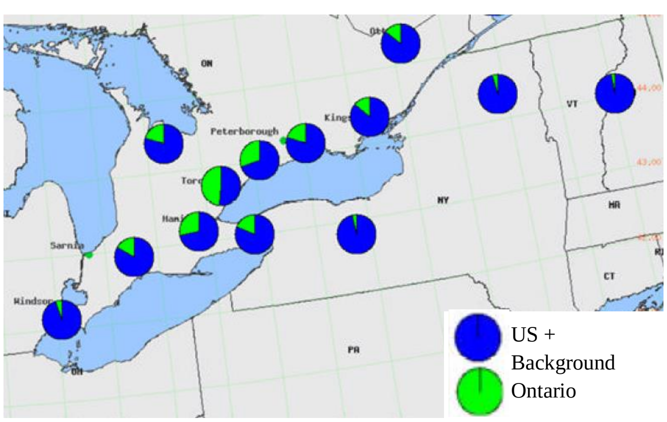
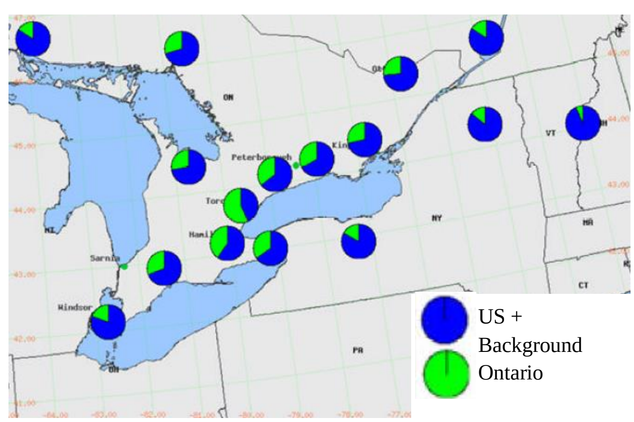
High $PM_{2.5}$ Days	Average $PM_{2.5}$ of Spring/Summer Season
	

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.

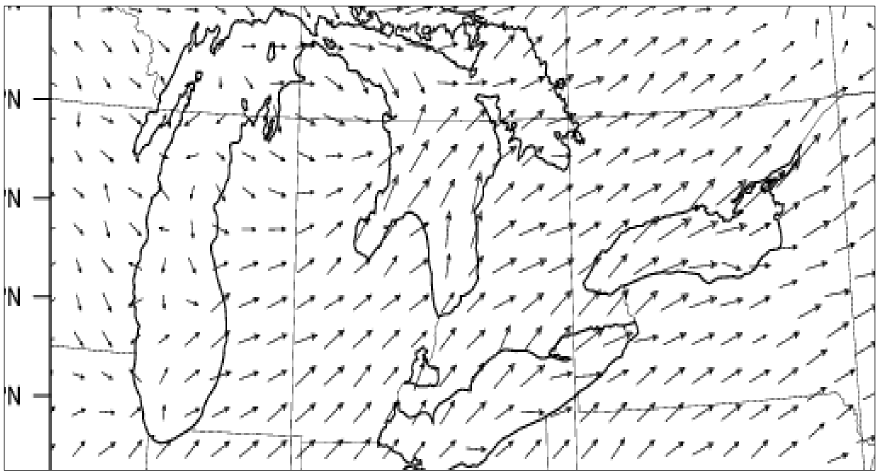


Figure 4: Typical Wind Direction during an Ontario Smog Episode

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 study area and that would be representative of background contaminant concentrations in the study 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 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 study area. The locations of the relevant ambient monitoring stations in relation to the study area are shown in **Figure 5**. Station information is presented in **Table 3**.

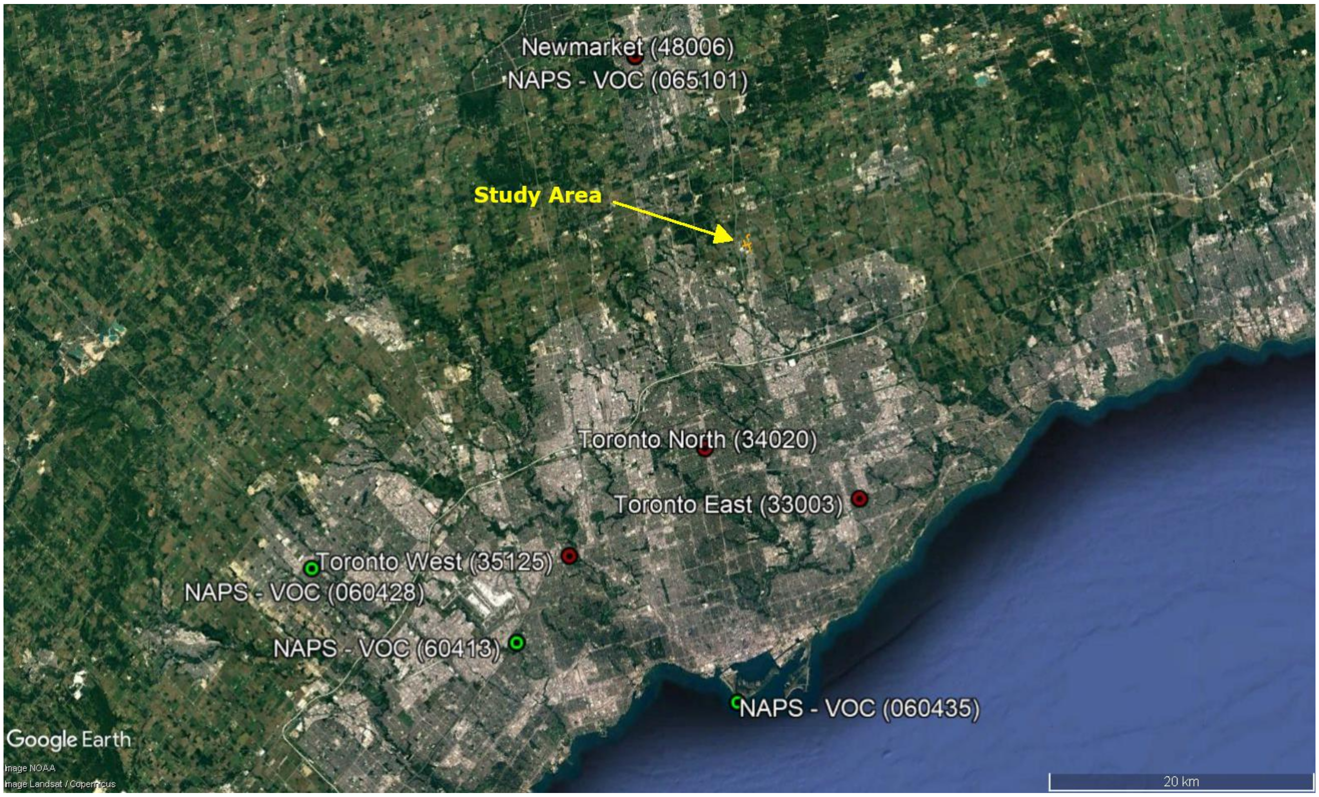


Figure 5: Relevant MECP (shown in red) and NAPS (shown in green) Monitoring Stations; Study Area in Orange

Table 3: Relevant MECP and NAPS Station Information

City/Town	Station ID	Location	Operator	Contaminants
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

Since there are several monitoring stations which could be used to represent the study area, a comparison was performed for the available data on a contaminant basis, to determine the worst-case representative background concentration (see **Section 2.3**). Selecting the worst-case ambient data will result in a conservative combined assessment.

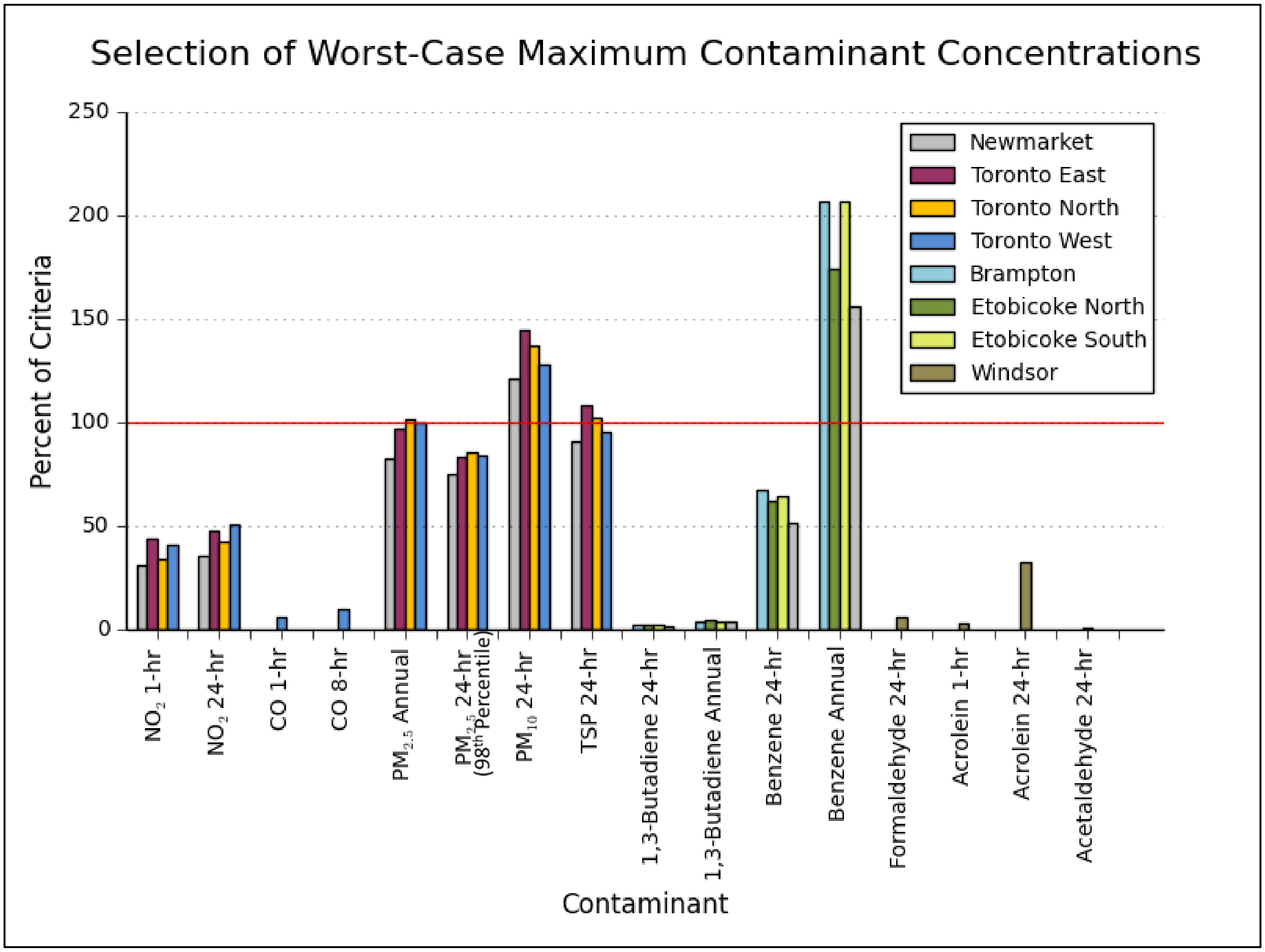
2.3 Selection of Worst-Case Monitoring Stations

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 at the Etobicoke North and Brampton NAPS stations, minimal data was available in 2016, therefore, 2011-2015 data was used for these stations. Formaldehyde, acetaldehyde and acrolein are only recently measured at the Windsor station, and were not measured after 2013. Therefore 2009-2013 data was used for these VOCs. For consistency with the combined effects analysis (using 2012-2016 meteorological data to predict roadway concentrations), the actual date of measured VOC data within dataset was used when possible.

The station with the highest maximum value over the five-year period for each contaminant and averaging period was selected to represent background concentrations in the study area. The maximum concentration represents an absolute worst-case background scenario. 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 90^{th} 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.

Following the above methodology, the worst-case concentrations for each contaminant and averaging period were summarized for each of the selected monitoring stations. The station with the highest concentration, for each contaminant and averaging period, was selected for the analysis**. Table 4** shows a comparison of the contaminant concentrations from each station and the selection of the worst-case station.

Table 4: Comparison and Selection of Background Concentrations



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

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

Note that the NO_2 1-hr and annual CAAQS are not shown in the graph above; the maximum 1-hr concentration at the Toronto East station is 176 µg/m^3 or 222% of the CAAQS and the maximum annual concentration at the Toronto West station is 33.78 µg/m^3 or 147% of the

CAAQS. As the CAAQS are new standards which don't come into effect until 2025, they have been included in this assessment for comparison purposes only. The one-hour standard has not been assessed based on the 3-year average of the annual 98th percentile of the NO_2 daily-maximum 1-hour average concentrations, and the annual averaging period has not been assessed for NO_x. This is in accordance with guidance from the MECP.

2.4 Detailed Analysis of Selected Worst-case Monitoring Stations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants 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 worst-case day. The 90th percentile concentration represents a day with reasonably worst-case background concentrations, and the average concentration represents a typical day. 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, all background concentrations were below their respective guidelines with the exception of 24-hour PM_{10}, 24-hour TSP, and annual $PM_{2.5}$ and benzene. It should be noted that PM_{10} and TSP were calculated based on their relationship to $PM_{2.5}$.

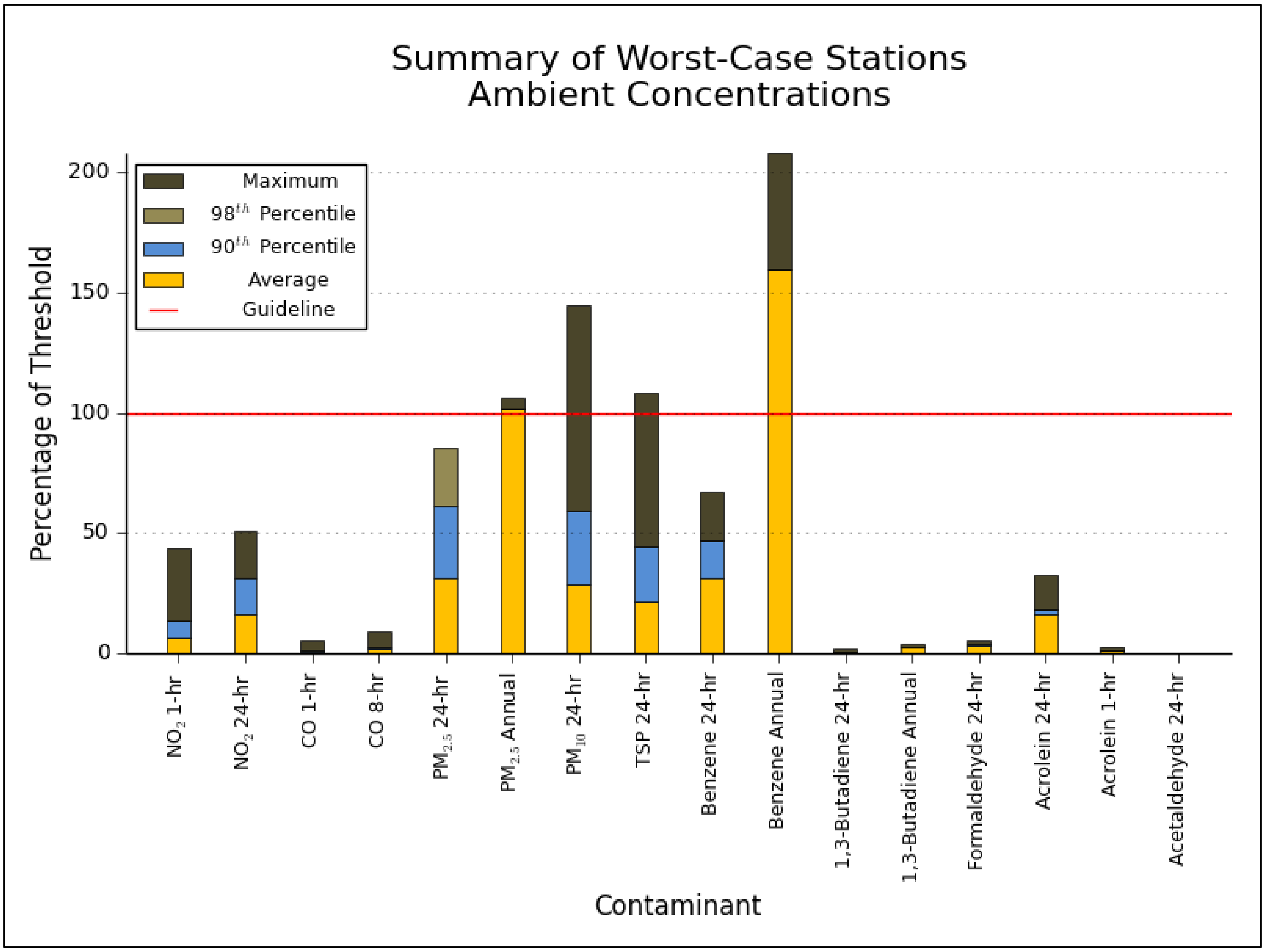


Figure 6: Summary of Background Conditions Applied in the Assessment

3.0 Local Air Quality Assessment

3.1 Overview

The worst-case impacts due to roadway vehicle emissions were assessed for two scenarios: 2017 Existing (or No Build/NB) and 2037 Future Build (FB). The two scenarios include the following activities:

2017 Existing (NB):

- Existing traffic volumes on 19th Avenue, Woodbine Avenue, and Honda Boulevard for the existing alignment.

