MEMORANDUM

Date: 15th November, 2021

To: The City of Pitt Meadows

File No.: 21162

Re: Interim Report - Pitt Meadows Preliminary Air Quality and Human Health Risk Assessment of Railway-source Diesel Emissions

This memo is intended as an interim report to provide an overview of the current status of the project and to present preliminary results of the emissions inventory and air dispersion modeling. Results presented here are subject to change. The project is still underway and a more in-depth analysis of results will be presented in a final project report.

1.0 OVERVIEW OF PROJECT

The City of Pitt Meadows has retained Envirochem Services Inc. (Envirochem) to conduct a preliminary air quality Human Health Risk Assessment (HHRA) of the current and future predicted air emissions from rail operations within the city's boundary. This study is underway and the current status of the project and findings are summarized in this memo as an interim report.

Canadian Pacific Railway (CP) operations within the city currently consist of the CP Vancouver Intermodal Facility (VIF) and a 5.3 km long rail corridor with two mainline tracks. Approximately 28 freight trains use the corridor each day and additional processing of the trains occurs in the VIF. This rail activity supports a considerable amount of goods that move to and from the Port of Vancouver.

Port growth is expected in future years and that growth will lead to additional freight trains travelling along the mainline on a daily basis. To facilitate this growth, CP has indicated that they are planning to extend their existing lead track from the east end of the VIF as well as adding a new rail siding alongside the VIF. It is understood that the future lead track extension and new siding will accommodate activities currently happening on the north mainline. Additionally, the CP Logistics Park: Vancouver (LPV) is at a proposal stage as a separate project in an area adjacent to the VIF.

This HHRA study is being conducted for the air emissions from current rail operations within the city's boundary as well as two future operation scenarios; 2030 predicted rail operations without the LPV, and 2030 predicted rail operations with the addition of the LPV. Current air quality in the area has also been reviewed and compared to applicable objectives. The main aspect of the project looks at human health concerns associated with diesel combustion emissions (DE) from the rail activities. While multiple air contaminants are emitted from diesel engines and are under evaluation in this study, Diesel Emissions Particulate (DEP, also referred to as Diesel Particulate Matter, DPM) has typically received the greatest attention from health perspectives in Canada and abroad for its potential health risks. Hence, DEP is the focus of this interim stage of the project.

In rail activities, DEP emissions are generated from diesel combustion in locomotive engines and primarily consists of fine particulates with a diameter of less than 2.5 microns (defined as fine Particulate Matter, $PM_{2.5}$). For the purposes of this study, it was assumed that particulate matter (PM), $PM_{2.5}$ and

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DEP emissions are equivalent from diesel locomotive combustion. Preliminary risk assessment results for model predicted $PM_{2.5}$/DEP concentrations are presented within this report.

It should be noted that the detailed CP rail activities are not available to the project's team at this time. Hence, for this interim report to identify the maximum potential health impacts and locations where they may occur, the operating scenarios and their related air emissions modelling is based on the estimated worst-case activity levels (based on understanding of rail operations in Pitt Meadows). The second part of the study aims to collect baseline air quality data from specific locations (identified by the air quality dispersion modelling) if possible, for further investigation.

1.1 Evaluated Scenarios

The following scenarios are being evaluated in this study. Details of these scenarios are expanded upon further in Section 3.

- **Scenario 1** – Current rail operations in the City of Pitt Meadows including freight and passenger rail traffic on the two mainline tracks through the city as well as operations of diesel locomotives at the CP Vancouver Intermodal Facility (VIF). On average, 28 freight trains use the corridor each day, along with 10 West Coast Express (WCE) passenger trains (5 westbound in the morning, 5 eastbound in the evening).
- **Scenario 2** – Future (2030) rail operations based on a predicted increase in rail traffic to 59 freight trains using the corridor per day, plus current operations moving to the extension of the lead track from the east end of the VIF, and a new rail siding alongside the VIF.
- **Scenario 3** – Future (2030) rail operations as evaluated in Scenario 2 with the addition of predicted rail operations at the proposed CP Logistics Park: Vancouver (LPV) located to the south of the VIF and mainline at the west end of Pitt Meadows.

1.2 Limitations

Estimating rail air emissions can be challenging for a number of reasons. Many variables influence emissions of air contaminants from diesel locomotives including, but not limited to: the model and age of the locomotive, track grade and curvature, train speed, train scheduling etc. Limited data on these variables, especially on a local level, is a common limitation across all rail emissions studies and therefore assumptions need to be made to predict air emissions.

Two main factors that influence the calculated air emissions and dispersion modelling used in this study are rail activity levels, and characterization of emission sources.

With regards to rail activity levels, it should be noted that information available from CP regarding the operations within the VIF and anticipated operations at the proposed LPV was limited in detail at this time. Therefore, through consultation with the City of Pitt Meadows, the project proceeded with activity level estimates based on the limited information available and activity levels at similar size rail facilities. Where ranges of potential activity values were considered, values on the upper end of the range were selected to avoid underestimating emissions (i.e., a conservative approach was taken).

With regards to the characterization of emission sources, due to limitations of the available data, identifying the exact locomotives and variables influencing their emission rates (e.g., throttle settings or emission control features) is not feasible. This is a common limitation across studies of rail emissions. In this study, rail emission sources were characterized using similar methodology to other studies of similar facilities. Emission factors (i.e., representative values identifying the amount of a pollutant released by an activity, for example, the amount of particulate matter emitted per litre of diesel used) were identified from the Railway Association of Canada (RAC) annual report, as applied by the Vancouver Fraser Port Authority (VFPA) for their 5-year regional emission inventories. RAC emission factors are categorized by locomotives used for freight line haul, yard switching, and passenger transport as the locomotives used for these activities differ, but emission factors are averaged across the makeup of the national fleet of rail locomotives in terms of specific models and the age of locomotives. The makeup of the locomotive fleet may be slightly different on a local level resulting in higher or lower emission rates. RAC emission rates used for all scenarios in this study are based on the most recent year available (2018). Please note that emission rates may decrease ahead of the 2030 scenarios modelled here, as older locomotives are retired from the fleet and replaced with new locomotives with improved emission controls. Emissions from new locomotives are required to meet the emission standards set out by the Canadian Locomotive Emissions Regulations enforced by Transport Canada.

2.0 BACKGROUND AIR QUALITY REVIEW

Existing air quality in the area is affected by many sources including: urban sources, vehicles and roads, construction projects, natural sources, industrial sources and rail activity (the focus of this study). Metro Vancouver (MV) operates an extensive network of ambient air quality monitoring stations that measure criteria air contaminants (CACs). **Figure 1** shows Metro Vancouver meteorological and ambient air quality monitoring stations, including the T20 station which is operated in Pitt Meadows.

To evaluate the existing ambient air quality in the area, historical hourly air quality data from the Pitt Meadows station was obtained from Metro Vancouver for the most recent four-years and compiled to achieve the relevant time-based averaging period to be compared with the related ambient air quality objectives.

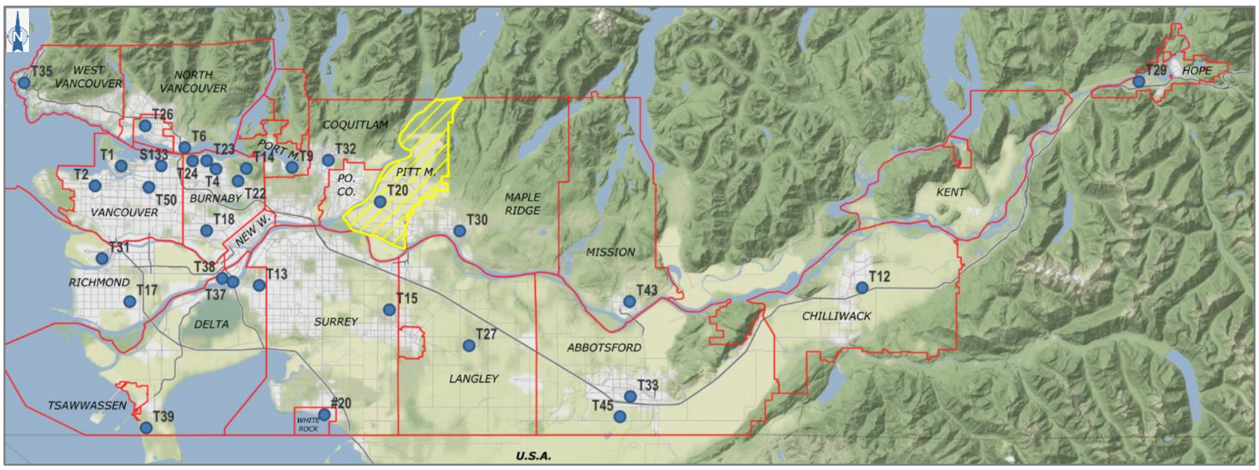


Figure 1: Metro Vancouver Ambient Air Quality Monitoring Network

Blue circles indicate the locations of Metro Vancouver air quality monitoring stations. Red outlines indicate municipal boundaries within the region with the City of Pitt Meadows highlighted in yellow.