2037 Future Build (FB):

- Projected vehicle volumes on 19th Avenue, Woodbine Avenue, Honda Boulevard, as well as the proposed new roadway alignments.

The assessment was performed using U.S. EPA approved vehicle emission and air dispersion models to predict worst-case impacts at representative sensitive receptor locations. The assessment was conducted in accordance with the MTO *Environmental Guide for Assessing and Mitigating the Air Quality Impacts and Greenhouse Gas Emissions of Provincial Transportation Projects*. The details of the assessment are discussed below.

3.2 Location of Sensitive Receptors within the Study Area

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

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

Fourteen sensitive receptors were evaluated to represent worst-case impacts surrounding the project area. Most receptors represent residential properties. Victoria Square Public School, was also included as a sensitive receptor. The receptor locations are identified in and **Figure 8.**

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

Figure 7: Receptor Locations R1-R7 Within the Study Area

Figure 8: Receptor Locations R7-R12 Within the Study Area

Figure 9: Receptor Locations R10-R14 Within the Study Area

3.3 Road Traffic Data

Traffic data was provided in the form of Annual Average Daily Traffic (AADT) volumes by CIMA+ for the intersections within the study area for both the Existing 2017 and 2037 FB configurations. Note that traffic volumes from Highway 404 were not included in this assessment based on discussions with CIMA+ and the fact that traffic emissions from the highway would dominate over the collector roads of interest. The AADT volumes used in the assessment are shown in **Table 5** with an assumed 50% split between travelling directions. Heavy-duty vehicle percentages were also provided for the existing and new roadways, with a 13% heavy-duty vehicle percentage on Woodbine Avenue, 5% for 19th Avenue and Honda Boulevard, and 10% on Roads A, C1, D, and E. Hourly traffic volumes were not available, the therefore the US EPA standard off-network and rural weekday hourly distribution was used for 2017 NB scenario, and urban weekday hourly distribution was used for 2037 FB. This is to account for the rural characteristics of the existing roadway and change to a more urban setting with the development of the new roadways. The hourly distributions are shown in

Table 6 and **Table 7**. Lastly, signal timing was provided by CIMA+ for all traffic lights within the study area.

Table 5: Traffic Volumes (AADT) Used in the Assessment

Roadway	NB 2017 AADT	FB 2037 AADT	Speed (km/hr)
19th Avenue	2,100	8,600	60
Woodbine Avenue	7,600	15,700	80
Honda Boulevard	4,800	6,900	50
Road A	N/A	3,100	
Road C1	N/A	3,200	
Road D	N/A	2,400	
Road E1	N/A	2,400	

Table 6: US EPA Rural, Weekday, Hourly Vehicle Distribution

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

Table 7: US EPA Off-Network, Urban, Weekday, Hourly Vehicle Distribution

Hour	MON	TUE	WED	THU	FRI	SAT	SUN
1	0.9%	0.9%	0.9%	0.9%	0.9%	2.2%	2.2%
2	0.6%	0.6%	0.6%	0.6%	0.6%	1.4%	1.4%
3	0.5%	0.5%	0.5%	0.5%	0.5%	1.0%	1.0%
4	0.4%	0.4%	0.4%	0.4%	0.4%	0.8%	0.8%
5	0.6%	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%
6	1.9%	1.9%	1.9%	1.9%	1.9%	1.0%	1.0%
7	4.6%	4.6%	4.6%	4.6%	4.6%	1.9%	1.9%
8	6.9%	6.9%	6.9%	6.9%	6.9%	2.6%	2.6%
9	6.1%	6.1%	6.1%	6.1%	6.1%	3.8%	3.8%
10	5.0%	5.0%	5.0%	5.0%	5.0%	4.8%	4.8%
11	5.1%	5.1%	5.1%	5.1%	5.1%	5.9%	5.9%
12	5.4%	5.4%	5.4%	5.4%	5.4%	6.5%	6.5%
13	5.8%	5.8%	5.8%	5.8%	5.8%	7.1%	7.1%
14	5.9%	5.9%	5.9%	5.9%	5.9%	7.1%	7.1%
15	6.2%	6.2%	6.2%	6.2%	6.2%	7.1%	7.1%
16	7.1%	7.1%	7.1%	7.1%	7.1%	7.2%	7.2%
17	7.7%	7.7%	7.7%	7.7%	7.7%	7.1%	7.1%
18	7.9%	7.9%	7.9%	7.9%	7.9%	6.8%	6.8%
19	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
20	4.4%	4.4%	4.4%	4.4%	4.4%	5.2%	5.2%
21	3.5%	3.5%	3.5%	3.5%	3.5%	4.3%	4.3%
22	3.1%	3.1%	3.1%	3.1%	3.1%	3.9%	3.9%
23	2.5%	2.5%	2.5%	2.5%	2.5%	3.2%	3.2%
24	1.9%	1.9%	1.9%	1.9%	1.9%	2.4%	2.4%

3.4 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 study area. The combined data was processed to reflect conditions at the study 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) is shown in **Figure 10**: Wind Frequency Diagram for Toronto Pearson International Airport (2012-2016)

As can be seen in this figure, predominant winds are from the south-westerly through northerly directions.

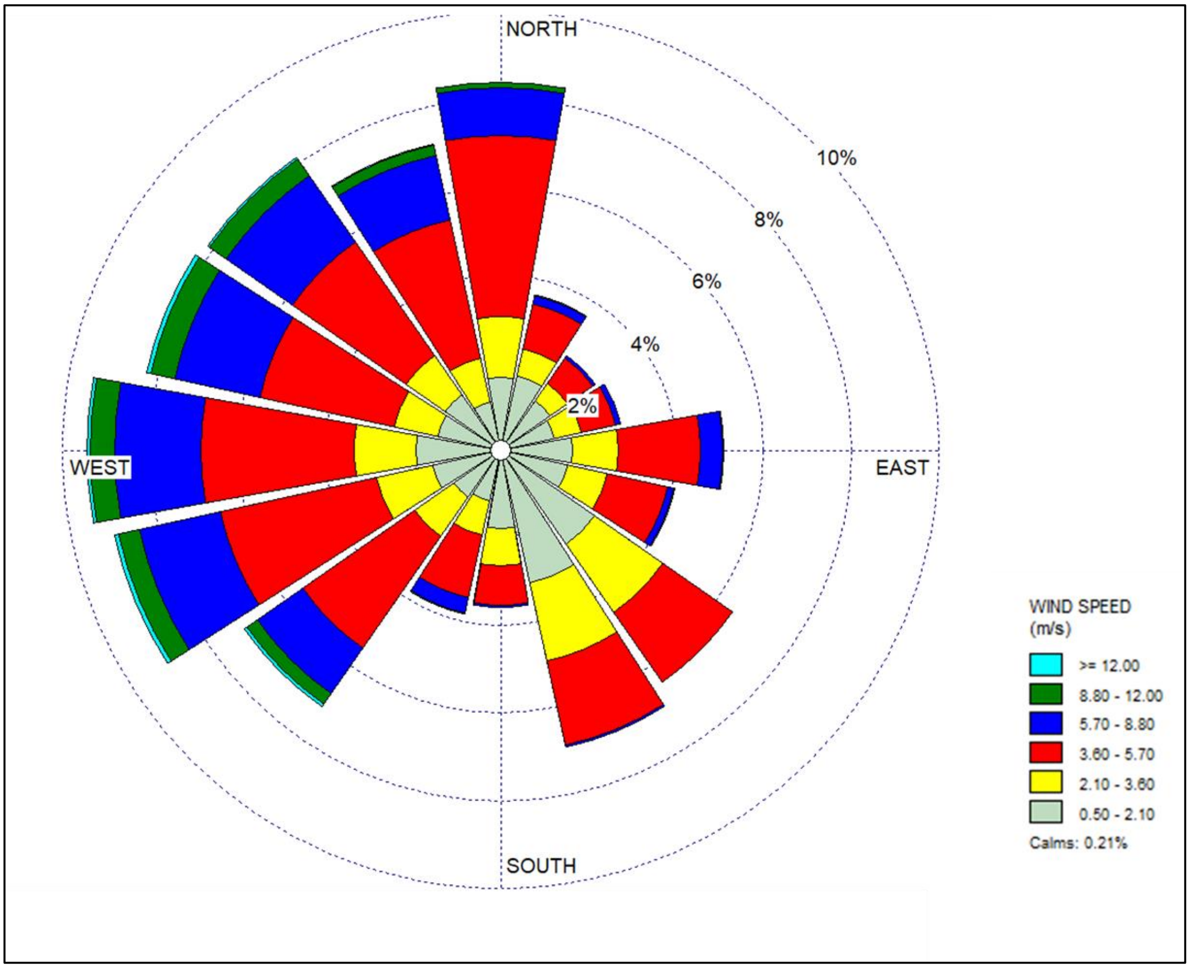


Figure 10: Wind Frequency Diagram for Toronto Pearson International Airport (2012-2016)

3.5 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 latest tool for estimating vehicle emissions due to the combustion of fuel, brake and tire wear, fuel evaporation, permeation, and refuelling leaks. The model is based on "an analysis of millions of emission test results and considerable advances in the Agency's understanding of vehicle emissions and accounts for changes in emissions due to proposed standards and regulations". For this project, MOVES was used to estimate vehicle emissions based on vehicle type, road type, model year, and vehicle speed. Emission rates were estimated based on the heavy-duty vehicle percentages provided by CIMA+. Vehicle age was based on the U.S. EPA's default distribution. **Table 8** specifies the major inputs into MOVES.

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	2017 (Existing) and 2037 (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 Collectors (Existing) and Urban Collectors (Future)
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 PM10 exhaust emission rate was used for TSP.
Vehicle Age Distribution	MOVES defaults based on years selected for the roadway.

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 Existing and Future Build years. Note that these emissions are for the highest heavy-duty vehicle percentage (13%). Emissions for the lower heavy-duty vehicle percentages would be lower. As shown in **Table 9**, emissions in the future year are generally predicted to decrease.

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

Year	Speed	CO	NO_x	Benzene	1,3-Butadiene	Formaldehyde	Acetaldehyde	Acrolein	$PM_{2.5}$	PM_{10}	TSP[1]
2017	80 km/hr	2.5764	0.3956	0.0022	0.0002	0.0021	0.0010	0.0001	0.0159	0.0368	0.0368
	60 km/hr	2.9909	0.3003	0.0025	0.0002	0.0016	0.0009	0.0001	0.0158	0.0550	0.0550
	50 km/hr	1.1677	0.2165	0.0010	0.0000	0.0017	0.0006	0.0001	0.0145	0.0704	0.0704
	Idle	12.7401	4.0127	0.0579	0.0056	0.0530	0.0271	0.0037	0.2630	0.2883	0.2883
2037	80 km/hr	0.8770	0.0835	0.0007	0.0000	0.0007	0.0002	0.0000	0.0061	0.0256	0.0256
	60 km/hr	0.9406	0.0539	0.0008	0.0000	0.0005	0.0002	0.0000	0.0086	0.0474	0.0474
	50 km/hr	0.9858	0.0752	0.0009	0.0000	0.0008	0.0003	0.0000	0.0112	0.0635	0.0635
	Idle	2.2375	0.5050	0.0104	0.0000	0.0110	0.0038	0.0005	0.0390	0.0434	0.0434

[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.

3.6 Re-suspended Particulate Matter Emission Rates

A large portion of roadway particulate matter emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the roadway. These emissions are estimated using empirically derived values presented by the U.S. EPA in their AP-42 report. The emissions factors for re-suspended 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) PM2.5	PM10	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	0.6914

3.7 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
Surface Roughness	The land type surrounding the project site is categorized as 'low intensity residential'. The average surface roughness height for low intensity residential for all seasons of 52 cm was applied in the model.
Vehicle Emission Rate	Emission rates calculated in MOVES and AP-42 were input in g/VMT

3.8 Modelling Results

Presented below are the modelling results for the 2017 Existing and 2037 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 2037 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 2037 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	8
	24-hour	4
CO	1-hour	4
	8-hour	2
$PM_{2.5}$	24-hour	7
	Annual	4
PM_{10}	24-hour	13
TSP	24-hour	13
1,3-Butadiene	24-hour	1
	Annual	1
Formaldehyde	24-hour	4
Benzene	24-hour	4
	Annual	4
Acrolein	1-hour	4
	24-hour	4
Acetaldehyde	24-hour	2

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 excesses of the guideline were predicted, frequency analysis was undertaken in order to estimate the number of occurrences above the guideline. Provided below are the modelling results for the contaminants of interest.

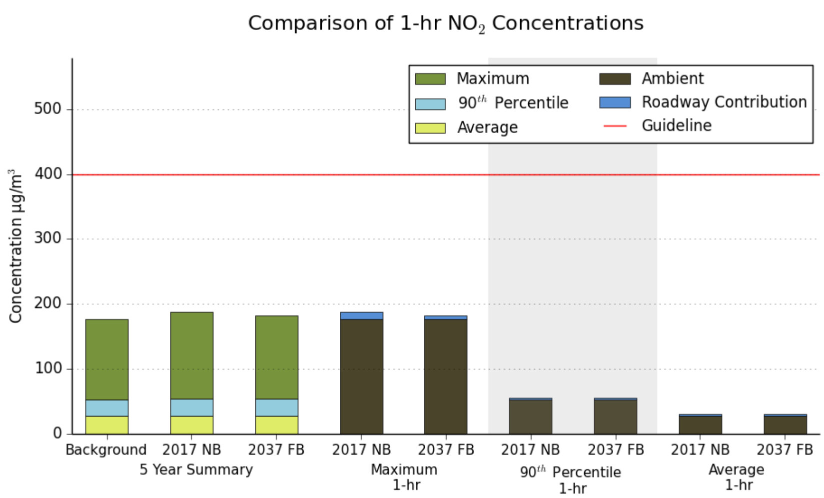
Nitrogen Dioxide

Table 13 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.*

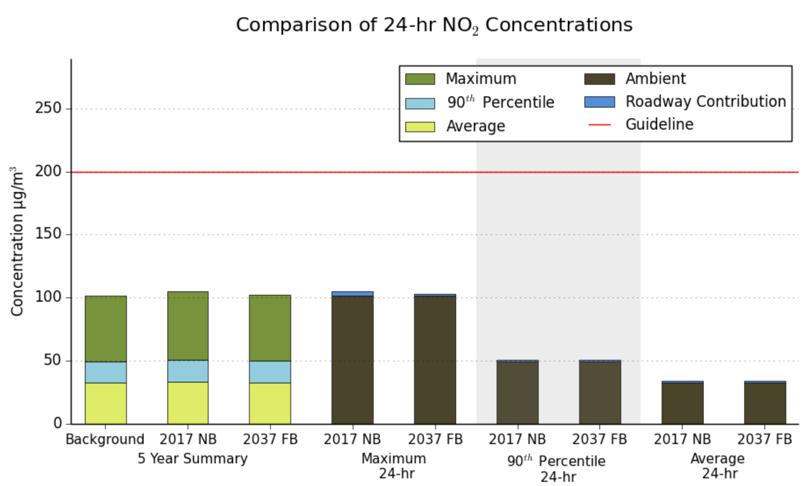
Table 13: Summary of Predicted NO_2 Concentrations

Statistical Analysis	2037 FB	



% of MECP Guideline:	
Maximum	45%
90th Percentile	13%
Average	7%
Roadway Contribution:	
Maximum	3%
90th Percentile	1%
Average	1%

All combined concentrations are below the 1-hour MECP 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, which is not included in the analysis.



% 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 less than 3%.

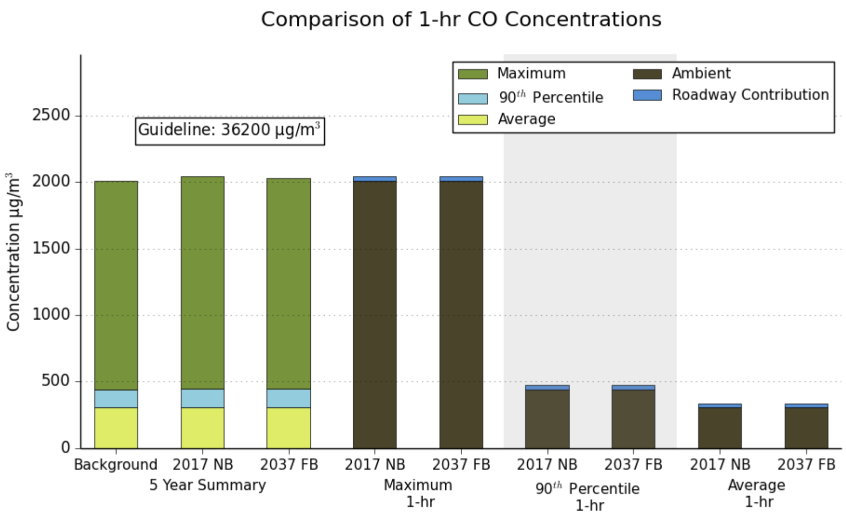
Carbon Monoxide

Table 14 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:

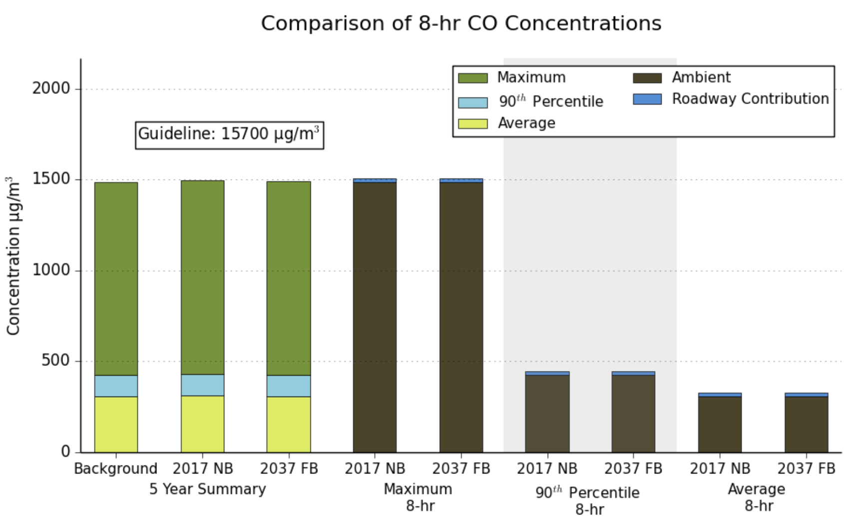
- *Both the maximum 1-hour and 8-hour CO combined concentrations were well below their respective MECP guidelines.*

Table 14: Summary of Predicted CO Concentrations

Statistical Analysis	2037 FB



% of MECP Guideline:	
Maximum	6%
90th Percentile	1%
Average	1%
Roadway Contribution:	
Maximum	1%
90th Percentile	1%
Average	1%



% of MECP Guideline:	
Maximum	9%
90th Percentile	3%
Average	2%
Roadway Contribution:	
Maximum	2%
90th Percentile	1%
Average	1%

Conclusions:

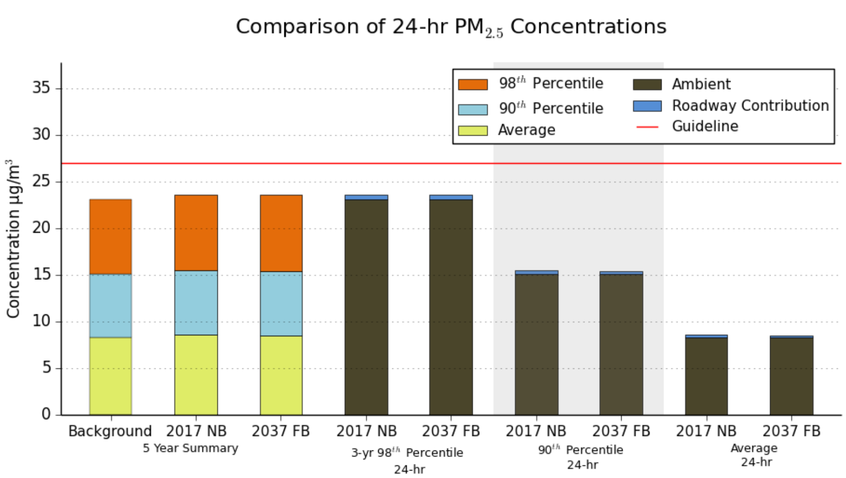
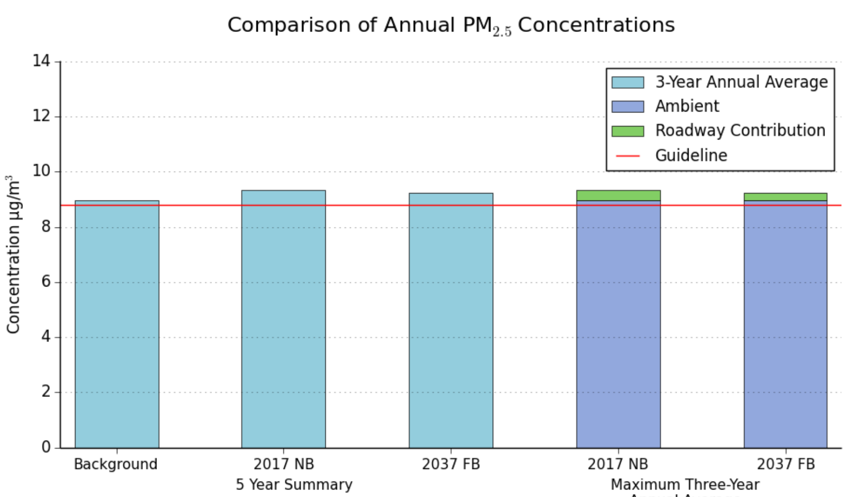
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 2% or less.

Fine Particulate Matter ($PM_{2.5}$)

Table 15 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 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 15: Summary of Predicted $PM_{2.5}$ Concentrations

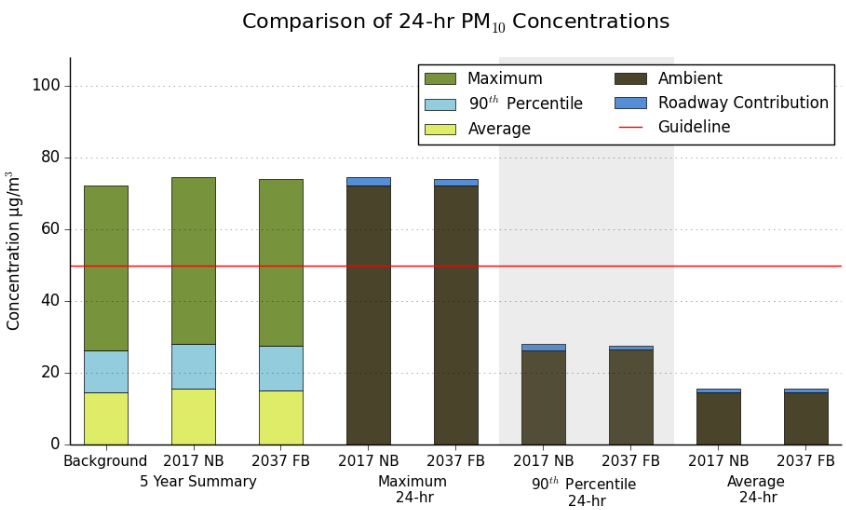
Statistical Analysis	2037 FB	
	**% of CAAQs Guideline:**	
	98th Percentile	87%
	90th Percentile	57%
	Average	32%
	Roadway Contribution:	
	98th Percentile	2%
	90th Percentile	2%
	Average	5%
	The $PM_{2.5}$ results were below the 3-year CAAQS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 23.35 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. It should be noted that ambient concentrations alone were 105% of the guideline.	

Coarse Particulate Matter (PM_{10})

Table 16 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 16: Summary of Predicted PM_{10} Concentrations

Statistical Analysis	2037 FB	
	**% of MECP Guideline:**	
	Maximum	148%
	90th Percentile	55%
	Average	30%
	Roadway Contribution:	
	Maximum	3%
	90th Percentile	4%
	Average	5%

Conclusions:

- The combined concentrations of PM_{10} surrounding the study area exceed the standard of 50 µg/m^3. It should be noted, however, that background concentrations alone exceeded the standard 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 14 days exceeded the guideline in the five-year period, which equates to less than 1% of the time.
- Frequency analysis showed that no additional exceedances are expected due to the roadway over the five-year period, when comparing the 2017 Existing scenario and the 2037 Future Build scenario.

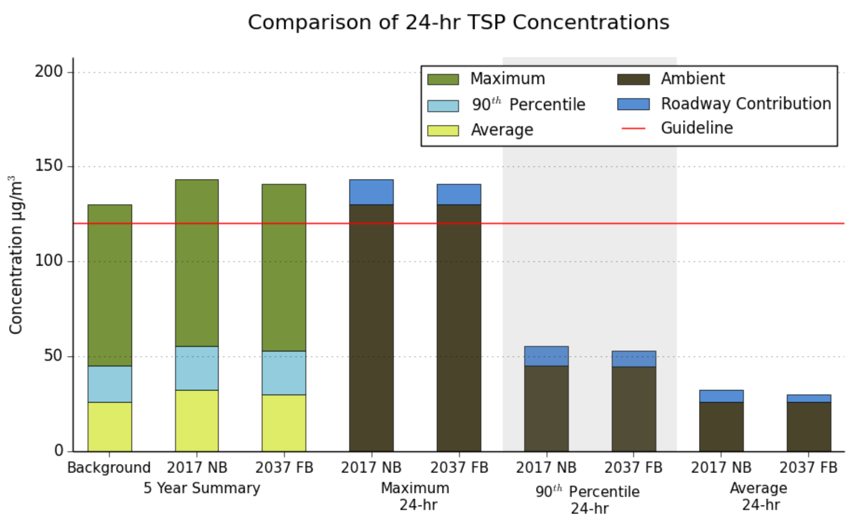
Total Suspended Particulate Matter (TSP)

Table 17 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 17: Summary of Predicted TSP Concentrations

Statistical Analysis	2037 FB



% of MECP Guideline:	
Maximum	117%
90th Percentile	44%
Average	25%
Roadway Contribution:	
Maximum	8%
90th Percentile	16%
Average	14%

Conclusions:

- The TSP results show that the combined concentrations exceed the guideline. It should be noted, however, that background concentrations alone exceeded the standard and that the roadway contribution is 8% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- 2 days exceeded the guideline in the five-year period in, which equates to less than 1%.
- Frequency analysis showed that no additional exceedances are expected due to the roadway over the five-year period, when comparing the 2017 Existing scenario and the 2037 Future Build scenario.

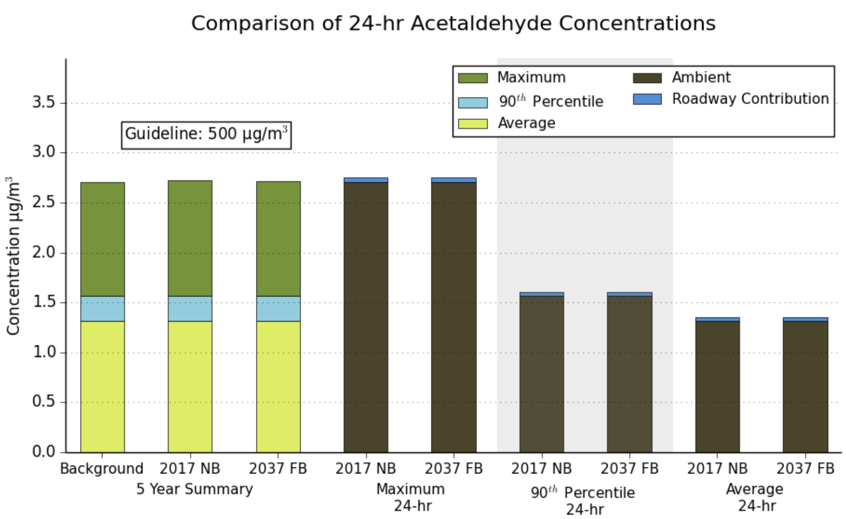
Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to combine the ambient data to the modelled results, the measured concentrations were applied to the following 6 days when measurements were 6 days apart. When measurements were further than 6 days apart, the 90th percentile 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.

Acetaldehyde

Table 18 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 18: Summary of Predicted Acetaldehyde Concentrations

Statistical Analysis	2037 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 their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was less than 1%.

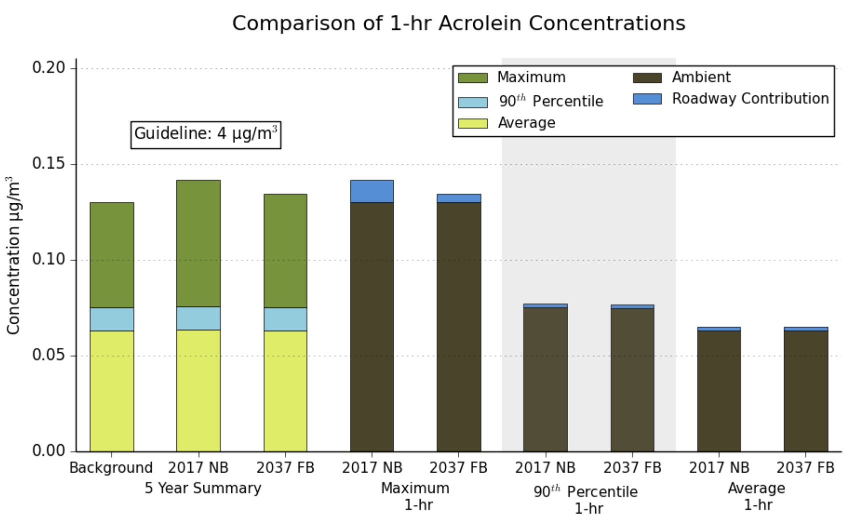
Acrolein

Table 19 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.*

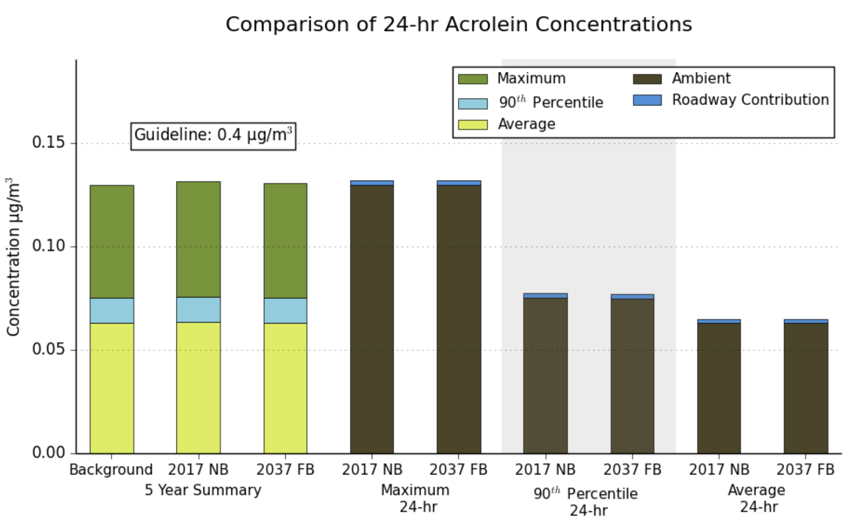
Table 19: Summary of Predicted Acrolein Concentrations

Statistical Analysis	2037 FB



% of MECP Guideline:	
Maximum	3%
90th Percentile	2%
Average	1%
Roadway Contribution:	
Maximum	3%
90th Percentile	<1%
Average	<1%

Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was 3% or less.



% of MECP Guideline:	
Maximum	33%
90th Percentile	19%
Average	16%
Roadway Contribution	
Maximum	<1%
90th Percentile	<1%
Average	<1%

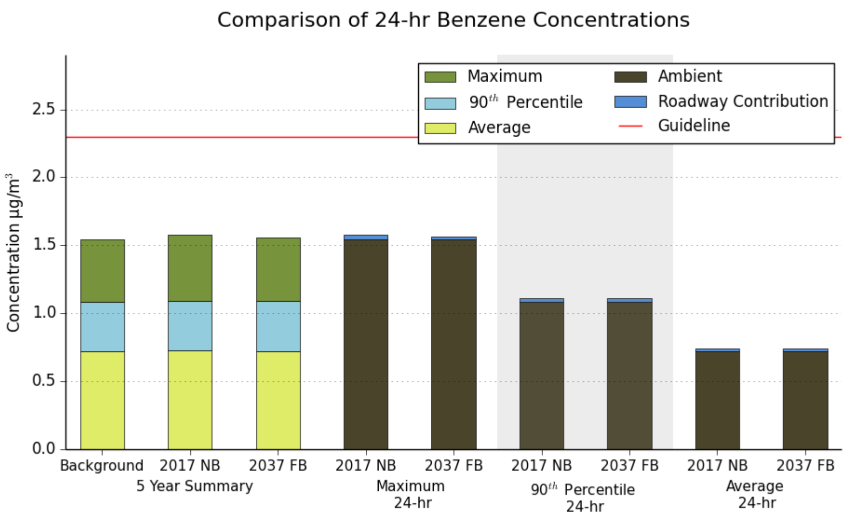
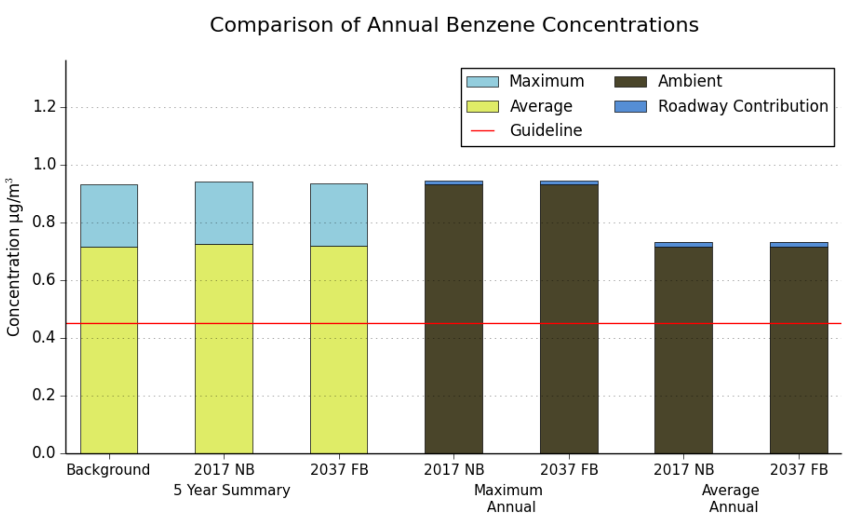
Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was less than 1%.