Map tiles by Stamen Design, under CC BY 3.0. Base map data by OpenStreetMap, under OdbL.

2.1 Pitt Meadows Air Quality Monitoring Station

The Metro Vancouver Pitt Meadows air quality monitoring station (T20) is operated on Old Dewdney Trunk Road. This location is approximately 700 m to the north of the CP VIF boundary, and 1 km from the rail mainline. The surrounding area to the north and east of the station is primarily agricultural land. South of the station is Lougheed Highway (~600 m), and the urban areas of Pitt Meadows. The Pitt River is to the west of the station, with the CP Coquitlam rail yard and Coquitlam urban areas on the west side of the river.

To add context to the air quality measured at the monitoring station, wind patterns using the hourly data at the monitoring station were evaluated and show that wind patterns in the area are dominated by winds flowing out of the valley between Coquitlam Mountain and Golden Ears and containing Pitt Lake, as seen in annual wind roses presented in **Table 1** and an overall wind rose from 2017-2020 in **Figure 2**. Wind patterns are very similar between the years analyzed.

How to read a wind rose

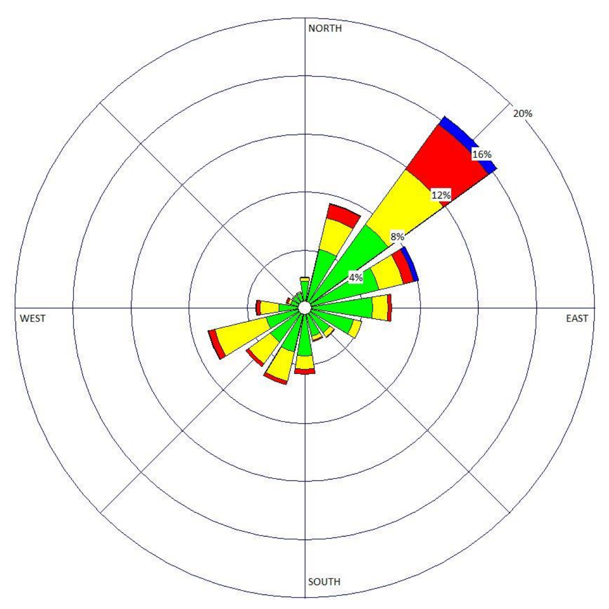
Wind rose diagrams are used to show the general wind direction and speed patterns at a location for a period of time. The circular format of the wind rose shows the direction the winds blew from and the length of each "spoke" around the circle shows how often the wind blew from that direction. For example, the wind rose for 2017 in ***Table 1*** *below shows that during this particular period (2017) the wind blew from the northeast approximately 16% of the time, and from the east approximately 6% of the time, etc.*

The different colors of each spoke provide details on the wind speed, in metres/second (1 m/s = 3.6 km/h), of the wind from each direction. Using the 2017 example, the longest spoke shows the wind blew from the northeast at speeds between 0.50 - 2.10 m/s (green) about 7% of the time, 2.10 - 3.60 m/s (yellow) about 5% of the time, 3.60 – 5.70 m/s about 3.5% of the time and 5.70 - 8.80 m/s (dark blue) about 0.5% of the time.

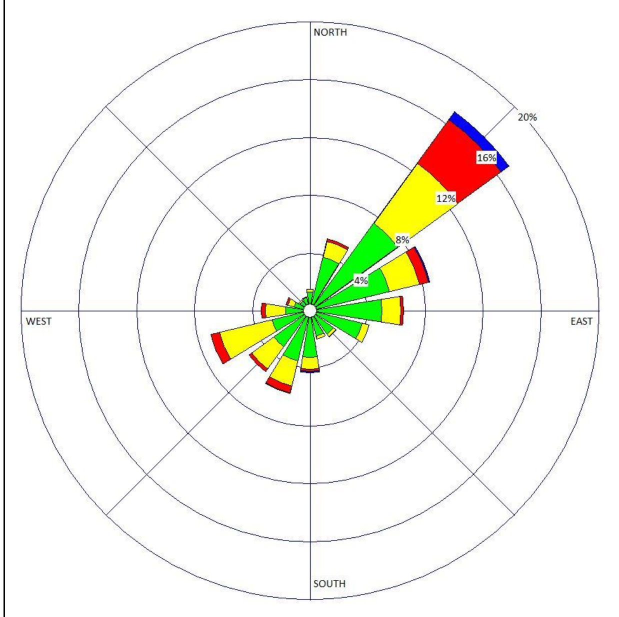
Table 1: Wind Rose Showing Wind Patterns Measured at the Pitt Meadows Air Quality Monitoring Station (2017, 2018, 2019, and 2020)

Direction shown as 'wind blowing from'.