Benzene

Table 20 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 annual benzene concentration exceeded the guidline due to ambient concentrations. The roadway contribution to the maximum annual average was 1%.*

Table 20: Summary of Predicted Benzene Concentrations

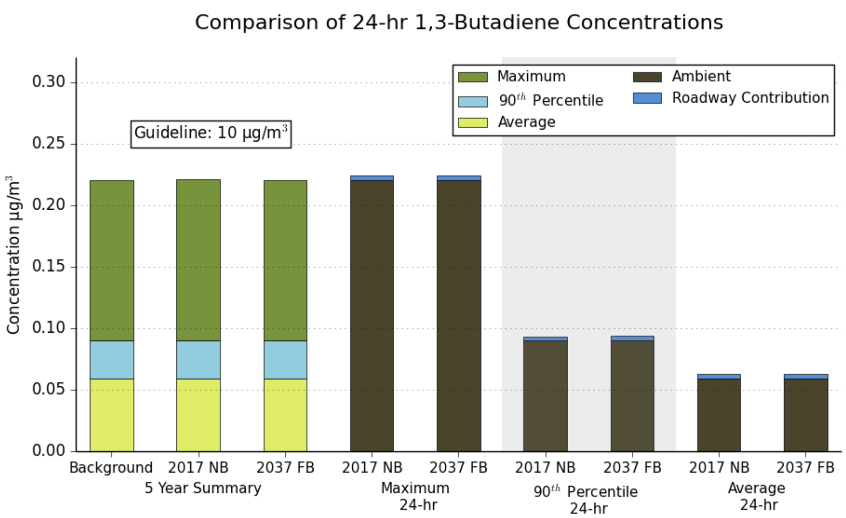
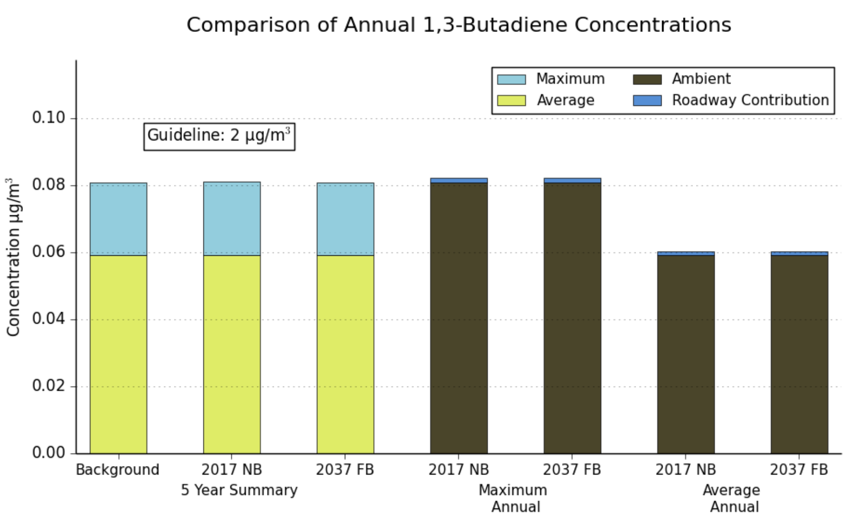
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2037 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>68%</td></tr>
<tr><td>90th Percentile</td><td>47%</td></tr>
<tr><td>Average</td><td>31%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was 1% or less.</td></tr>
<tr><td rowspan="7">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>208%</td></tr>
<tr><td>Average</td><td>160%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Conclusions:
The combined concentration exceeded the MECP guideline. It should be noted that ambient concentrations were 208% of the guideline and the roadway contribution to the maximum was 1%.</td></tr>
</table>

1,3-Butadiene

Table 21 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 21: Summary of Predicted 1,3-Butadiene Concentrations

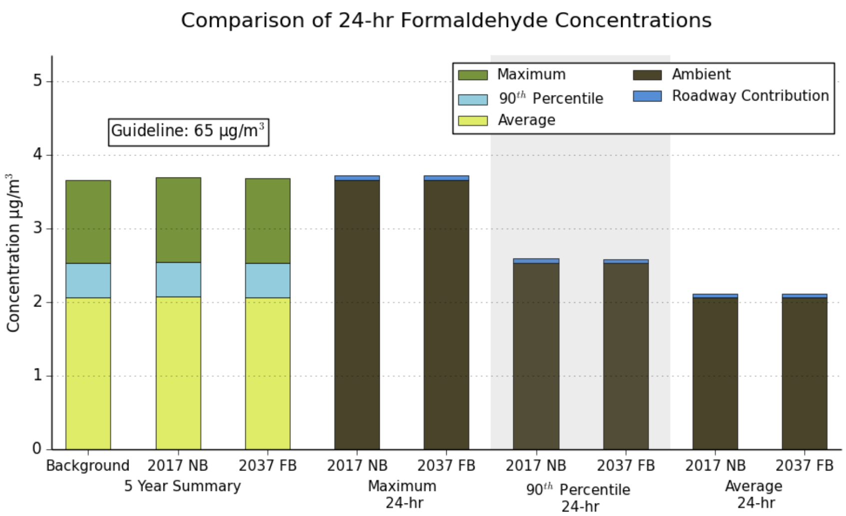
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2037 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>2%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was less than 1%.</td></tr>
<tr><td rowspan="7">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>4%</td></tr>
<tr><td>Average</td><td>3%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was less than 1%.</td></tr>
</table>

Formaldehyde

Table 22 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 22: Summary of Predicted Formaldehyde Concentrations

<table>
<tr><th>Statistical Analysis</th><th colspan="2">2037 FB</th></tr>
<tr><td rowspan="8">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>6%</td></tr>
<tr><td>90th Percentile</td><td>4%</td></tr>
<tr><td>Average</td><td>3%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="3">Conclusions:
• All combined concentrations were below their respective MECP guideline.
• The contribution from the roadway to the combined concentration was less than 1%.</td></tr>
</table>

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 2017 Existing and 2037 Future Build scenarios as well the total emission to the 2030 provincial and Canada-wide GHG targets. Total GHG emissions from the roadway were determined based on the length of the 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 duty vehicle percentage in the study area. **Table 23** summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions in the study area for the 2017 Existing and 2037 Future Build scenarios.

Table 23: Summary of New Kirby Road Extension Traffic Volumes, Roadway Length and Emission Rates

Roadway	2017 Two-Way AADT	2037 Two-Way AADT	Length of Roadway (Miles)	Heavy Duty Vehicle Percentage (%)	Posted Speed (km/hr)	2017 CO_2 Equivalent Emission Rate (g/VMT)	2037 CO_2 Equivalent Emission Rate (g/VMT)
19th Avenue	2,100	8,600	0.91	5%	60	391	247
Woodbine Avenue	7,600	15,700	1.60	13%	80	390	256
Honda Boulevard	4,800	6,900	0.49	5%	50	416	264
Road A	N/A	3,100	0.29	10%	50	N/A	291
Road C1	N/A	3,200	0.30	10%	50	N/A	291
Road D	N/A	2,400	0.45	10%	50	N/A	291
Road E1	N/A	2,400	0.40	10%	50	N/A	291

The total predicted annual GHG emission for the 2017 Existing and 2037 Future Build scenarios are shown in **Table 24**. 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 as well as the four newly built roadways, total GHG emissions will increase by 61%.

Table 25: Predicted GHG Emissions shows the total GHG emissions in the study area represent 0.0037% of the provincial target and 0.0007% of the Canada-wide target. The contribution of GHG emissions from the project is small in comparison to these provincial and national targets.

Table 24: Changes in predicted GHG Emissions

Roadway	2017 Total CO_2 Equivalent (tonnes/year)	2037 Total CO_2 Equivalent (tonnes/year)	Change in Emissions (%)
19th Avenue	306	725	159%
Woodbine Avenue	1730	2346	36%
Honda Boulevard	356	325	-9%
Road A	N/A	96	
Road C1	N/A	101	
Road D	N/A	115	
Road E1	N/A	103	
TOTAL 404 North Study Area	**2358**	**3790**	**+61%**

Table 25: Predicted GHG Emissions compare to GHG targets

Source	Total CO_2 Equivalent (tonnes/year)
Total 404 North Study Area	3,790
Comparison to Canada-wide Target	0.000733%
Comparison to Ontario-wide Target	0.00370%
Comparison to Transportation Target	0.00231%
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**

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

[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

chemical suppressants to reduce dust, use of wind barriers, and limiting exposed areas which may be a source of dust and equipment washing. It is recommended that these best management practices be followed during construction of the roadway to reduce any air quality impacts that may occur.

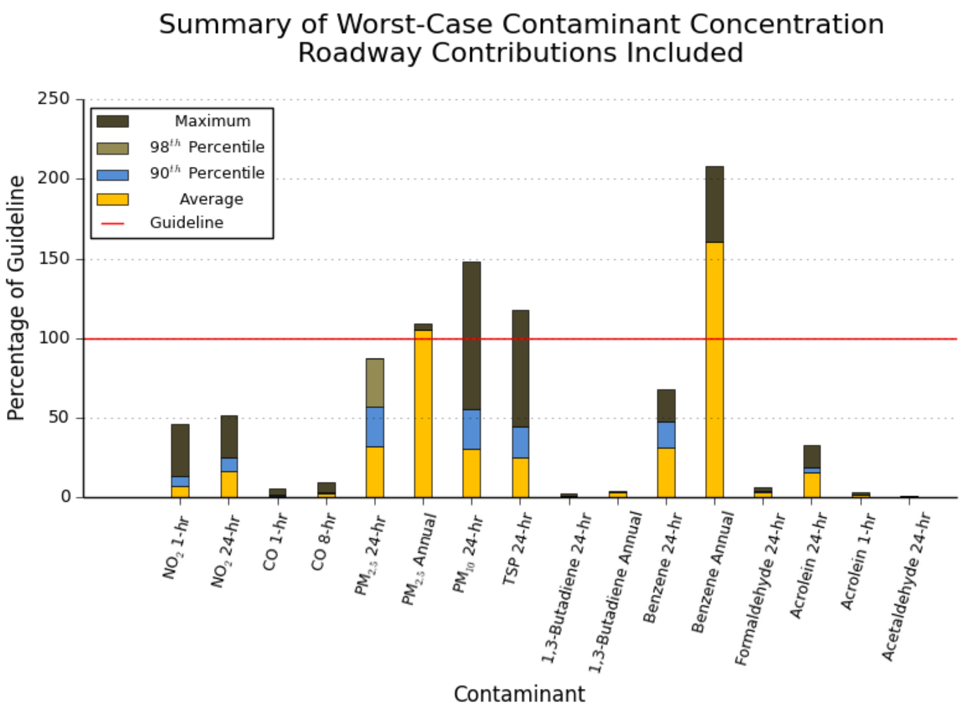
6.0 Conclusions and Recommendations

The potential impact of the proposed project infrastructure on local air quality has been assessed and the results are summarized in **Table 26**. An assessment of GHG emissions was also conducted. The following conclusions and recommendations are a result of this assessment.

- *The maximum combined concentrations for the future build scenario were all below their respective MECP guidelines or CAAQS, with the exception of annual $PM_{2.5}$, 24-hr PM_{10}, 24-hr TSP and annual benzene. Note that for each of these contaminants, background concentrations alone exceeded the guidelines.*
- *Frequency Analysis determined that there were no additional days on which exceedances of PM_{10} or TSP occurred in 2037 Future Build scenarios in comparison to the 2017 Existing scenario. For both PM_{10} and TSP, exceedances of the guideline occurred less than 1% of the time.*
- *Mitigation measures are not warranted, due to the small number of days which are expected to exceed the guideline.*
- *Total GHG emissions in the study area were predicted and compared to the provincial, sector and Canada-wide targets. Overall, the contributions from the project account for less than 0.004% of the province target and sector target.*

Table 26: Summary of 2037 Future Build Results

5 Year Statistical Summary



Note: The $PM_{2.5}$ results are in compliance with the CAAQS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 23.35 μg/m³ or 86% of the CAAQS.

% of Guideline

2037 Future Build	
NO_2 (1-hr)	46%
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}	148%
TSP	117%
Acetaldehyde	<1%
Acrolein (1-hr)	3%
Acrolein (24-hr)	33%
Benzene (24-hr)	68%
Benzene (Annual)	208%
1,3-Butadiene (24-hr)	2%
1,3-Butadiene (Annual)	4%
Formaldehyde	6%

7.0 References

Air & Waste Management Association, 2011. The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions. [online] http://www.epa.gov/nrmrl/appcd/nearroadway/pdfs/baldauf.pdf

CCME, 2000. Canadian Council of Ministers of the Environment. Canada-Wide Standards of Particulate Matter and Ozone. *Endorsed by CCME Council of Ministers,* Quebec City. [Online]http://www.ccme.ca/assets/pdf/pmozone_standard_e.pdf

Environment Canada. 2000. Priority Substances List Assessment Report: Respirable Particulate Matter Less Than or Equal to 10 Microns. Canadian Environmental Protection Act, 1999. Environment Canada, Health Canada. [Online] http://www.ec.gc.ca/Substances/ese/eng/psap/final/PM-10.cfm.

Health Canada. 1999. National Ambient Air Quality Objectives for Particulate Matter Part 1: Science Assessment Document. Health Canada. A report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines.

Lall, R., Kendall, M., Ito, K., Thurston, G., 2004. Estimation of historical annual $PM_{2.5}$ exposures for health effects assessment. *Atmospheric Environment* 38(2004) 5217-5226.

Ontario Publication 6570e, 2008. *Ontario's Ambient Air Quality Criteria.* Standards Development Branch, Ontario Ministry of the Environment.

Ontario Ministry of the Environment, 2005. *Transboundary Air Pollution in Ontario.* Queens Printer for Ontario.

Randerson, D., 1984. *Atmospheric Science and Power Production* . United States Department of Energy.

Seinfeld, J.H. and Pandis, S.P.,2006. *Atmospheric Chemistry and Physics From Air Pollution to Climate Change.* New Jersey: John Wiley & Sons.

United States Environmental Protection Agency, 2008. *AERSURFACE User's Guide*. USEPA.

United States Environmental Protection Agency, 1997. *Document AP 42,* Volume I, Fifth Edition, Chapter 13.2.1. USEPA.

United States Environmental Protection Agency, 2010. *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition*. USEPA.

United States Environmental Protection Agency, 2009. *MOVES 2010 Highway Vehicles: Population and Activity Data*. USEPA.

WHO. 2005. WHO air quality guidelines global update 2005. Report on a Working Group meeting, Boon, Germany, October 18-20, 2005.

Appendix A
Receptor Specific Modelling Results

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This section shows the maximum results predicted by the air dispersion modelling at each receptor within the study area for the 2037 Future Build scenarios. **Figures A1 to A3** show the location of the evaluated receptors within the study area.

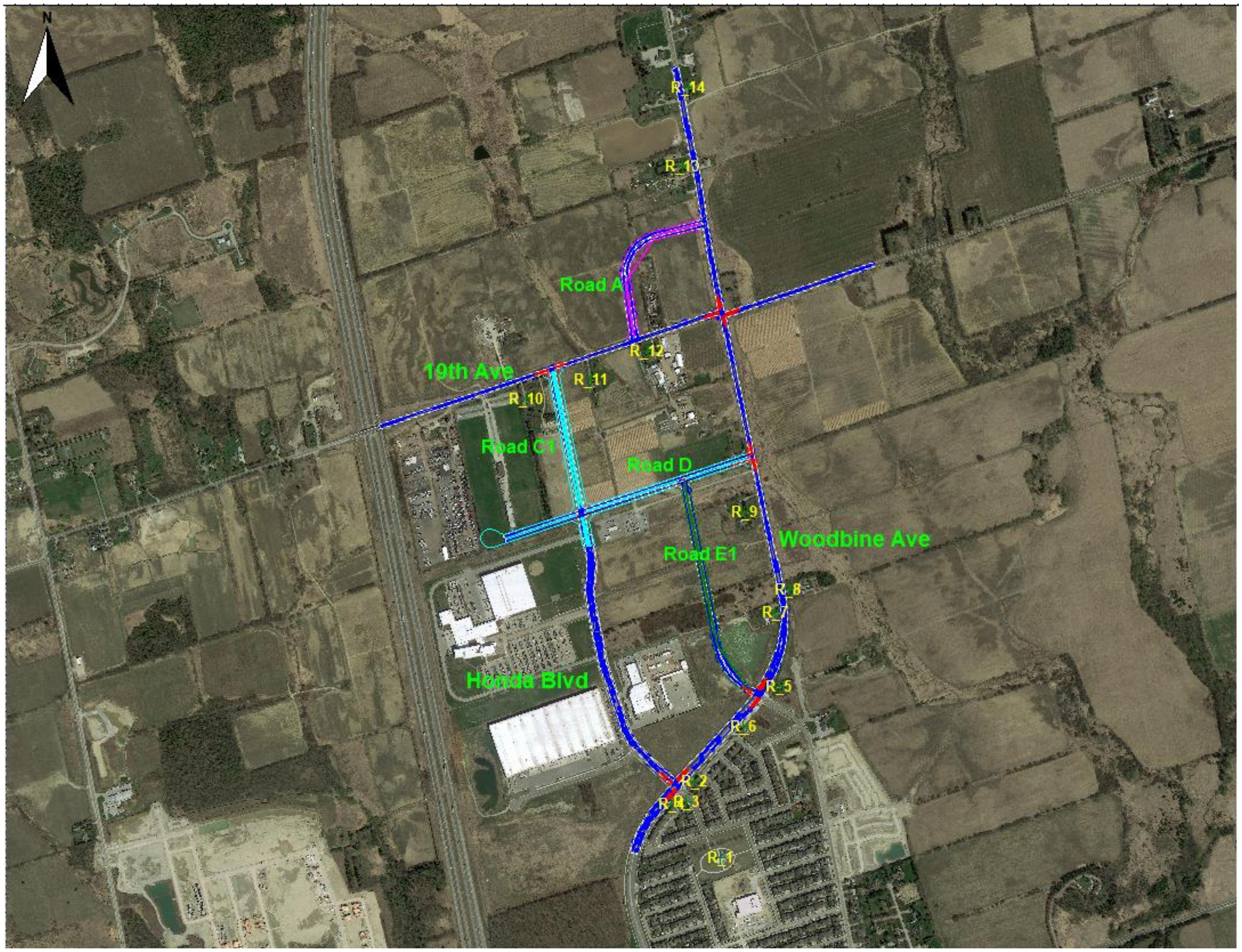


Figure A1: Receptor R1-R14 Locations within the Study Area

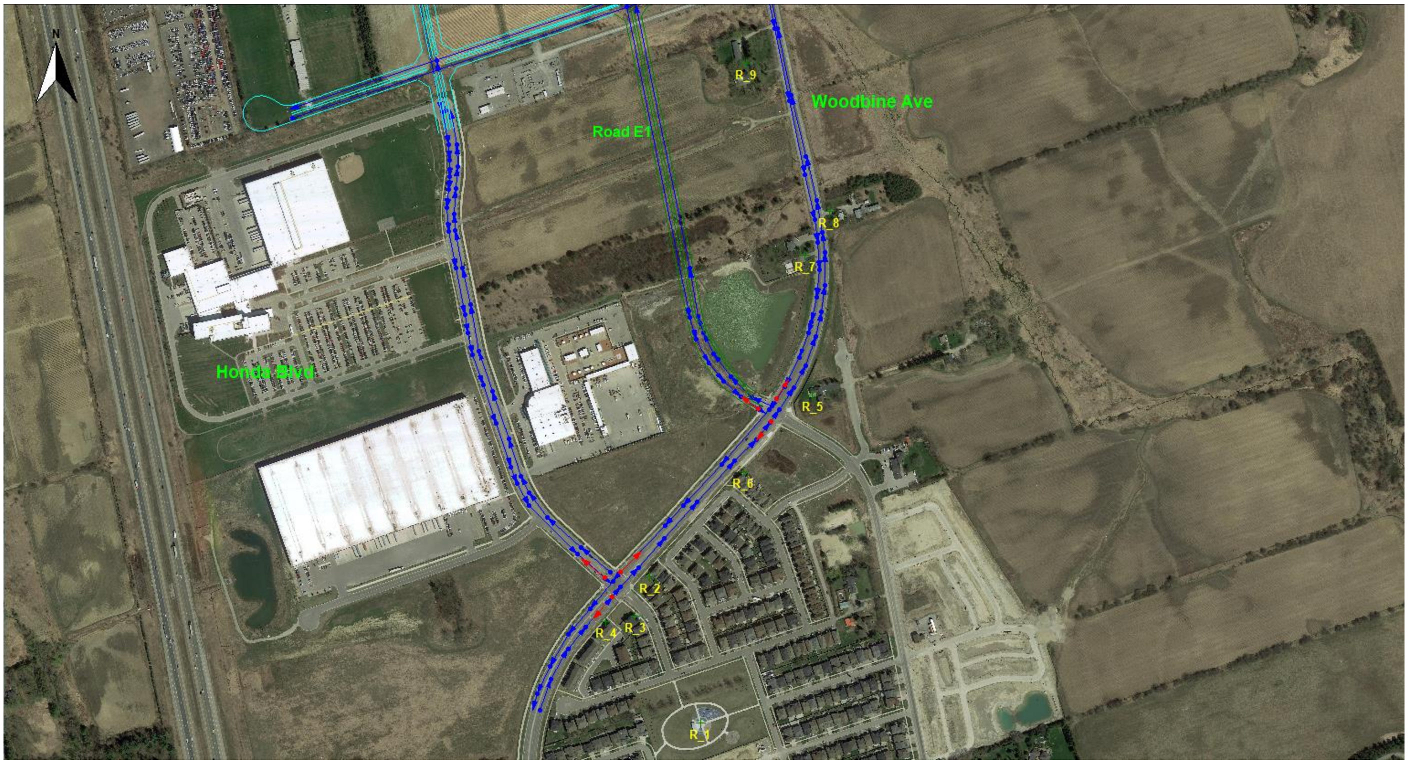


Figure A2: Receptor R1-R9 Locations within the Study Area

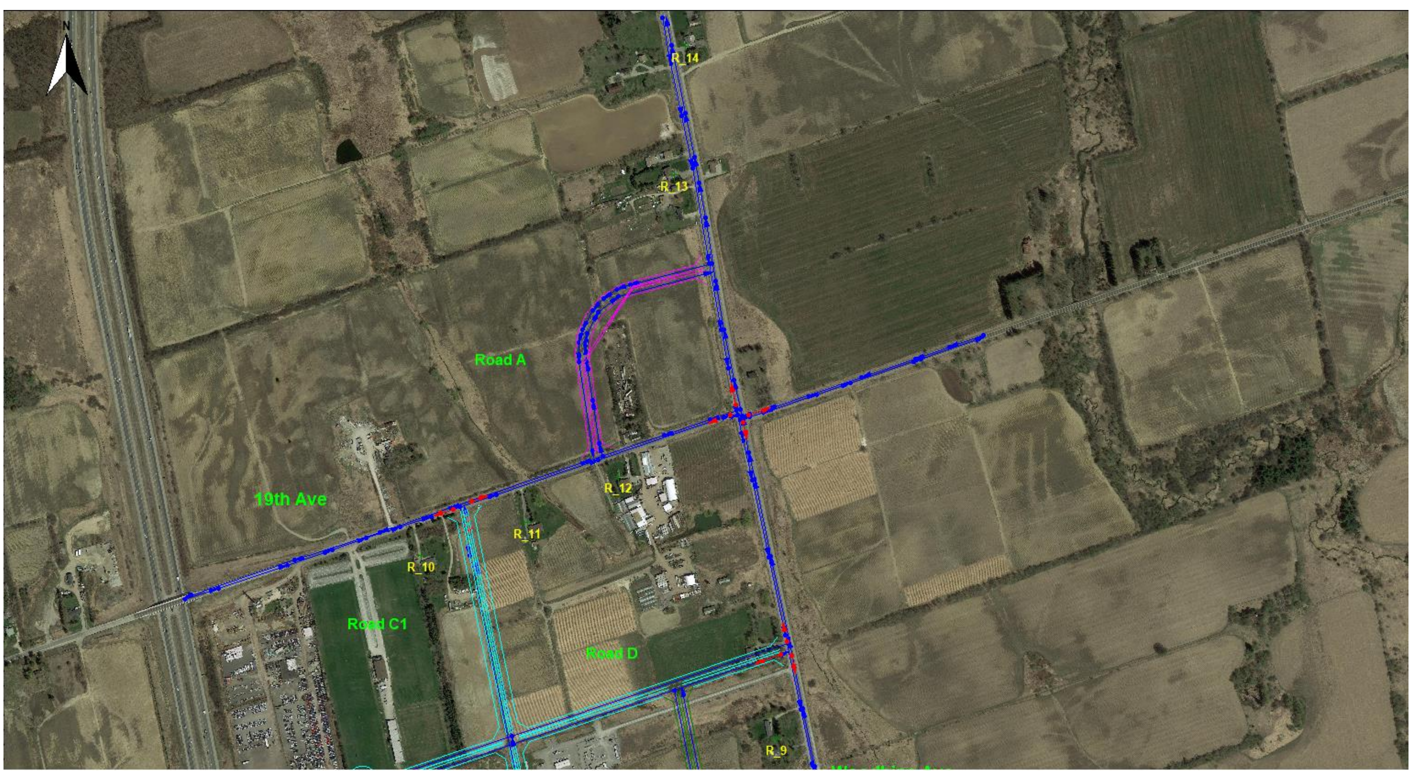
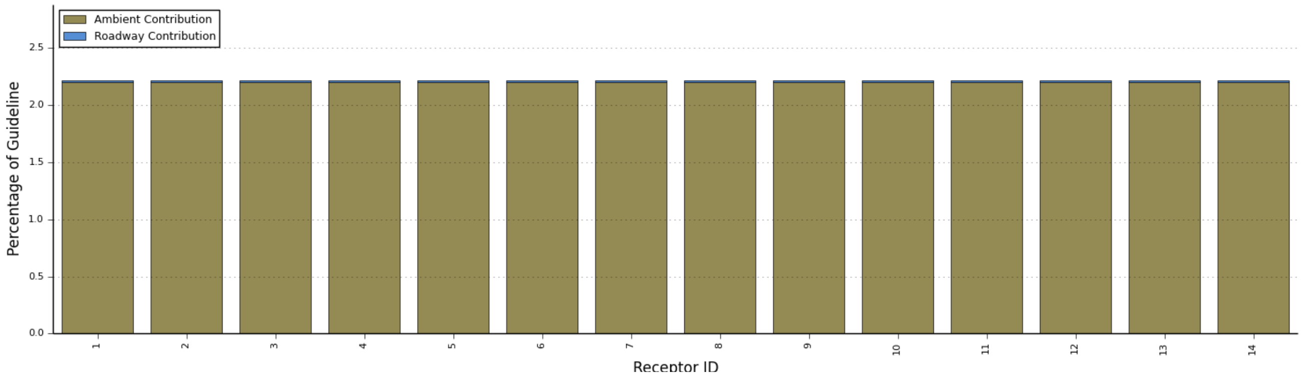
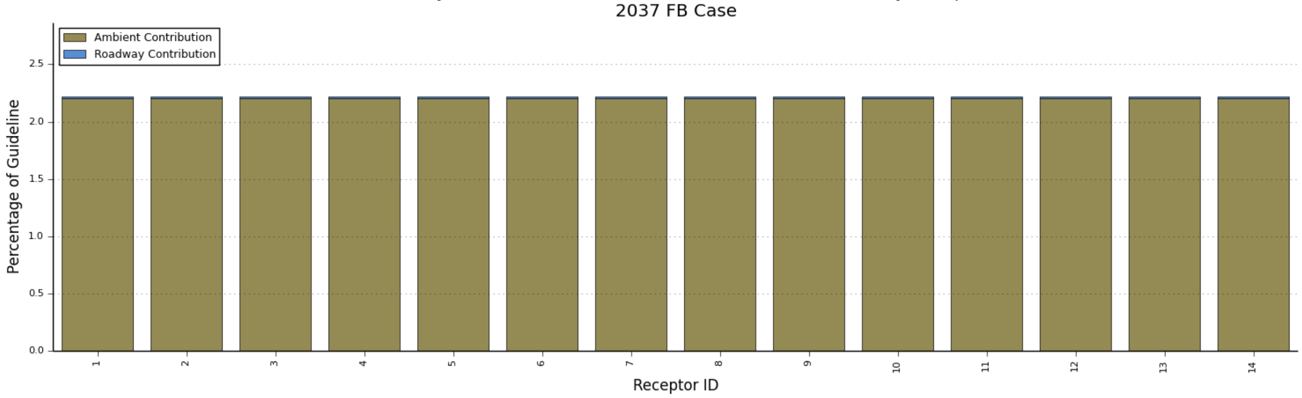


Figure A3: Receptor R9-R14 Locations within the Study Area

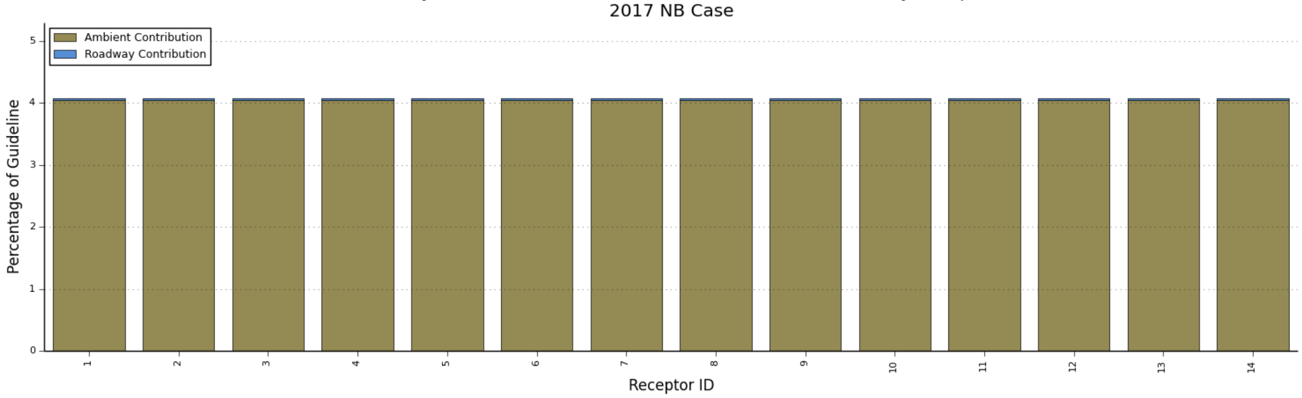
Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2017 NB Case

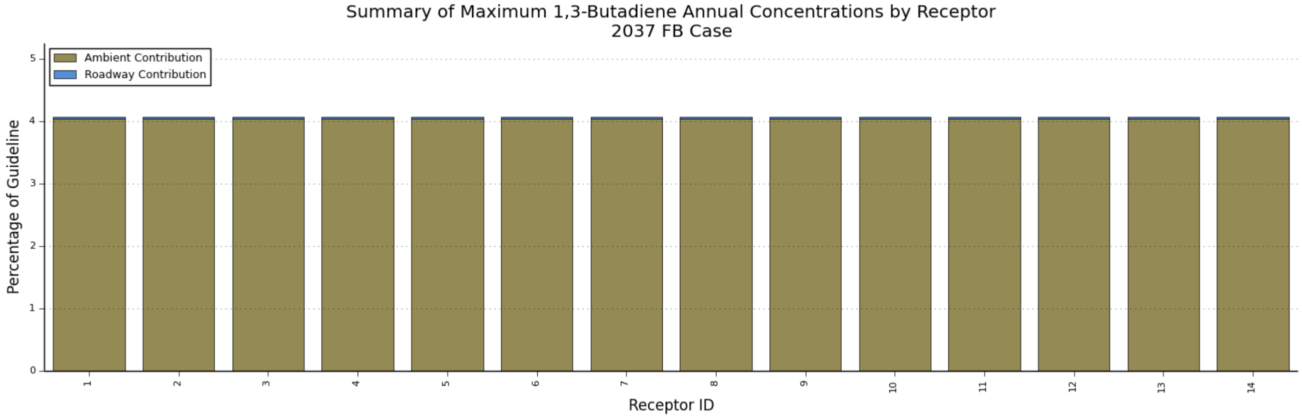


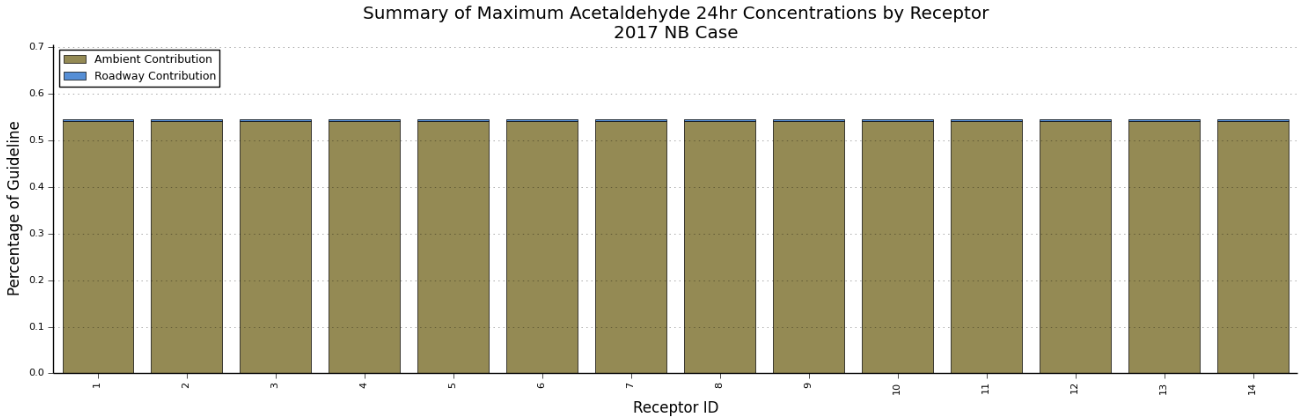
Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2037 FB Case