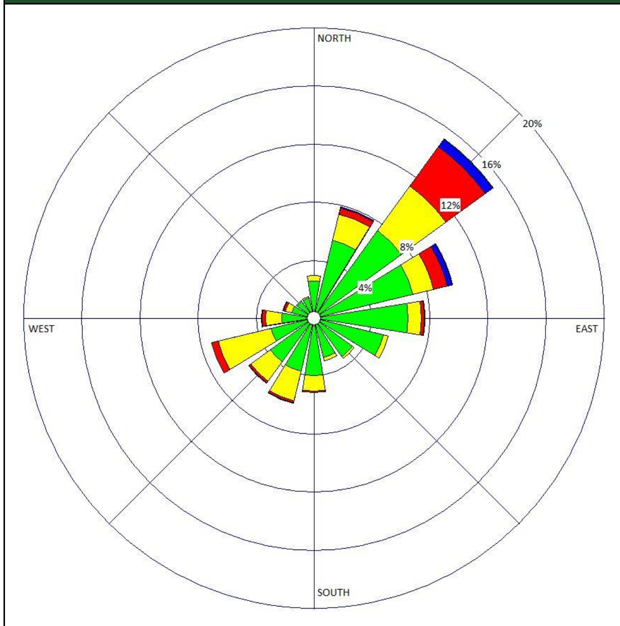
2017



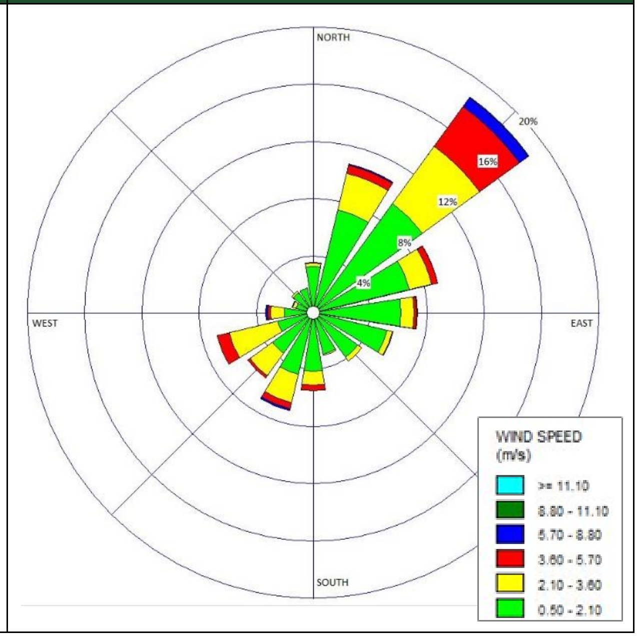
2018



2019



2020



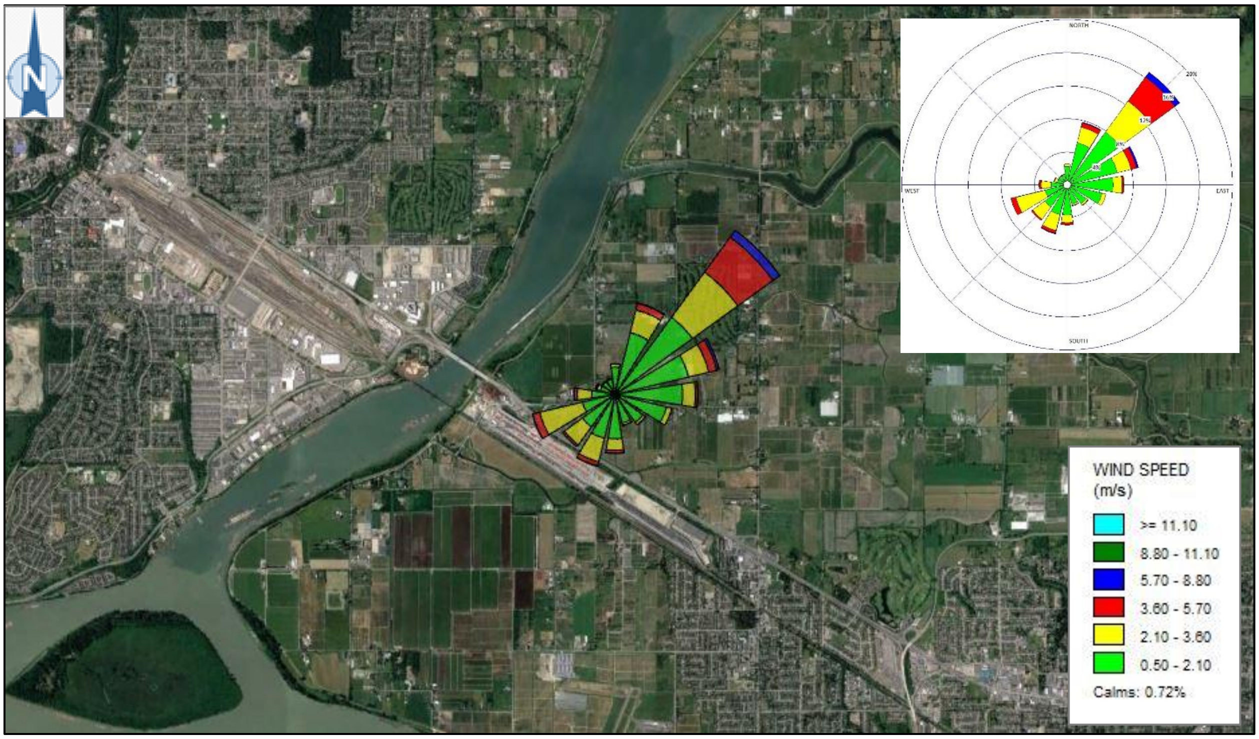


Figure 2: Wind Rose Showing Wind Patterns Measured at the Pitt Meadows Air Quality Monitoring Station (2017-2020 Inclusive)

Direction shown as 'wind blowing from'.

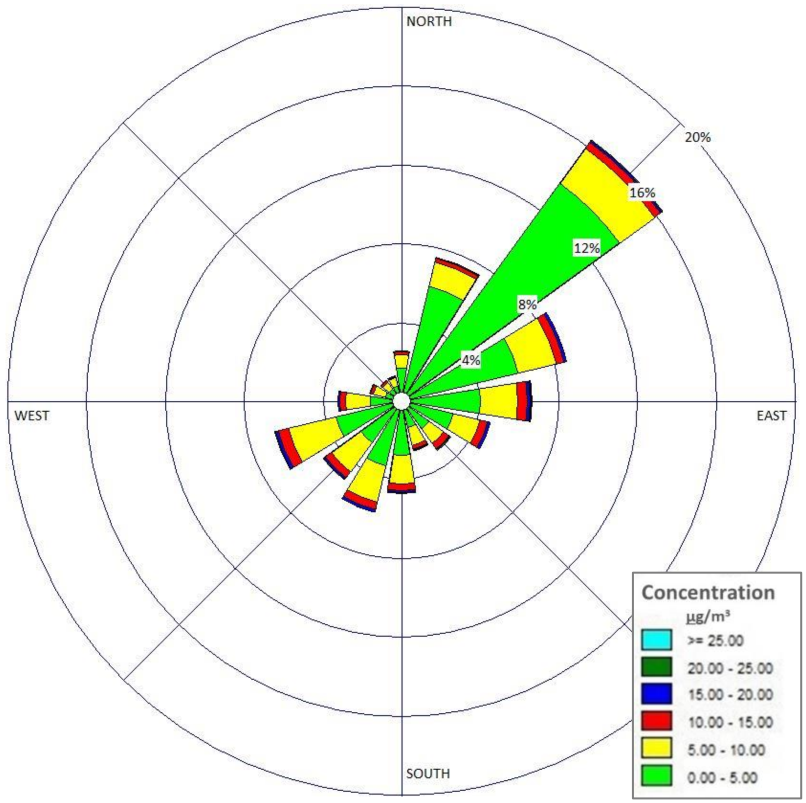
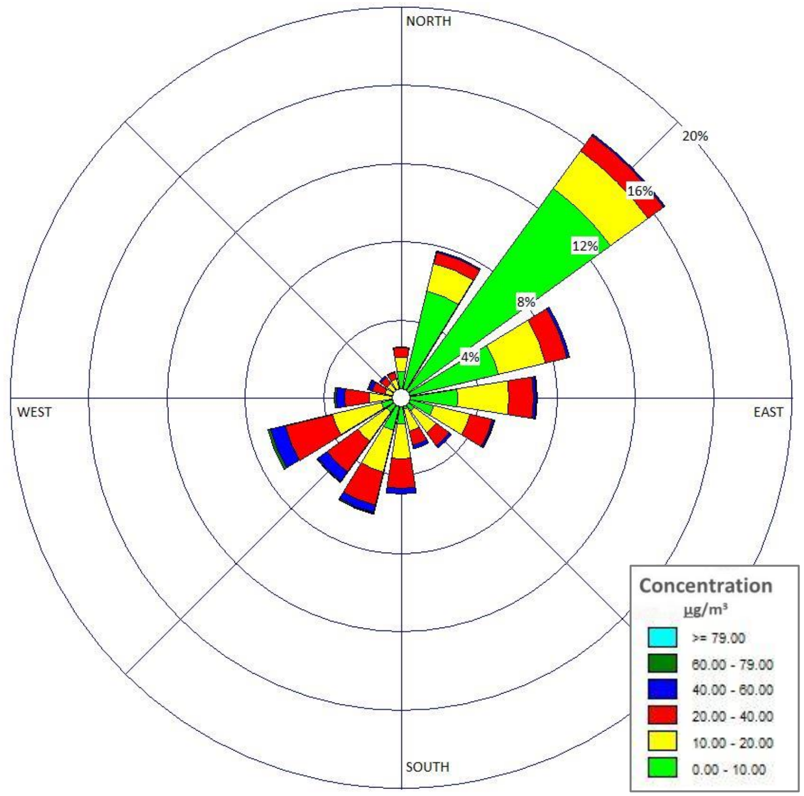
Additionally, $PM_{2.5}$ and NO_2 hourly monitoring data were compared to the wind directions at the time of measurement from 2017 to 2020 and are presented in **Table 2**. At times where wind directions are from the south, higher concentrations of $PM_{2.5}$ and NO_2 appear to be measured more frequently compared to when wind direction is from the north.

How to read a pollution rose

Pollution rose diagrams are used to show the general wind direction and contaminant concentration patterns for a substance at a location for a period of time. The circular format of the pollution rose shows the direction the winds blew from and the length of each "spoke" around the circle shows how often the wind blew from that direction.

The different colors of each spoke provide details on the typical concentration readings for the contaminant examined, in micrograms/cubic metres, at times the wind was blowing from each direction.

Table 2: Pollution Roses Showing Comparison of Measured $PM_{2.5}$ and NO_2 Concentrations and Wind Direction at the Pitt Meadows Air Quality Monitoring Station

Fine Particulate Matter ($PM_{2.5}$)	Nitrogen Dioxide (NO_2)
	

[(a)] *Direction shown as 'wind blowing from'*

[(b)] *$PM_{2.5}$ data excludes dates where Metro Vancouver Air Quality Advisories were in place due to wildfire smoke.*

2.2 Relevant Ambient Air Quality Objectives (AAQOs)

Ambient Air Quality Objectives (AAQOs) are set at federal, provincial, and regional levels. These are targets that define the acceptable outdoor concentration of key air contaminants, based on human and environmental health considerations. Metro Vancouver has delegated authority under the BC Environmental Management Act to manage air quality within the region. Metro Vancouver uses a variety of approaches to manage air contaminants in the region, including AAQOs. MV uses AAQOs to:

- Assess regional and local air quality
- Support the development of air quality management plans and regulations
- Guide air management and decisions, including when to issue permits and air quality advisories

MV AAQOs are in line (or in some cases more stringent than) the federal Canadian Ambient Air Quality Standards (CAAQS) or the provincial British Columbia ambient air quality objectives. Therefore, the MV AAQOs only have been presented in **Table 3** for simplicity. The CAAQS are planned to decrease in 2025 for NO_2 and SO_2 and these lower objectives are also presented. Metro Vancouver has stated that their 2025 objectives will be at least as stringent as the federal CAAQS. AAQOs are presented in units of micrograms per cubic metre of air (µg/m^3).

There are currently no ambient air quality objectives available in BC nor in MV for some of the air contaminants which may be of specific interest to studies of rail emissions such as diesel emissions particulate (DEP) or specific volatile organic compounds (VOCs). It should be noted that ambient air quality objectives are not based solely on health effects; therefore, further health-based thresholds and objectives for other parameters are considered in the HHRA aspect of this study that is currently underway.