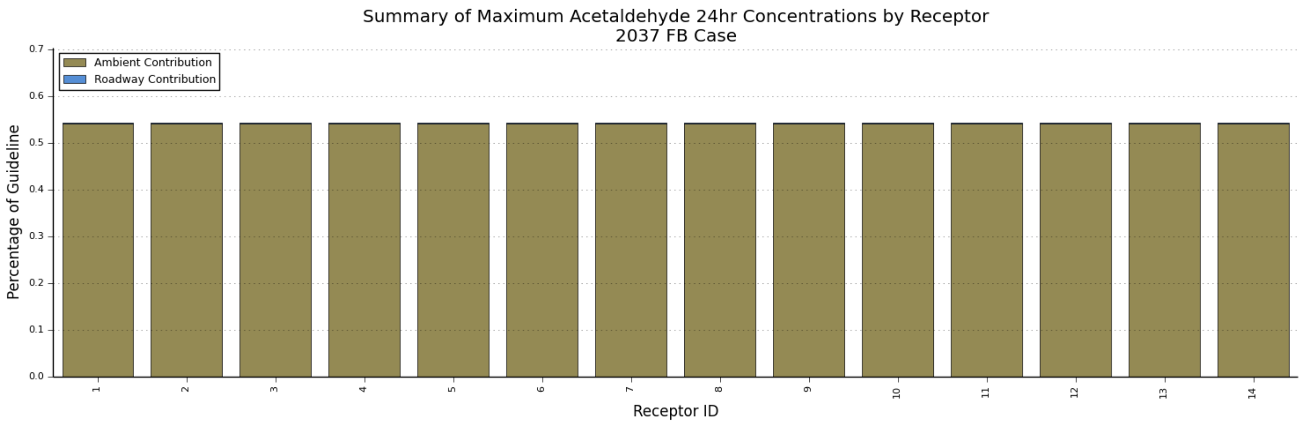


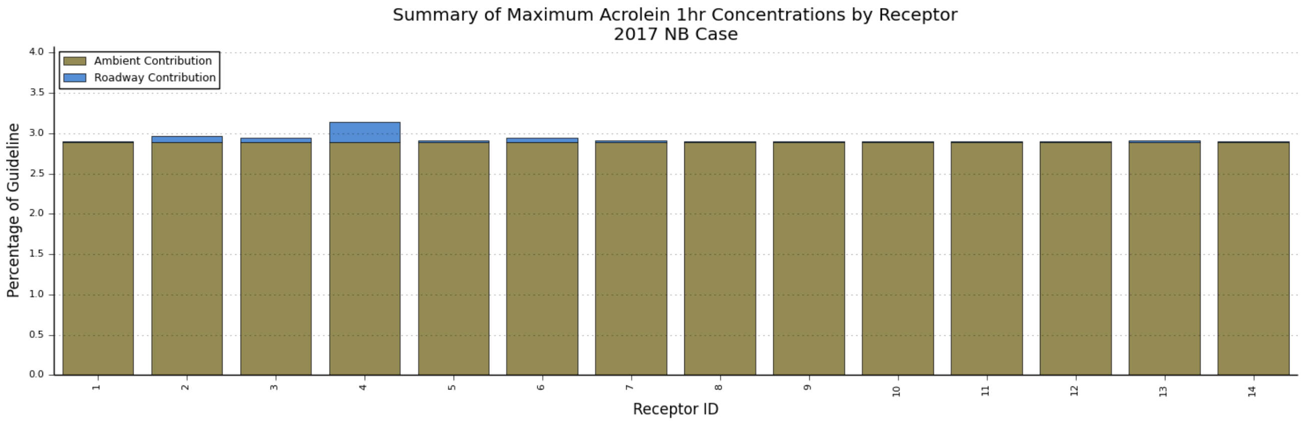
Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2017 NB Case

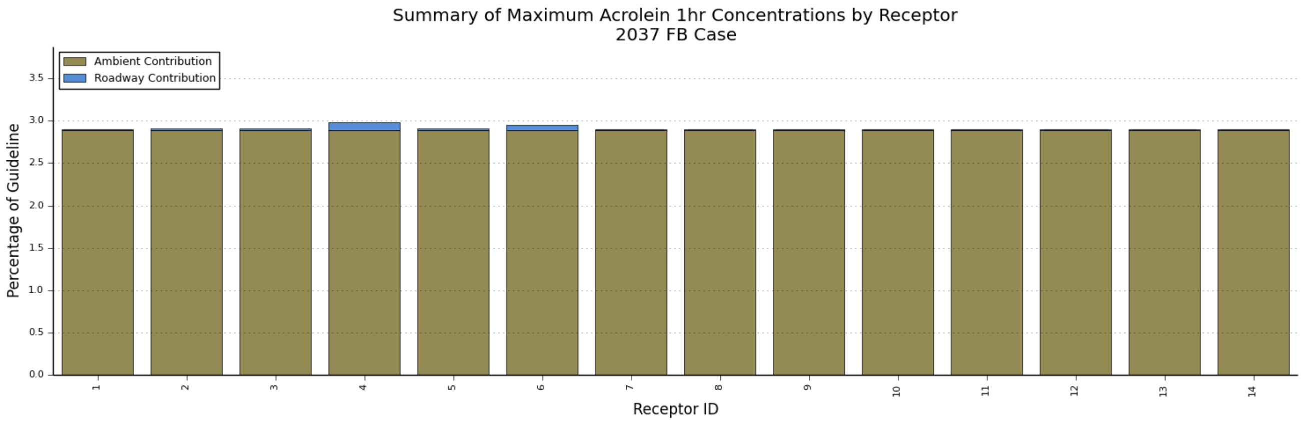


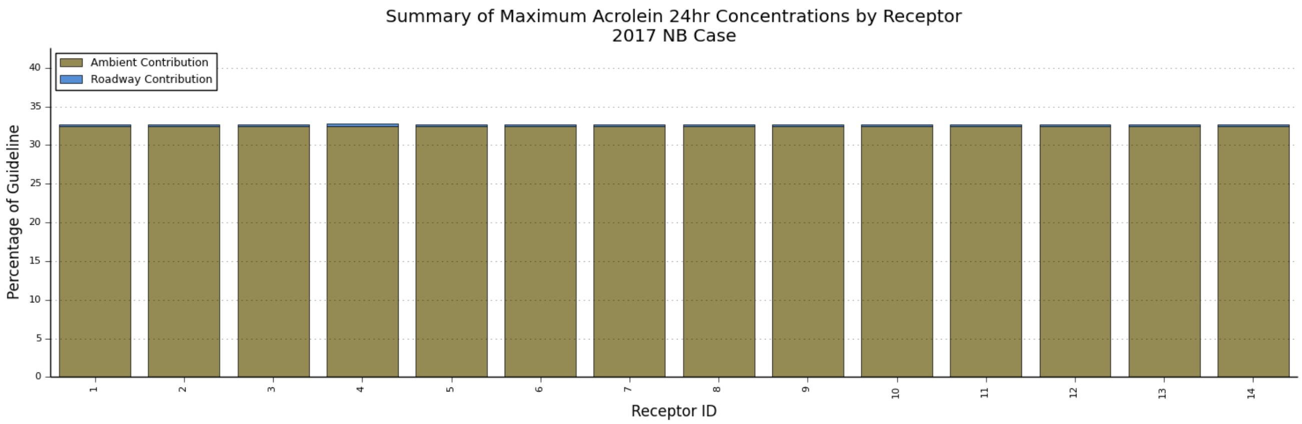

Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2037 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

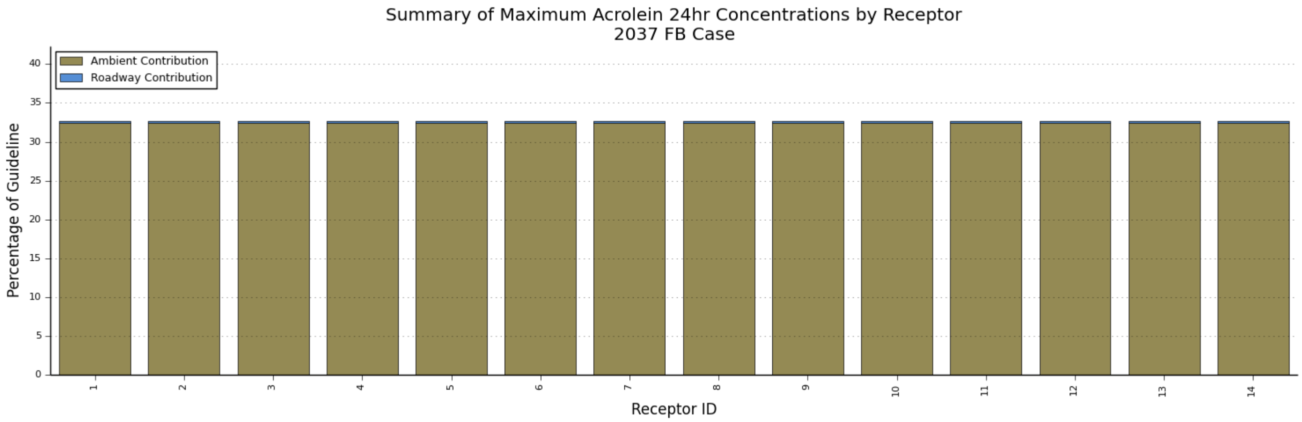

Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
2017 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
2037 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 1hr Concentrations by Receptor
2017 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 1hr Concentrations by Receptor
2037 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 24hr Concentrations by Receptor
2017 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 24hr Concentrations by Receptor
2037 FB Case
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Roadway Contribution
Percentage of Guideline
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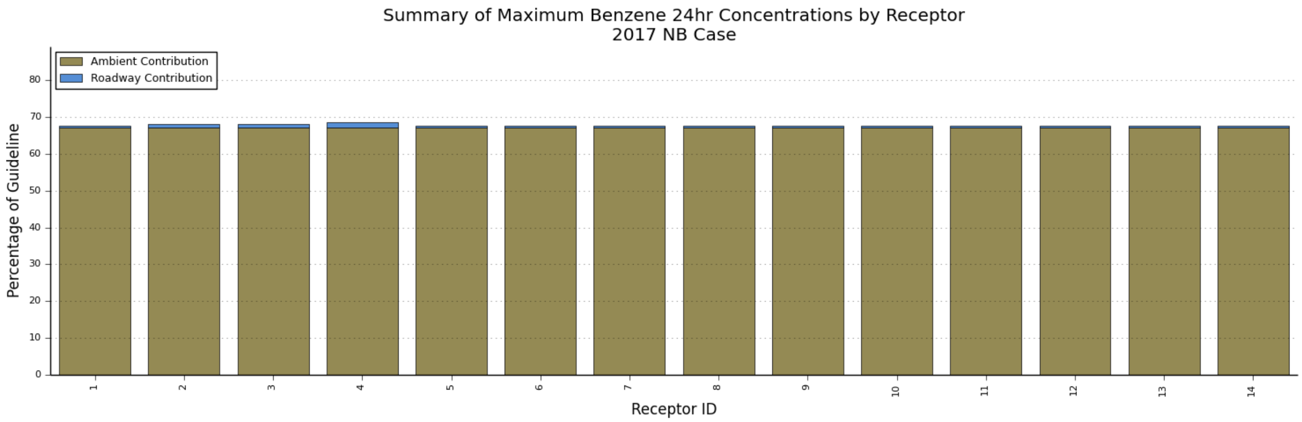
Receptor ID


Summary of Maximum Benzene 24hr Concentrations by Receptor
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Roadway Contribution
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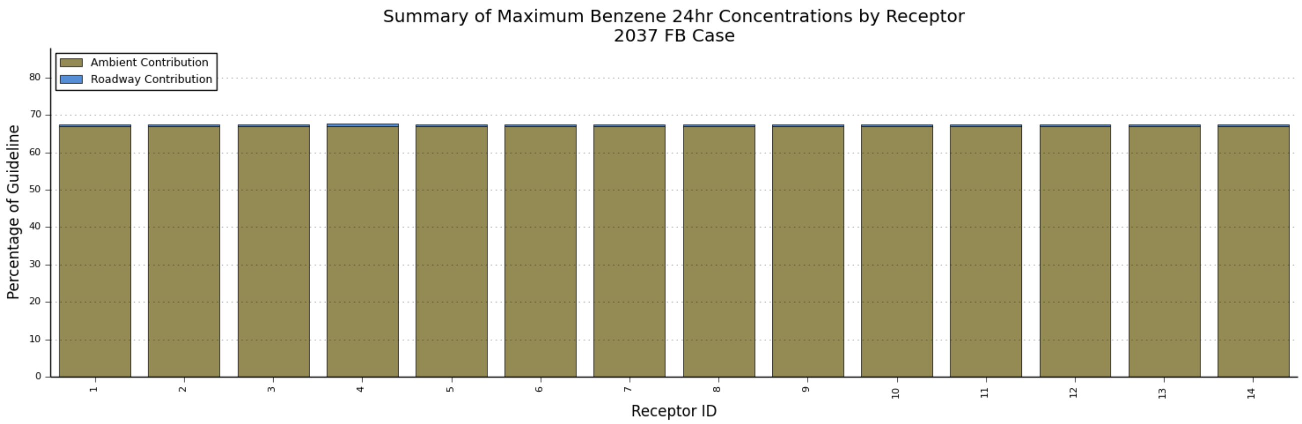
Summary of Maximum Benzene 24hr Concentrations by Receptor
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Ambient Contribution
Roadway Contribution
Percentage of Guideline
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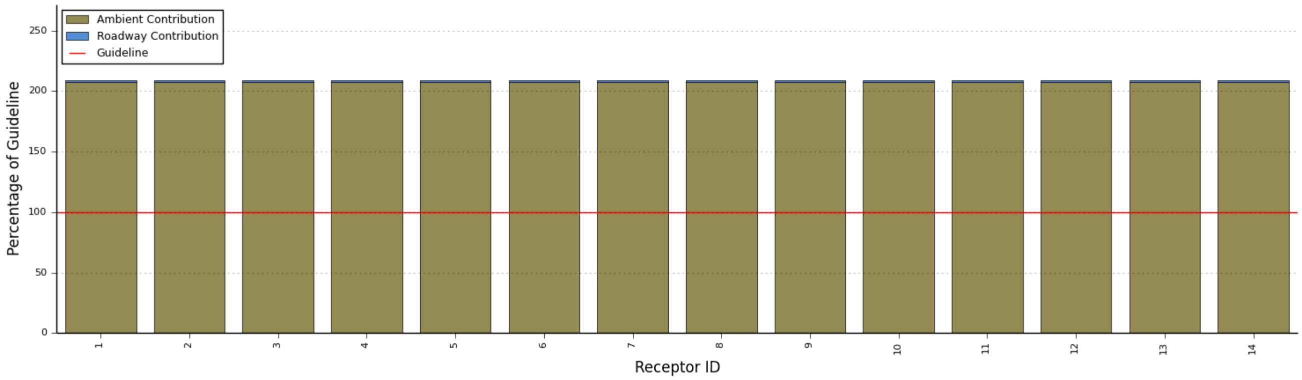
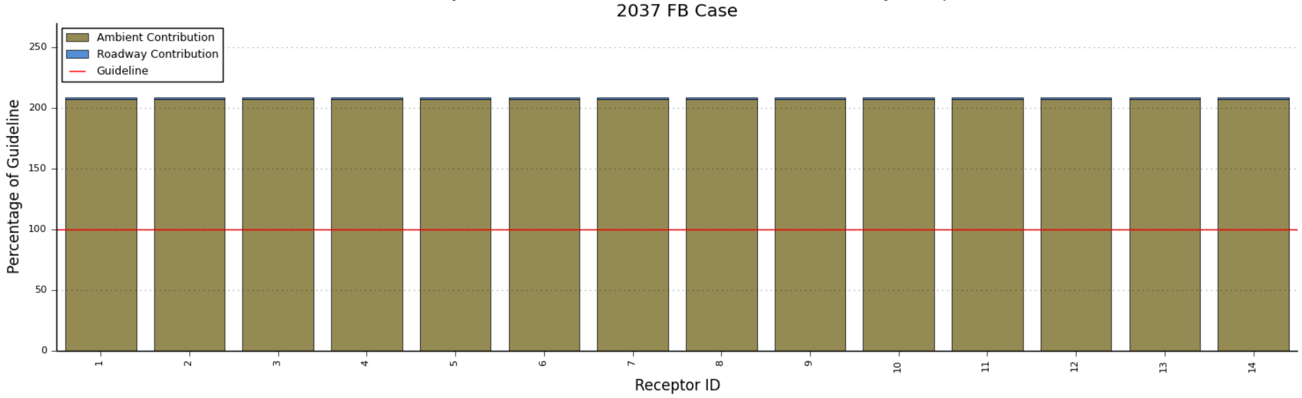
Receptor ID

Summary of Maximum Benzene Annual Concentrations by Receptor
2017 NB Case



Summary of Maximum Benzene Annual Concentrations by Receptor
2037 FB Case



Summary of Maximum CO 1hr Concentrations by Receptor
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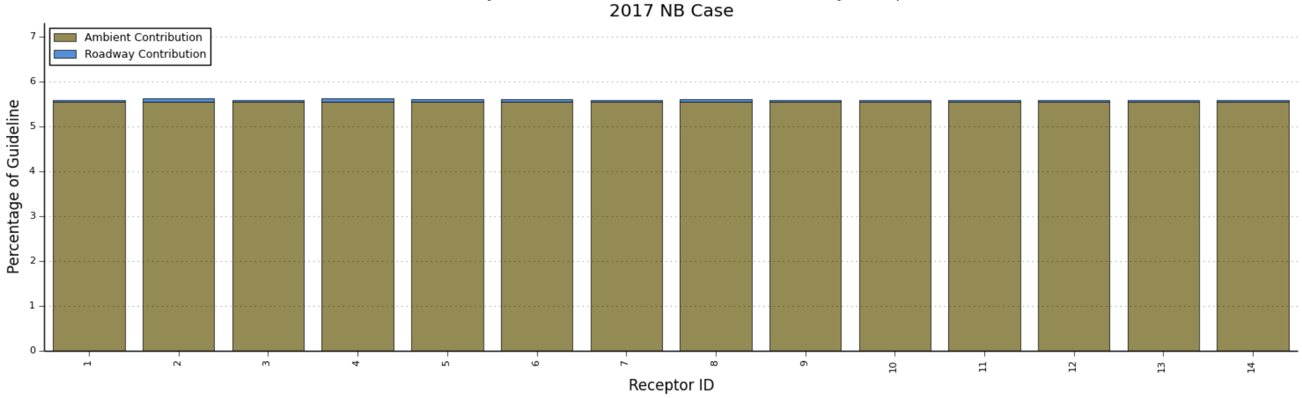

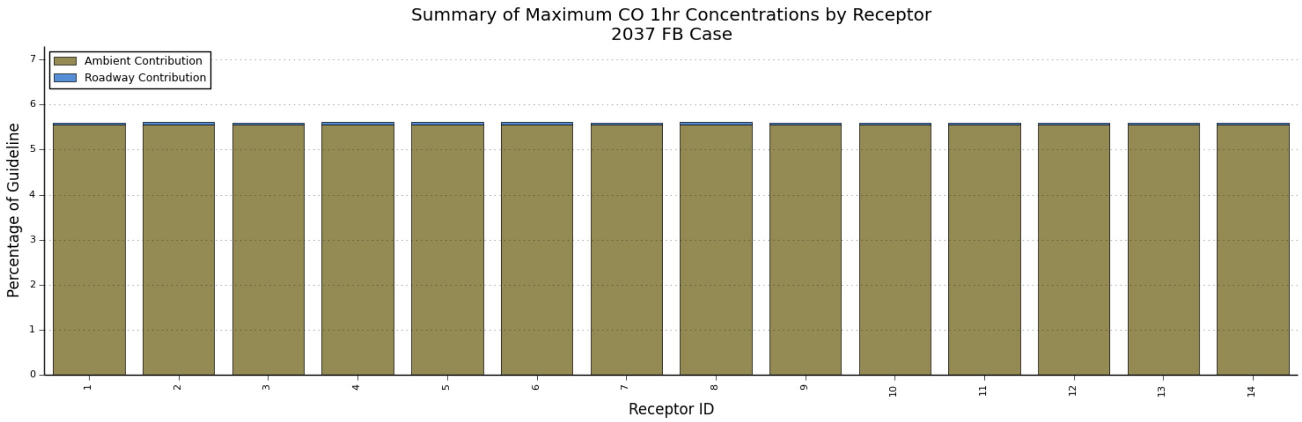
Summary of Maximum CO 1hr Concentrations by Receptor
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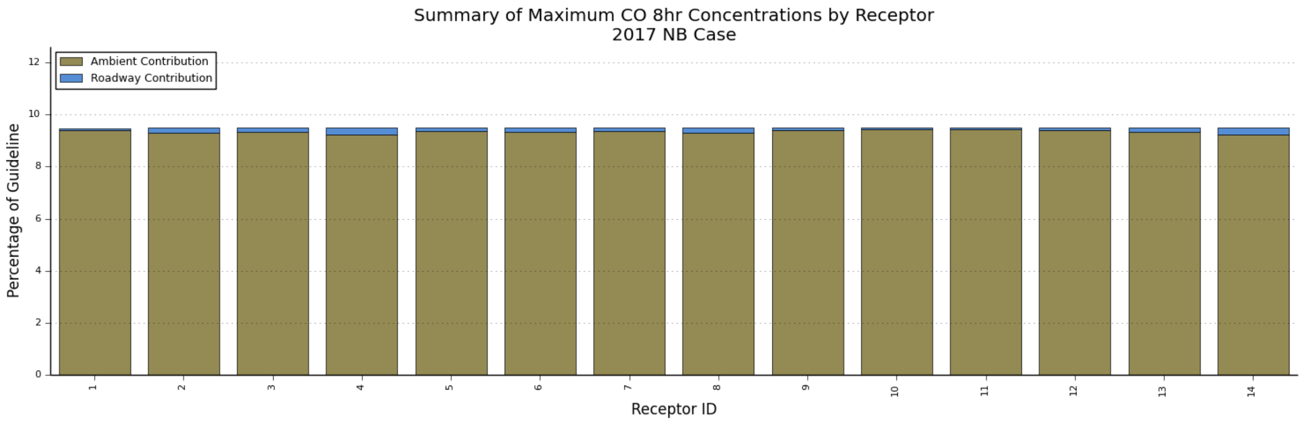
Roadway Contribution
Percentage of Guideline
Receptor ID


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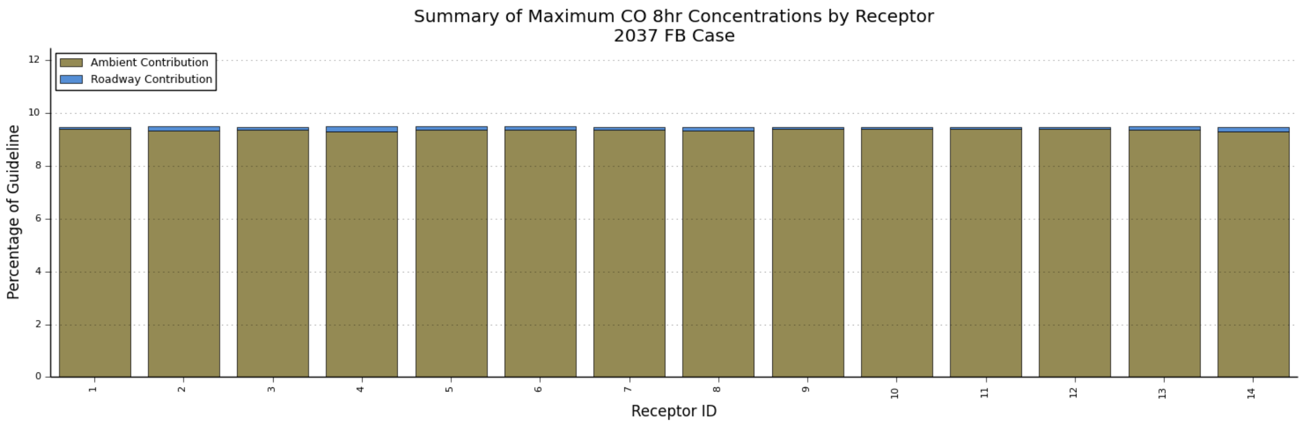
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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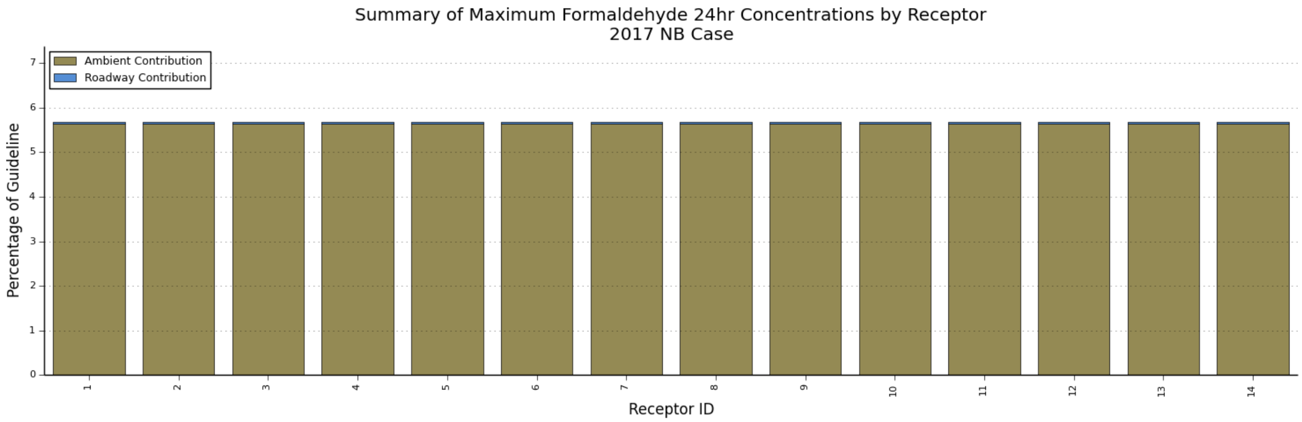
Percentage of Guideline
Receptor ID


Summary of Maximum Formaldehyde 24hr Concentrations by Receptor
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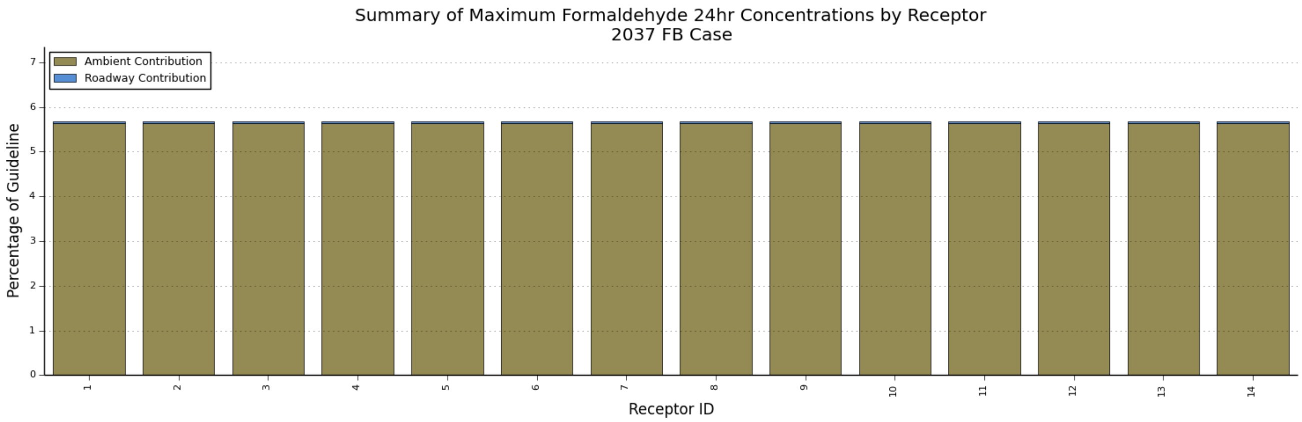
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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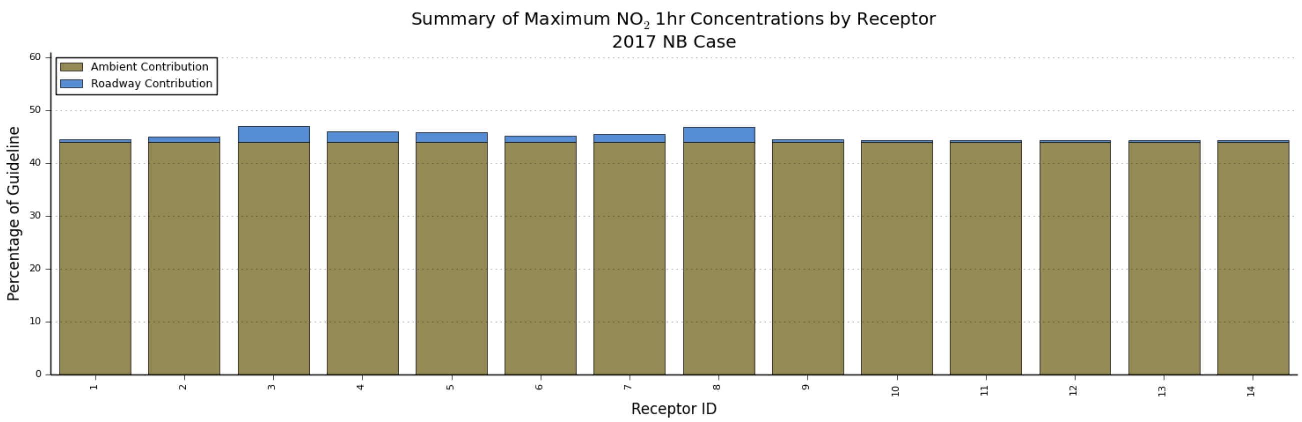
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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Roadway Contribution
Percentage of Guideline
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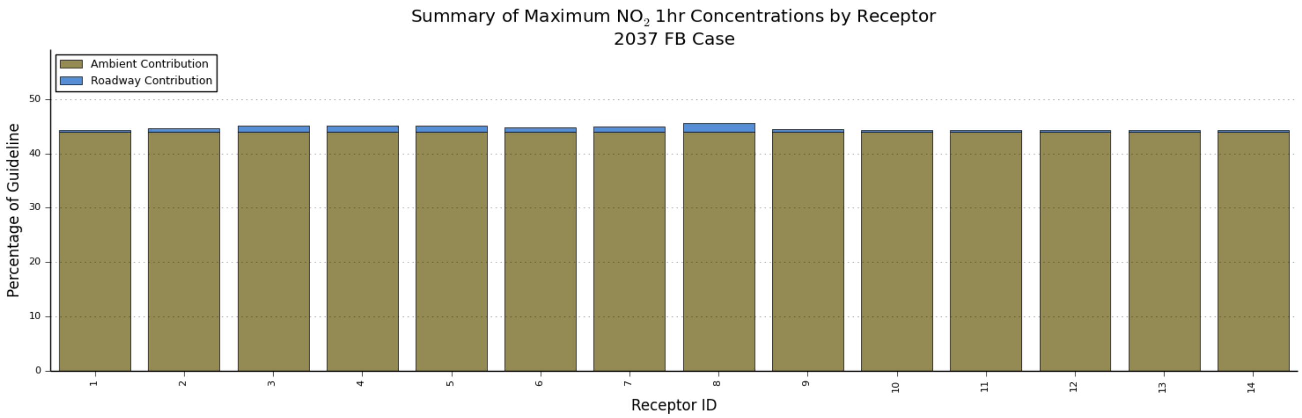
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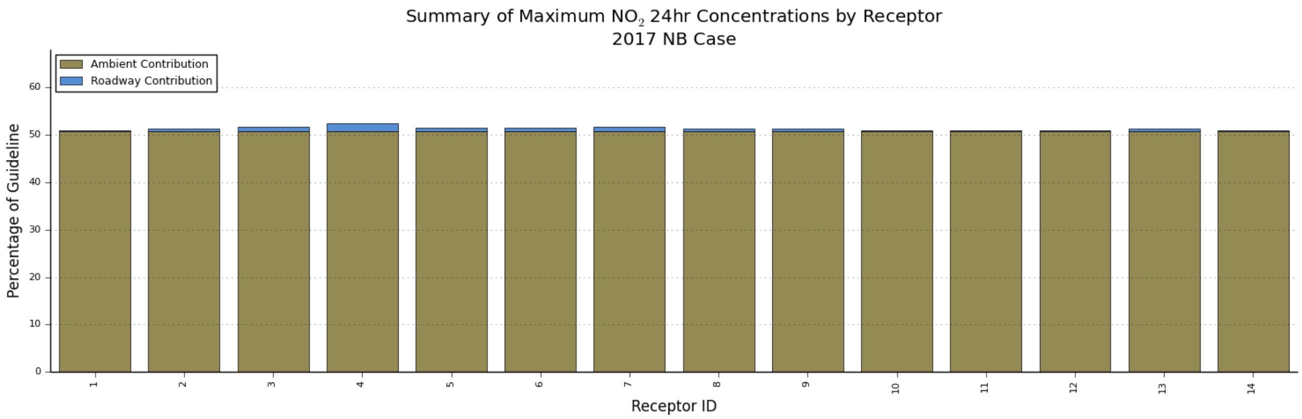
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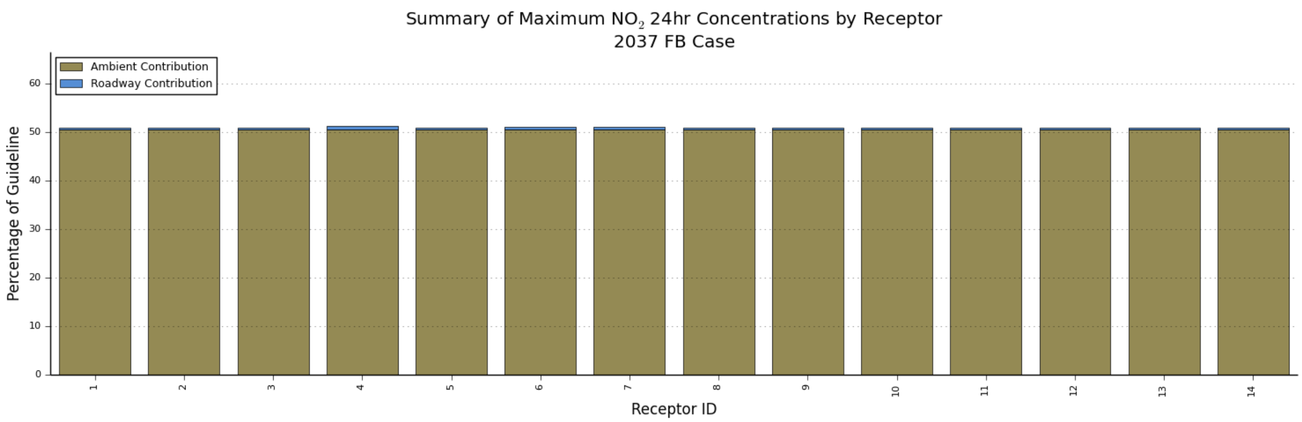
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Roadway Contribution
Percentage of Guideline
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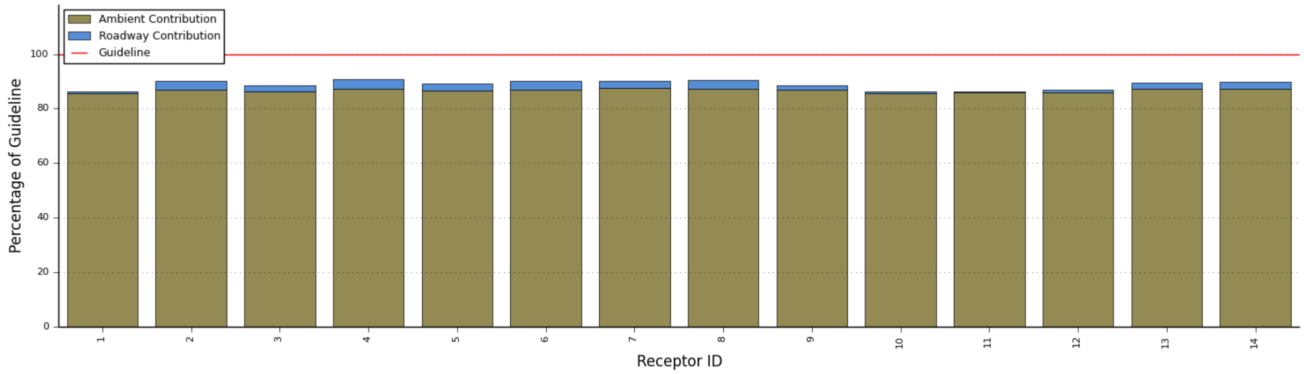
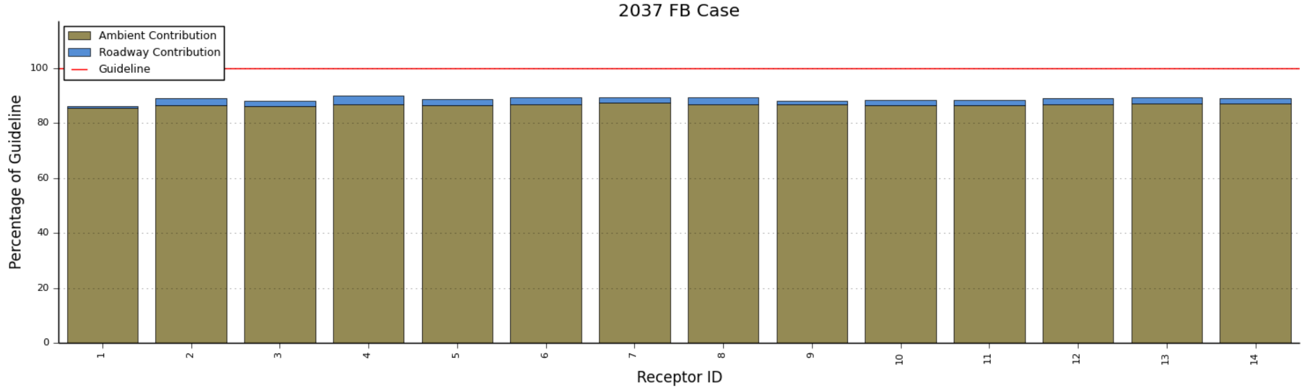
Receptor ID