Table 3: Relevant Metro Vancouver Ambient Air Quality Objectives

Air Contaminant	Averaging Period	Metro Vancouver Objectives [(a)] *(µg/m^3)*
Carbon Monoxide (CO)	1-hour	14,900
	8-hour [(b)]	5,700
Fine Particulate Matter ($PM_{2.5}$)	24-hour [(b)]	25
	Annual	8 (6) [(d)]
Nitrogen Dioxide (NO_2)	1-hour [(c)]	113 (CAAQS 2025 - 79) [(e)]
	Annual	32 (CAAQS 2025 - 23) [(e)]
Sulphur Dioxide (SO_2)	1-hour	183 (CAAQS 2025 - 173) [(e)]
	Annual	13 (CAAQS 2025 - 11) [(e)]

(a) Except where noted, Metro Vancouver objectives are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level.
(b) Objectives based on rolling average.
(c) Achievement based on annual 98th percentile of the daily maximum 1-hour concentration, averaged over three consecutive years.
(d) Metro Vancouver's annual $PM_{2.5}$ planning goal of 6 µg/m^3 is a longer-term aspirational target to support continuous improvement.
(e) The 2025 Canadian Ambient Air Quality Standards (CAAQS) are presented as context for how Metro Vancouver's AAQO's may decrease for NO_2 and SO_2 in 2025.

2.3 Calculated Background Air Quality

For the air dispersion modelling purposes to consider the cumulative effects of all contributing sources to the air quality in the region, the background air quality is usually added to the modelling results from the new or upgraded sources and compared with the applicable ambient air quality objectives. For this study, appropriate time-based averages of the historical monitoring data from T20 station (Pitt Meadows) were calculated as the background air quality data based on the BC air quality dispersion modelling guideline[1].

Annual averages of hourly data are calculated for each of the four years while for short-term periods (1-hour and 24-hour) the applicable percentile of each time-based averages of the data were calculated based on the BC air quality dispersion modelling guideline. The BC air quality dispersion modelling guideline recommends using 98th percentiles to establish background values for short-term averaging periods (1-hour and 24-hour) for most contaminants to be used in dispersion modelling studies (please note 99th is recommended for SO_2). 98th percentiles are a common statistical approach to calculate the value which the data is less than 98% of the time to provide context on the high values observed in a dataset (i.e., only 2% of the data is above this value). It should be also noted that as per the modeling guideline, the 1-hour NO_2 background data for the dispersion modelling purposes is calculated differently and is based on the 98th percentile of the daily maximum 1-hour values.

In recent years, wildfire smoke events have impacted the Metro Vancouver area, leading to episodes of elevated $PM_{2.5}$ concentrations. In addition to evaluating all $PM_{2.5}$ data, $PM_{2.5}$ from dates not impacted by wildfire smoke was also reviewed. To do this, $PM_{2.5}$ data from the dates where Metro Vancouver air quality advisories were in place were removed from consideration to exclude the impact of these high concentrations on the calculation of background averages.

The calculated background air quality data are presented in **Table 4**. The background air quality data can be also compared to each of the relevant Metro Vancouver ambient air quality objectives as applicable to have a general understanding of the recent air quality in the region. In addition to the applicable background air quality data, other measures such as average, median, and 98th percentile of the data are presented in this table for further statistical information on the general air quality in the region. It should be noted that although the background air quality data were calculated here, they were not used for the HHRA at this interim report stage. They will be investigated further in the final report.

[1] British Columbia Air Quality Dispersion Modelling Guideline – British Columbia Ministry of Environment and Climate Change Strategy 2015

Table 4: Background Air Quality Concentrations for T20 Pitt Meadows Air Quality Monitoring Station (2017-2020)

Air Contaminant	Averaging Period	Ambient Air Quality Objective *(µg/m³)*	Measure	Year(s) of Analysis Monitoring Data				
				2017	2018	2019	2020	2017-2020
$PM_{2.5}$ *All Data*	24-hour Rolling Average	25	Maximum *(24-hour Rolling Average)*	63.0	115.3	24.2	153.9	153.9
			98th Percentile *(of 24-hour Rolling Averages)*	38.8	31.2	13.2	52.6	25.3
	Annual	8 (6)	Average	6.1	6.8	5.2	6.2	6.1
			Median	3.8	4.5	4.4	3.5	4.0
$PM_{2.5}$ *With Wildfire Smoke Events Excluded* (a)	24-hour Rolling Average	25	Maximum *(24-hour Rolling Average)*	18.3	28.0	24.2	18.5	28.0
			98th Percentile *(of 24-hour Rolling Averages)*	14.4	13.9	13.2	11.3	13.5
	Annual	8 (6)	Average	4.7	5.4	5.2	4.3	4.9
			Median	3.6	4.3	4.4	3.4	3.9
NO_2	1-hour	113 (2025 CAAQS of 79)	Maximum	92.2	84.9	93.9	86.3	93.9
			98th Percentile *(All Data)*	58.0	49.3	51.6	44.2	51.4
			98th Percentile of Daily 1-hour Maximums (b)	76.1	71.2	79.8	63.3	73.9
	Annual	32 (2025 CAAQS of 23)	Average	18.1	16.5	16.2	13.2	16.0
			Median	14.7	13.6	13.4	10.1	12.8
SO_2	1-hour	183 (2025 CAAQs of 173)	Maximum	30.3	14.1	18.6	13.6	30.3
			99th Percentile	6.7	5.3	5.9	3.7	5.9
	Annual	13 (2025 CAAQs of 11)	Average	1.1	0.9	1.0	0.7	0.9
			Median	0.5	0.5	0.5	0.0	0.5

(a) Data from dates during Metro Vancouver air quality advisories for wildfire smoke was removed from consideration in the analysis of monitored $PM_{2.5}$ concentrations.
(b) The 98th percentile of 1-hour daily maximums is presented for NO_2 as this is the exceedance criteria for the Metro Vancouver AAQO.

2.4 Comparison of Background Concentration to Metro Vancouver Ambient Air Quality Objectives

For each of the four years analyzed, none of the annual calculated background concentrations exceeded the existing annual Metro Vancouver AAQO's as seen in **Table 4**. In the case of $PM_{2.5}$, the annual averages were each below the current objective of 8 µg/m^3 but in all years except 2019 they were above the long-term planning goal of 6 µg/m^3. When $PM_{2.5}$ calculations were performed for the dates where wildfire smoke was not impacting the airshed (data from dates where Metro Vancouver air quality advisories were in place were removed), the annual averages were each below the long-term planning goal of 6 µg/m^3.

For the short-term Metro Vancouver ambient air quality objectives, the frequency of exceedance was calculated and is presented in **Table 5**.

In most cases Metro Vancouver's AAQOs "…are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level". It should be noted that the NO_2 objective is evaluated differently and is based on the annual 98th percentile of the daily maximum 1-hour objectives averaged over three consecutive years.

Table 5: Background Air Quality Comparison to Short-Term Metro Vancouver Ambient Air Quality Objectives

Air Contaminant	Averaging Period	Objective *µg/m³*	Measure	Year(s) of Analysis				
				2017	2018	2019	2020	2017-2020
$PM_{2.5}$ *All Data*	24-hour Rolling Average	25	Number of Exceedances	272	218	0	198	688
			Percentage of Exceedances (a)	3.11%	2.49%	0 %	2.25%	1.96%
$PM_{2.5}$ *With Wildfire Smoke Events Excluded* (b)	24-hour Rolling Average	25	Number of Exceedances	0	13	0	0	13
			Percentage of Exceedances	0 %	0.15%	0 %	0 %	0.04%
NO_2	1-hour	Current Objective: 113	Number of Exceedances (c)	0	0	0	0	0
			Percentage of Exceedances (c)	0 %	0 %	0 %	0 %	0 %
		2025 CAAQs: 79	Number of Exceedances (c)	8	4	16	1	29
			Percentage of Exceedances (c)	0.09%	0.05%	0.18%	0.01%	0.08%
SO_2	1-hour	Current Objective: 183	Number of Exceedances	0	0	0	0	0
			Percentage of Exceedances	0 %	0 %	0 %	0 %	0 %
		2025 CAAQs: 173	Number of Exceedances	0	0	0	0	0
			Percentage of Exceedances	0 %	0 %	0 %	0 %	0 %

(a) *Percentage of hours exceeding is based on a count of available data (e.g. wildfire removed $PM_{2.5}$ is calculated as the number of 24 hour rolling averages above the objective divided by the total hours of remaining data after advisory dates were removed).*

(b) *Data from dates during Metro Vancouver air quality advisories for wildfire smoke was removed from consideration in the analysis of monitored $PM_{2.5}$ concentrations.*

(c) *The Metro Vancouver AAQO for 1-hour average NO_2 concentrations is assessed based on the 98th percentile over three consecutive years of the daily maximum 1-hour average values. This allows for up to 2% of the daily maximum values to be higher than the objective level before the objective is deemed to be exceeded.*

2.5 Preliminary Air Quality Monitoring Data

Preliminary air quality monitoring has been conducted at a residence along the mainline approximately 500m east of the Harris Road rail crossing. A continuous $PM_{2.5}$ monitoring instrument was installed in the garden of the residence which backs onto the rail line to measure ambient $PM_{2.5}$ concentrations along the rail line. Measured one-hour average concentrations are presented in **Figure 3** below. **Figure 4** presents the 24-hour rolling average concentration, which corresponds with the Metro Vancouver short-term AAQO, measured by the temporarily installed $PM_{2.5}$ monitoring instrument and comparison to the $PM_{2.5}$ concentrations measured at the Metro Vancouver T20 Pitt Meadows air quality monitoring station. Further evaluation of this collected data is currently underway.

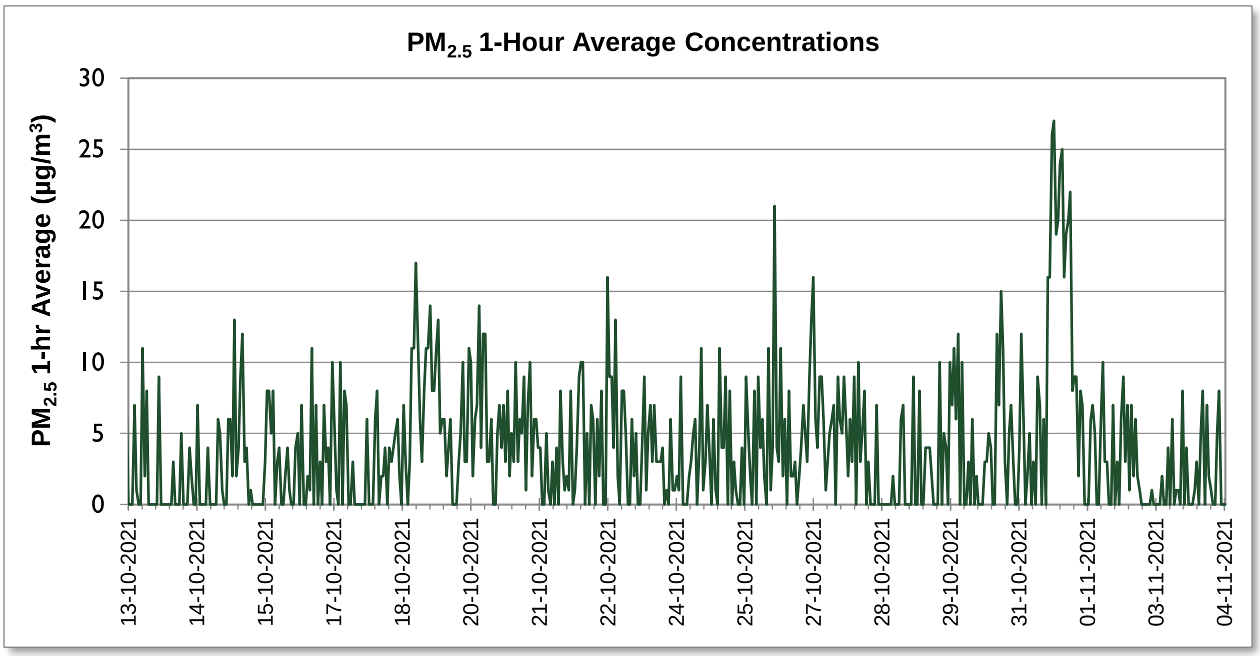


Figure 3: $PM_{2.5}$ 1-hour Average Concentrations Measured by the Temporarily Installed $PM_{2.5}$ Instrument

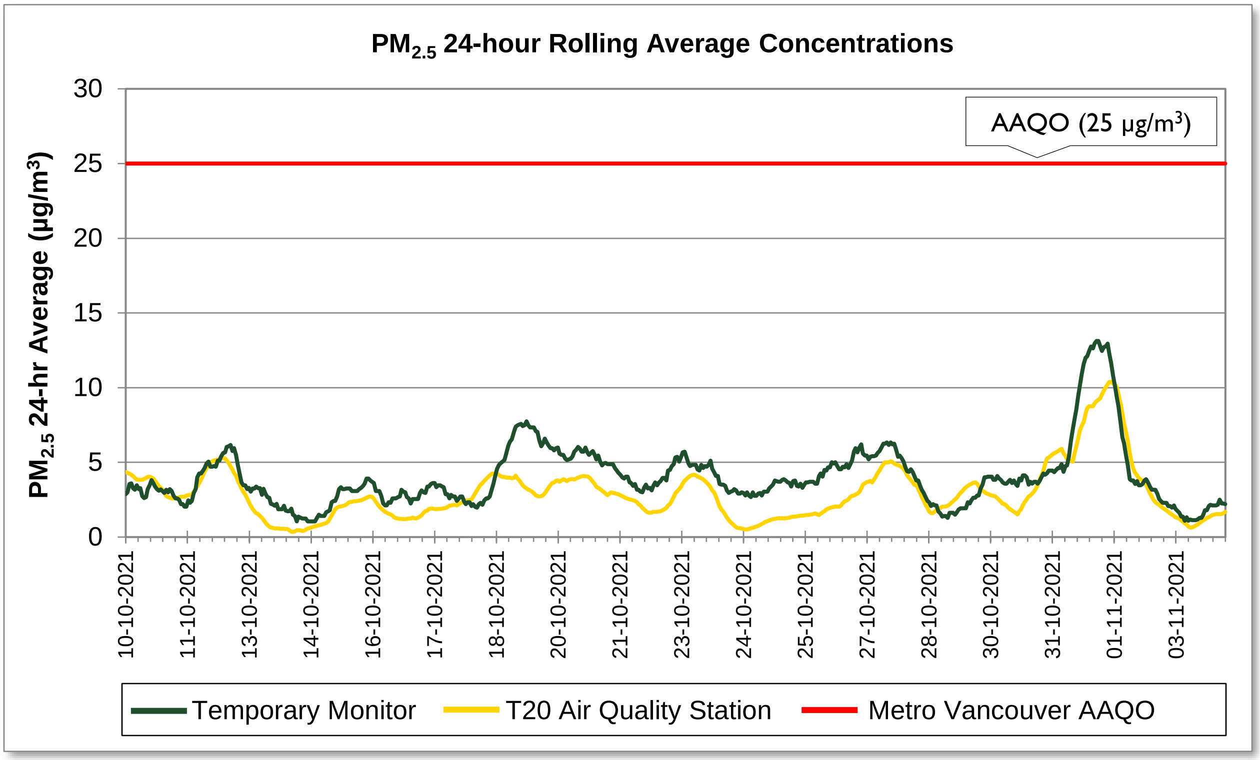


Figure 4: $PM_{2.5}$ 24-hour Rolling Average Concentrations Measured by the Temporarily Installed $PM_{2.5}$ Instrument and at the Metro Vancouver T20 Air Quality Monitoring Station

Note: Data from the T20 station is presented as raw data and has not been passed through Metro Vancouver's data validation procedures which are conducted on an annual basis.

3.0 RAIL EMISSIONS INVENTORY

The activity-based rail emissions inventories for the three scenarios and their various components (i.e., mainline, VIF, and proposed Logistics Park) are presented in the sub-sections below. As noted above, where specific information/details were not available, conservatively high activity level estimates were used to ensure emission projections were not underestimated.

Diesel-electric locomotives operate with their engines in one of eight specific throttle positions known as notches or with their engine idling. Annual and maximum hourly fuel consumption for the activities considered in each scenario (e.g., mainline travel, switching activities, idling, etc.) was therefore calculated based on fuel consumption rates for representative trains by notch setting utilization (i.e., the amount of time spent in each throttle position). A summary of the fuel consumption rates used for the line-haul/passenger/switch locomotives used for this study is shown in **Table 6** below.

Table 6: Fuel Consumption for Line Haul/Passenger, and Switcher Locomotives

Locomotive Type	Model	Fuel Consumption by Throttle Notch Position *(L/hour)*									
		Idle	1	2	3	4	5	6	7	8	DB [a]
Line Haul/Passenger [2]	GE AC4400	11.4	45.4	102.2	204.4	299.1	397.5	530.0	647.3	794.9	44.4
Switcher Locomotives [3]	SD40-2	20.8	34.4	94.3	156.7	216.5	299.0	410.7	549.6	634.8	79.5
	GP38	17.4	26.5	60.6	118.9	177.2	241.5	314.6	389.1	463.3	56.8

[a] *DB = Dynamic Braking*

The locomotive engines assumed in this study were based on typical models expected in CP's fleet and switching yards. The GE AC4400 (a relatively high-powered locomotive typically used for line-haul operations) was used to model line-haul locomotives. The GE AC4400 was also used to model the typically lower powered passenger trains travelling/idling on the mainline, again, to ensure emissions rates were not under-estimated. Switchers in the switching yards for the VIF and proposed Logistics Park were represented by SD40-2 and GP38 locomotive engine models based on available information.

The duty cycle (i.e., time spent in each throttle notch setting) and the associated fuel consumption rates for each activity considered in the study were based on a combination of available information, literature values, and estimates on the upper range of expected values. For line-haul trains, an average of operation in notches 4 and 5 were used to estimate train movements on the mainline. Notch 5 was used to estimate passenger train movements (based on communication with Translink - West Coast Express). The distribution of typical times spent in each notch position for switching activities were based on locomotive duty cycle data from the Railway Association of Canada Locomotive Emissions Monitoring Program (RAC LEM 2008[4]).