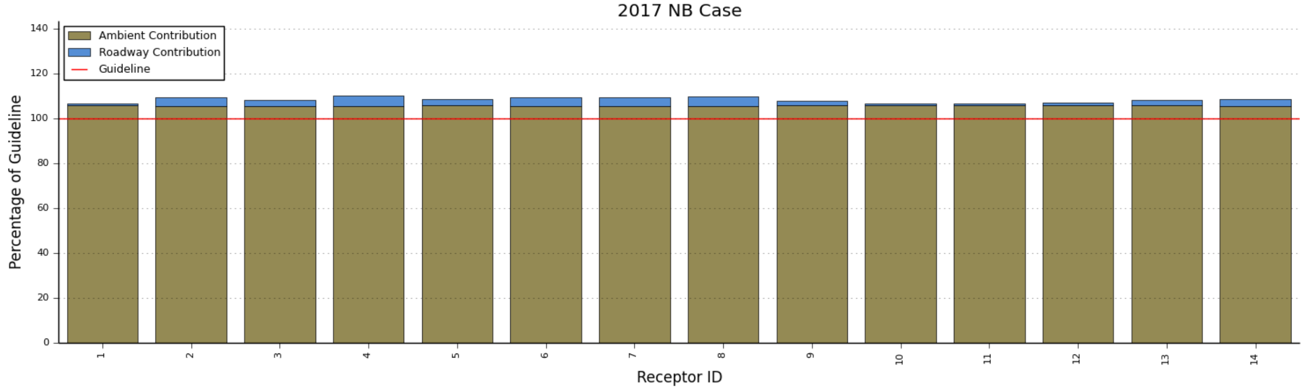
Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2017 NB Case

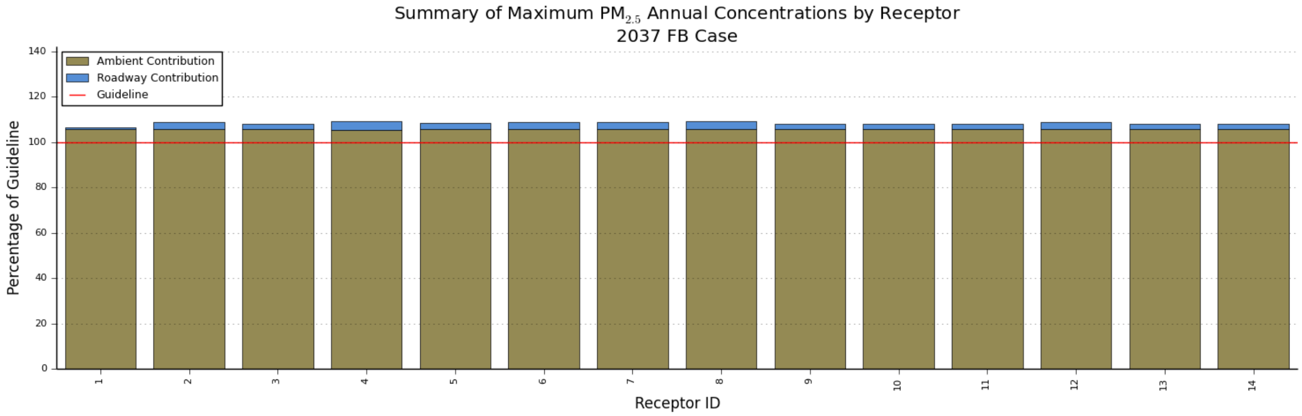


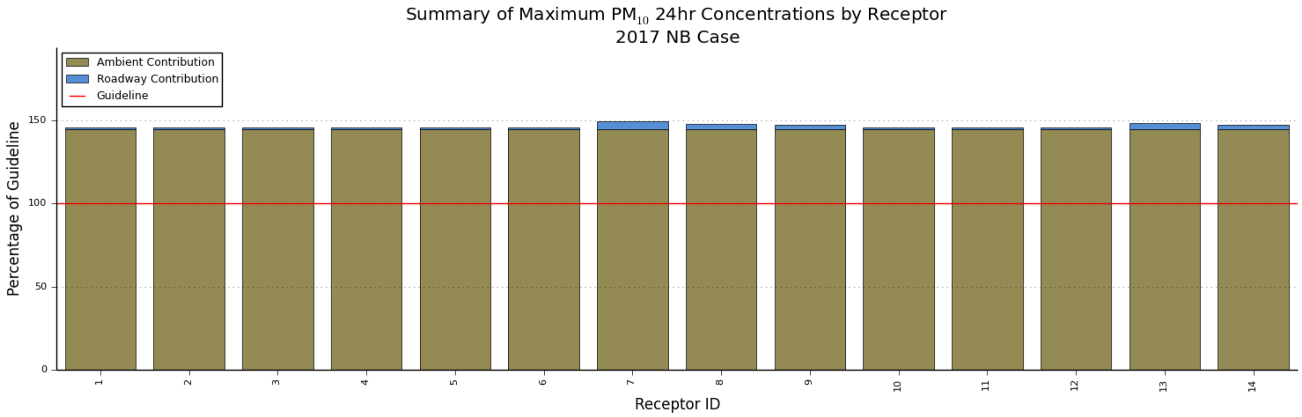
Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2037 FB Case

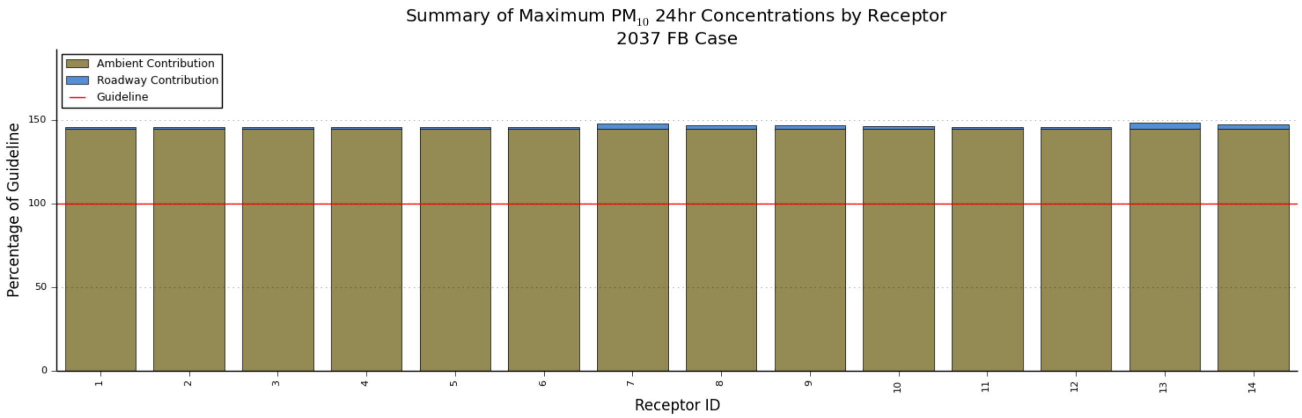


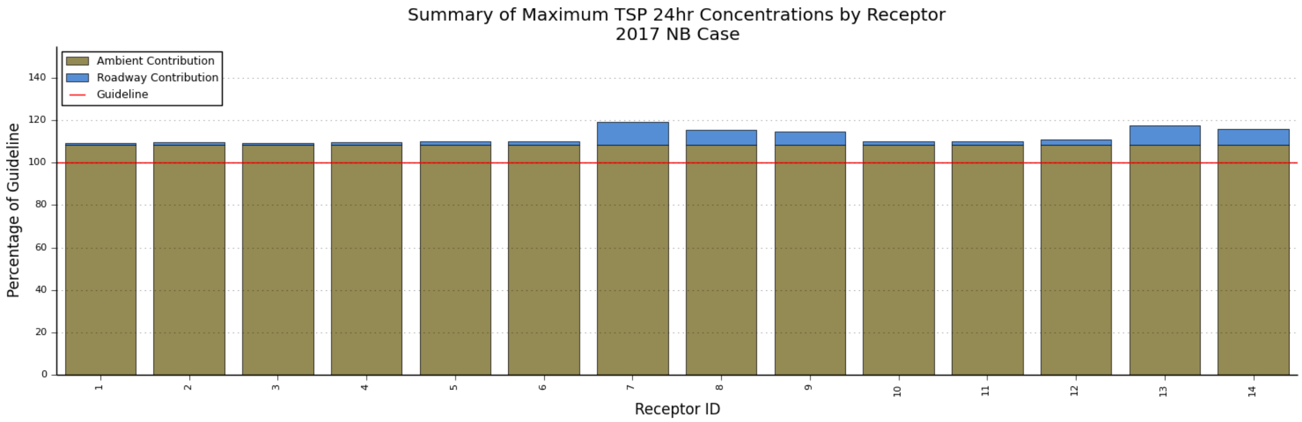
Summary of Maximum $PM_{2.5}$ Annual Concentrations by Receptor
2017 NB Case




Summary of Maximum $PM_{2.5}$ Annual Concentrations by Receptor
2037 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum PM_{10} 24hr Concentrations by Receptor
2017 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum PM_{10} 24hr Concentrations by Receptor
2037 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum TSP 24hr Concentrations by Receptor
2017 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
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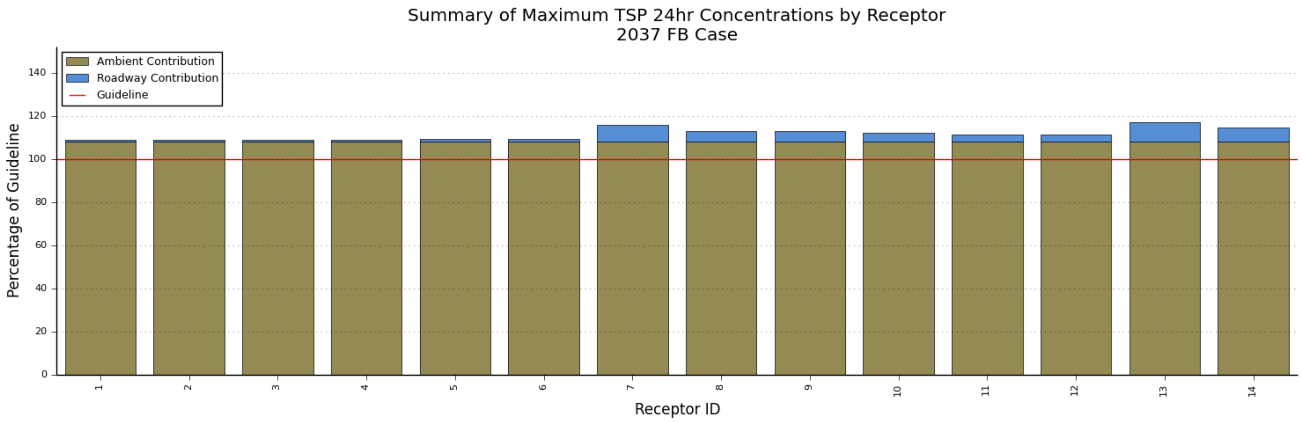
Summary of Maximum TSP 24hr Concentrations by Receptor
2037 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
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Receptor ID