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[2] US EPA, 1998. Locomotive Emissions Standards, Regulatory Supporting Document
3 Railserve Leaf – Utilizing Genset Technology in Locomotive Power at Intermodel Railyard Operations
[4] Railway Association of Canada – Locomotive Emissions Monitoring Program 2008

Once the annual and maximum hourly fuel consumption values for each activity were estimated based on activity times and the rates above, emission totals/rates were then calculated using fuel-based emission factors from the Railway Association of Canada (RAC) Locomotive Emissions Monitoring Report[5]. These emission factors are based on active locomotive fleets for line-haul locomotives, yard switching locomotives, and passenger locomotives across Canada. Fuel-based emission factors from the most recent fleetwide study available (2018) were used and are summarized in **Table 7** for reference. The fuel-based emission factors used are consistent with those employed by the Vancouver Fraser Port Authority (VFPA) in their 5-year emission inventories for rail operation. It should be noted that these emission rates may decrease ahead of the 2030 scenarios modelled here, as older locomotives are retired from the fleet and are replaced with new locomotives with improved emission controls. Emissions from new locomotives are required to meet the emission standards set out by the Canadian Locomotive Emissions Regulations.

Table 7: Railway Association of Canada Fuel-Based Emission Factors

Locomotive Type	Emission Factor *g/L*				
	NOx	PM [(a)]	CO	HC	SO_2
Freight: Line-Haul	34.56	0.78	7.02	1.54	0.02
Total Yard Switching	56.67	1.18	7.35	3.33	0.02
Total Passenger	54.37	1.11	7.03	2.1	0.02

(a) Based on correspondence with RAC, the PM emission factor here refers to PM_{10} (particulate matter with a diameter of less than 10 microns). For the purposes of this study, it was assumed that PM, PM_{10}, $PM_{2.5}$ and DEP are equivalent from diesel locomotive combustion.

The estimated time associated with each activity and the calculated emission totals and rates for each scenario are presented in Sections 3.1, 3.2, and 3.3.

3.1 Scenario 1 – Current Operations

The components included in Scenario 1 are reflective of current operations as a baseline for comparison with the future scenarios considered (i.e., Scenario 2 and 3).

Components included in Scenario 1 include emissions from the mainline from freight travel, emissions from the mainline from WCE passenger trains, idling emissions at the Pitt Meadows WCE station, and activities at the VIF rail yard.

Based on current traffic data, 28 freight trains per day were modelled to be travelling on the mainline per day. An additional 10 passenger trains per day were modelled to account for WCE traffic on the mainline.

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[5] Railway Association of Canada – Locomotive Emissions Monitoring Report 2018

Travel on the mainline was modelled including a buffer of 1 km either side of the City of Pitt Meadows boundary and was broken into three main sections of track totaling 7.2 km. Travel times for each section of the three sections of track were determined using section distances and maximum travel speed information (speeds for eastbound travel is 25 mph over the Pitt River bridge and 60 mph when clear of bridge, speeds for westbound travel is maximum of 45 mph, slowing to 25 mph at the bridge). Since only maximum travel speeds were available, a 0.75 factor was applied to conservatively estimate the amount of time needed to cross each section of track. Four line-haul locomotives were assumed for each freight train travelling on the mainline and one locomotive per train was assumed for each passenger train travelling on the mainline. Based on correspondence with TransLink, 1.5 minutes at the WCE station was used to model idling time in addition to the modelled moving activity. A reduced speed was assumed for passenger train travel on the modelled mainline segment east of the VIF to account for additional time needed for slowing down and speeding up of trains from the stations.

Locomotive rail activity at the VIF was estimated based on provided daily traffic information:

- 2 trains departing eastbound per day,
- 2 trains terminating westbound per day,
- 1 shuttle train both arriving and departing to Deltaport.

Based on activity times from similar sized facilities/operations, switching times are typically 30-60 minutes for arrival trains and 45-90 minutes for departing trains/train make-ups. Since exact switching times at the VIF were not available, the high end of the ranges noted above were used to model switching activities at the VIF (i.e., 60 minutes for arrival trains, and 90 minutes for departing trains/train make-ups). Four switch locomotives were assumed to be operational at the VIF as seen in studies of other similar sized rail facilities.

Using the activity estimates above, maximum 1-hour emission rates were determined. These emission rates reflect the expected worst-case scenarios associated with each activity (to avoid under-estimating emissions). A maximum of three freight trains and two passenger trains were expected in 1-hour. Maximum 1-hour emissions in the switching yard assumes all four switcher locomotives operating at the same time for the full hour.

In addition, idling of a pair of locomotives is modelled on the north mainline track under the Bonson Road pedestrian bridge between two schools as a worst-case location scenario. Idling near the Bonson Road pedestrian bridge was assumed to occur for 30 minutes (based on on-site observations of train building during a departing train from the VIF) for both eastbound trains leaving the VIF facility per day for a total of one hour per day. Maximum 1-hour emission rates for this idling activity assumes two locomotives (at the front of the train) idling for the full hour.

Additionally, idling emissions for two trains a day were also assumed on the existing north mainline track to account for trains waiting for the Pitt River rail bridge to close (i.e., when the bridge is drawn up/not crossable due to vessel movements on the Pitt River). Idling was estimated to occur for 20 minutes for each bridge event. Idling trains waiting for the rail bridge to close were assumed to have four locomotives per train, consistent with line-haul trains noted in the sections above. Maximum 1-hour emission rates for this idling activity assume all four locomotives on the train idling for the full duration of time estimated to close the bridge (20 minutes).

A summary table including the estimated activity times/operational details included in this scenario and emission totals and rates are provided in **Table 8**.

Table 8: Scenario 1 Emissions Inventory Summary

Scenario Details								Annual								Maximum 1-hour						
											Emissions (Tonnes/yr)							Emissions (g/s)				
Scenario Component	Activity	Modelled Sections	Length (m)	Number of Locomotives	Speed (km/h)	Minutes per Delivery/ Activity	Number of Deliveries per Day	Number of Deliveries per Year	Total Hours per Year	Fuel Consumption (L/yr)	CO	NOx	HC	$PM_{2.5}$	SOx	Max 1-hour Deliveries/ Scenarios	Fuel Consumption (L/hr)	CO	NOx	HC	$PM_{2.5}$	SOx
Freight Trains	Mainline Travel	Mainline-1: West of VIF	1,165	4	30.2	2.32	28	10220	395	549,656	3.86	19.00	0.85	0.43	0.01	Max of 3 trains in one hour	161.3	0.31	1.55	0.07	0.03	8.96E-04 [(a)]
		Mainline 2: Alongside VIF	3,070		63.4	2.91			495	689,739	4.84	23.84	1.06	0.54	0.01		202.5	0.39	1.94	0.09	0.04	1.12E-03
		Mainline 3: East of VIF	2,954		63.4	2.8			476	663,677	4.66	22.94	1.02	0.52	0.01		194.8	0.38	1.87	0.08	0.04	1.08E-03
	VIF Departing Train Idling	LTI: Idling on mainline under Bonson Road Pedestrian Bridge	-	2	-	30	2	730	365	8,293	0.06	0.29	0.01	0.01	1.66E-04	2 Locomotives in the front, idling for full hour	22.7	0.04	0.22	9.72E-03	4.92E-03	1.26E-04
	Idling waiting for the Pitt River rail bridge to close	SI: Idling on mainline under Bonson Road Pedestrian Bridge	-	4	-	20	2	730	243	11,057	0.08	0.38	0.02	0.01	2.21E-04	4 Locomotives idling for 20 minutes	15.1 [(b)]	- [(b)]	- [(b)]	- [(b)]	- [(b)]	- [(b)]
West Coast Express Passenger Trains	Mainline Travel	Mainline-1: West of VIF	1,165	1	30.2	2.32	10	3650	141	56,011	0.39	3.05	0.12	0.06	1.12E-03	Max of 2 trains in an hour	30.7	0.06	0.46	0.02	9.46E-03	1.71E-04
		Mainline 2: Alongside VIF	3,070		63.4	2.91			177	70,286	0.49	3.82	0.15	0.08	1.41E-03		38.5	0.08	0.58	0.02	0.01	2.14E-04
		Mainline 3: East of VIF	2,954		31.7	5.59			340	135,260	0.95	7.35	0.28	0.15	2.71E-03		74.1	0.14	1.12	0.04	0.02	4.12E-04
	Idling	At WCE Station	-		-	1.5			91	1,037	7.29E-03	5.64E-02	2.18E-03	1.15E-03	2.07E-05		0.568	1.11E-03	8.58E-03	3.31E-04	1.75E-04	3.16E-06
VIF	Moving freight/ switching/ idling	VIF	-	4	-	90	3 Departing	1095	1643	223,333	1.64	12.66	0.74	0.26	4.47E-03	Max operation of 4 locomotives at once	136	0.28	2.14	0.13	0.04	7.55E-04
					-	60	3 Arriving	1095	1095	148,888	1.09	8.44	0.50	0.18	2.98E-03							

(a) *Written in scientific notation. For example: 3.23E-03 = 3.23×10^{-3} = 0.00323*
(b) *Idling of trains departing the VIF eastbound, and idling waiting for the Pitt River rail bridge were modelled in the same location on the north mainline under the Bonson Road Pedestrian Bridge in Scenario 1. The higher of the two calculated maximum hourly emission rates (lead track idling departing the VIF) were used to model maximum 1-hour rates for this location as two trains cannot both be idling on the same section of mainline.*

3.2 Scenario 2 – Future (2030) Predicted Operations

Scenario 2 builds on Scenario 1 and reflects the predicted increases in mainline traffic by 2030 (59 trains compared to the 28 trains in Scenario 1). VIF operations and West Coast Express emissions are modelled with the same activity levels and assumptions as it is understood they will not change significantly.

Additionally, freight train idling emissions were assumed to be the same as Scenario 1, however in different locations. The estimated idling of two trains a day to account for trains waiting for the Pitt River rail bridge to close (i.e., when the bridge is drawn up/not crossable due to vessel movements on the Pitt River) were assumed to be moved from the north mainline track (Scenario 1 modelled under the Bonson Road pedestrian bridge) to a new siding alongside the VIF and closer to the river. Similar to mainline idling in Scenario 1, idling at the new siding in Scenario 2 was estimated to occur for 20 minutes for each bridge event. Idling trains waiting for the rail bridge to close were assumed to have four locomotives per train, consistent with line-haul trains noted in the sections above. Maximum 1-hour emission rates at the new siding assume all four locomotives on the train idling for the full duration of time estimated to close the bridge (20 minutes).

The locomotive idling during each eastbound train departure from the VIF will move from the north mainline track to the extended lead track from the east end of the VIF. These emissions were still modelled under the Bonson Road pedestrian bridge between two schools as a worst-case location scenario. This idling activity was assumed to occur for 30 minutes (based on on-site observations of train building during a departing train from the VIF) for both eastbound trains leaving the VIF facility per day for a total of one hour per day. Maximum 1-hour emission rates assume two locomotives (at the front of the train) idling for the full hour.

A summary table including the estimated activity times/operational details included in this scenario and emission totals/rates are provided in **Table 9**.

Table 9: Scenario 2 Emissions Inventory Summary

Scenario Details								Annual								Maximum 1-hour						
											Emissions *(Tonnes/yr)*							Emissions *(g/s)*				
Scenario Component	Activity	Modelled Sections	Length *(m)*	Number of Locomotives	Speed *(km/h)*	Minutes per Delivery/ Activity	Number of Deliveries per Day	Number of Deliveries per Year	Total Hours per Year	Fuel Consumption *(L/yr)*	CO	NOx	HC	$PM_{2.5}$	SOx	Max 1-hour Deliveries/ Scenarios	Fuel Consumption *(L/hr)*	CO	NOx	HC	$PM_{2.5}$	SOx
Freight Trains	Mainline Travel	Mainline-1: West of VIF	1,165	4	30.2	2.32	59	21535	831	1,158,205	8.13	40.03	1.78	0.90	0.02	Max of 7 deliveries in an hour	376.5	0.73	3.61	0.16	0.08	2.09E-03 [(a)]
		Mainline 2: Alongside VIF	3,070		63.4	2.91			1043	1,453,378	10.20	50.23	2.24	1.13	0.03		472.4	0.92	4.54	0.20	0.10	2.62E-03
		Mainline 3: East of VIF	2,954		63.4	2.8			1004	1,398,462	9.82	48.33	2.15	1.09	0.03		454.6	0.89	4.36	0.19	0.10	2.53E-03
	VIF departing train idling	LTI: Idling on extended VIF east lead track under Bonson Road Pedestrian Bridge	-	2	-	30	2	730	365	8,293	0.06	0.29	0.01	0.01	1.66E-04	2 Locomotives idling for the full hour	22.7	0.04	0.22	9.72E-03	4.92E-03	1.26E-04
	Idling waiting for the Pitt River rail bridge to close	SI: Idling on new siding alongside VIF	-	4	-	20	2	730	243	11,057	0.08	0.38	0.02	0.01	2.21E-04	4 Locomotives idling for 20 minutes	15.1	0.03	0.15	6.48E-03	3.28E-03	8.41E-05
West Coast Express Passenger Trains	Mainline Travel	Mainline-1: West of VIF	1,165	1	30.2	2.32	10	3650	141	56,011	0.39	3.05	0.12	0.06	1.12E-03	Max of 2 deliveries in an hour	30.7	0.06	0.46	0.02	9.46E-03	1.71E-04
		Mainline 2: Alongside VIF	3,070		63.4	2.91			177	70,286	0.49	3.82	0.15	0.08	1.41E-03		38.5	0.08	0.58	0.02	0.01	2.14E-04
		Mainline 3: East of VIF	2,954		31.7	5.59			340	135,260	0.95	7.35	0.28	0.15	2.71E-03		74.1	0.14	1.12	0.04	0.02	4.12E-04
	Idling	At WCE Station	-		-	1.5			91	1,037	7.29E-03	5.64E-02	2.18E-03	1.15E-03	2.07E-05		0.568	1.11E-03	8.58E-03	3.31E-04	1.75E-04	3.16E-06
VIF	Moving freight/ switching/ idling	VIF	-	4	-	90	3 Departing	1095	1643	223,333	1.64	12.66	0.74	0.26	4.47E-03	Max operation of 4 locomotives at once	136	0.28	2.14	0.13	0.04	7.55E-04
					-	60	3 Arriving	1095	1095	148,888	1.09	8.44	0.50	0.18	2.98E-03							

(a) Written in scientific notation. For example: 3.23E-03 = 3.23 x 10^{-3} = 0.00323

3.3 Scenario 3 – Future (2030) Predicted Operations with Inclusion of Proposed CP Logistics Park: Vancouver

Scenario 3 builds on Scenario 2 and includes the proposed CP Logistics Park: Vancouver (LPV) to be located south of VIF operations. As with Scenario 2, Scenario 3 also includes expected mainline traffic in 2030 (59 trains on the mainline). Emissions from VIF operations, West Coast Express, and the freight train idling are modelled with the same activity levels and assumptions.

The proposed LPV is planned to consist of operations for the transloading of agricultural products, automobiles, and liquid products in three distinct areas of the LPV. Additional activities modelled in Scenario 3 include idling emissions from the agricultural hub/rail loop, and rail switching activities associated with the automobile and liquid products subsites. Idling on the LPV lead track just north of Highland Park Elementary was also considered as a worst-case scenario.

Agricultural products are proposed to arrive to the LPV in 147-car, 8,500-ft unit trains. Once arrived on-site, unit trains for agricultural products will move as a solid train (no switching required) through the proposed rail loop in a clockwise direction. Agricultural cars will be bottom unloaded into a conveyor in an unloading pit. Based on provided descriptions, one unit train can be unloaded every 24 hours, with an average of one train unloaded every three days. Trains were assumed to be idling during unloading operations. As with the other mainline freight trains considered in this study, fuel consumption rates from GE4400AC locomotives were used with an assumed four locomotives per train. Maximum 1-hour emission rates at the rail loop assume all four locomotives on the train idling for the full hour.

Automobile and liquid products will arrive at the LPV via mixed-product trains and directed to the receiving staging yard. Switcher locomotives will move loaded railcars from the receiving staging yard to commodity specific locations on-site. Empty/unloaded railcars from the automobile/liquid subsites will then be sorted in destination specific blocks for departure. It was assumed approximately two mixed-product trains will be arriving and departing the LPV each day.

Activity times for switching activities at the LPV were assumed to be consistent with the activity times assumed at the VIF (i.e., 60 minutes for arrival trains, and 90 minutes for departing trains/train make-ups). Four switch locomotives were also assumed to be operational at the LPV. Maximum 1-hour emissions in the switching yard assumes all four switcher locomotives operating at the same time for the full hour.

To consider the additional siding associated with the LPV facility, idling of a pair of locomotives is modelled on the proposed siding just north of Highland Park Elementary as a worst-case location close to sensitive receptors. Idling near the school was assumed to occur for 30 minutes during the departure of two trains per day from the LPV facility, similar to the assumption used for the VIF (based on on-site observation of a departing train). Maximum 1-hour emission rates near Highland Park Elementary assumes two locomotives (at the front of the train) idling for the full hour.

A summary table including the estimated activity times/operational details included in this scenario and emission totals and rates are provided in **Table 10**.

Table 10: Scenario 3 Emissions Inventory Summary

Scenario Details								Annual								Maximum 1-hour						
											Emissions *(Tonnes/yr)*							Emissions *(g/s)*				
Scenario Component	Activity	Modelled Sections	Length *(m)*	Number of Locomotives	Speed *(km/h)*	Minutes per Delivery/ Activity	Number of Deliveries per Day	Number of Deliveries per Year	Total Hours per Year	Fuel Consumption *(L/yr)*	CO	NOx	HC	$PM_{2.5}$	SOx	Max 1-hour Deliveries/ Scenarios	Fuel Consumption *(L/hr)*	CO	NOx	HC	$PM_{2.5}$	SOx
Freight Trains	Mainline Travel	Mainline-1: West of VIF	1,165	4	30.2	2.32	59	21535	831	1,158,205	8.13	40.03	1.78	0.90	0.02	Max of 7 deliveries in an hour	376.5	0.73	3.61	0.16	0.08	2.09E-03 (a)
		Mainline 2: Alongside VIF	3,070		63.4	2.91			1043	1,453,378	10.20	50.23	2.24	1.13	0.03		472.4	0.92	4.54	0.20	0.10	2.62E-03
		Mainline 3: East of VIF	2,954		63.4	2.8			1004	1,398,462	9.82	48.33	2.15	1.09	0.03		454.6	0.89	4.36	0.19	0.10	2.53E-03
	VIF departing train idling	LTI: Idling on extended VIF lead track under Bonson Road Pedestrian Bridge	-	2	-	30	2	730	365	8,293	0.06	0.29	0.01	0.01	1.66E-04	2 Locomotives idling for the full hour	22.7	0.04	0.22	9.72E-03	4.92E-03	1.26E-04
	Idling waiting for the Pitt River rail bridge to close	SI: Idling on new siding alongside VIF	-	4	-	20	2	730	243	11,057	0.08	0.38	0.02	0.01	2.21E-04	4 Locomotives idling for 20 minutes	15.1	0.03	0.15	6.48E-03	3.28E-03	8.41E-05
West Coast Express Passenger Trains	Mainline Travel	Mainline-1: West of VIF	1,165	1	30.2	2.32	10	3650	141	56,011	0.39	3.05	0.12	0.06	1.12E-03	Max of 2 deliveries in an hour	30.7	0.06	0.46	0.02	9.46E-03	1.71E-04
		Mainline 2: Alongside VIF	3,070		63.4	2.91			177	70,286	0.49	3.82	0.15	0.08	1.41E-03		38.5	0.08	0.58	0.02	0.01	2.14E-04
		Mainline 3: East of VIF	2,954		31.7	5.59			340	135,260	0.95	7.35	0.28	0.15	2.71E-03		74.1	0.14	1.12	0.04	0.02	4.12E-04
	Idling	At WCE Station	-		-	1.5			91	1,037	7.29E-03	5.64E-02	2.18E-03	1.15E-03	2.07E-05		0.568	1.11E-03	8.58E-03	3.31E-04	1.75E-04	3.16E-06
VIF	Moving freight/switching/ idling	VIF	-	4	-	90	3 Departing	1095	1643	223,333	1.64	12.66	0.74	0.26	4.47E-03	Max operation of 4 locomotives at once	136	0.28	2.14	0.13	0.04	7.55E-04
					-	60	3 Arriving	1095	1095	148,888	1.09	8.44	0.50	0.18	2.98E-03							
LPV	Agricultural Products Transloading	Idling along LPV rail loop for agricultural products	-	4	-	1440	1/3	122	2920	132,685	0.93	4.59	0.20	0.10	2.65E-03	Max idling is 4 locomotives	45.4	0.09	0.44	0.02	9.85E-03	2.52E-04
	Moving freight/ switching/ idling	Automobiles & Liquids areas of proposed LPV	-	4	-	90	2 Departing	730	1095	148,888	1.09	8.44	0.50	0.18	2.98E-03	Max operation of 4 locomotives at once	136.0	0.28	2.14	0.13	0.04	7.55E-04
					-	60	2 Arriving	730	730	99,259	0.73	5.63	0.33	0.12	1.99E-03							
	Idling on LPV lead track	LPLTI: Idling on proposed lead track just north of Highland Park Elementary	-	2	-	30	2	730	365	8,293	0.06	0.29	0.01	0.01	1.66E-04	2 locomotives idling for the full hour	22.7	0.04	0.22	9.72E-03	4.92E-03	1.26E-04

(a) *Written in scientific notation. For example: 3.23E-03 = 3.23 x 10^{-3} = 0.00323*

4.0 AIR DISPERSION MODELLING

4.1 Methodology

Air dispersion modelling was performed to predict the dispersion of emissions in the areas surrounding the rail operations and predict ground level air contaminant concentrations. An air dispersion modelling plan was developed and submitted to the City of Pitt Meadows for their review prior to this interim report.

Modelling was performed using the CALPUFF air dispersion modelling system and followed the British Columbia Air Quality Dispersion Modelling Guideline 2015 (BC AQMG). The BC AQMG provides key guidance on a variety of topics: model selection, application of models for regulatory purposes in BC, and best modelling practices. The CALPUFF modelling system consists of two main model packages including CALMET, a diagnostic 3-dimensional meteorological model, and CALPUFF, an air quality dispersion model.

Meteorological modelling was performed using CALMET for a 1-year period using a domain of 25 km x 25 km centred on Pitt Meadows. CALMET was ran in hybrid mode where both mesoscale meteorological model output data and local measured meteorological station data for the modelled year (2012) are used along with geophysical data (terrain elevations, land use and land cover etc.) to predict 3D wind fields. QA/QC checks of the model output data was conducted and will be included in the final study report. The 2012 (January 1, 2012 to December 31, 2012) Weather Research and Forecasting (WRF) model output prognostic data with 1 km grid resolution was used.

CALPUFF is a multi-layer, multi-species, non-steady-state Lagrangian Gaussian air quality modelling system for regulatory use that can simulate the effects of varying meteorological conditions in time and space on pollutant transport. CALPUFF modelling was performing using similar parameters for rail emission sources as used in other rail yard studies. Rail activities were modelled as a mixture of road sources to simulate the train movements along the mainline, volume sources to cover switching locomotives moving around the VIF and LPV, and point sources to simulate stationary idling locomotives.

Model results were extracted using the appropriate emission rates based on the annual and maximum 1-hour activity estimates for each modelled emission source for each of the three modelled scenarios.

4.2 Preliminary Dispersion Modelling Results

Preliminary model predicted ground level concentrations are presented in **Table 11** for each of the three worst-case scenarios for $PM_{2.5}$ only. While multiple air contaminants are emitted from diesel engines and are under evaluation in this study, diesel emissions particulate (DEP) has typically received the greatest attention from health perspectives in Canada and abroad for its potential health risks and results for this air contaminant were therefore focused on at this interim stage of this project. Results including other air contaminants will be presented in the final study report with respective averaging periods for comparison to air quality standards as appropriate.

For the purposes of this study, it was assumed that particulate matter (PM), $PM_{2.5}$ and DEP emissions are equivalent from diesel locomotive combustion. Preliminary risk assessment results for model predicted $PM_{2.5}$/DEP concentrations are presented within this report.

While it should be noted that background concentrations are not included here and these results are based on the estimated worst-case scenarios for locomotive emissions within the municipal boundary of the City of Pitt Meadows (plus 1 km buffer on each end of the mainline) only, the highest model predicted 24-hour rolling average $PM_{2.5}$ concentration (6.0 micrograms per cubic metre of air (µg/m^3) close to the CP fence line in Scenario 3) in any of the three scenarios was less than 25% of the Metro Vancouver 24-hour ambient air quality objective of 25 µg/m^3. However, please note that these AAQOs are for any type of $PM_{2.5}$, not specifically DEP. Further health-based thresholds specific to DEP are evaluated in the preliminary HHRA presented in the following section.

Annual average results were also below the Metro Vancouver long-term planning goal of 6 µg/m^3 in all three scenarios, with a maximum result of 2.1 µg/m^3 close to the CP fence line in Scenario 3.

While there are no 1-hour ambient air quality objectives in BC nor in MV for comparison of predicted $PM_{2.5}$ concentrations under the worst-case maximum 1-hour scenarios, these results are presented for use in the preliminary HHRA aspect of this project.

The model results are discussed for the receptors outside of the CP “fenceline”, that is, where there is public access. Results presented in **Table 11** are for the receptors identified to have the maximum predicted concentration within each receptor category (i.e., concentration at the residence with the highest predicted concentration of all modelled residences, concentration at the school with the highest predicted concentration of all modelled schools etc.). Therefore, the result under each averaging period and for each scenario may not necessarily be at the same receptor (i.e., a different residence may be predicted to have the highest 1-hour average than the residence predicted to have the highest annual average).

Table 12 presents preliminary isopleth figures showing the maximum model predicted 24-hour rolling averages and the annual averages of $PM_{2.5}$ concentrations across the area surrounding the modelled rail operations. Model predicted concentrations were found to follow the mainline with higher results close to the current VIF rail yard and proposed LPV in Scenario 3. Predicted concentrations are shown to reduce relatively quickly with distance from the rail tracks.

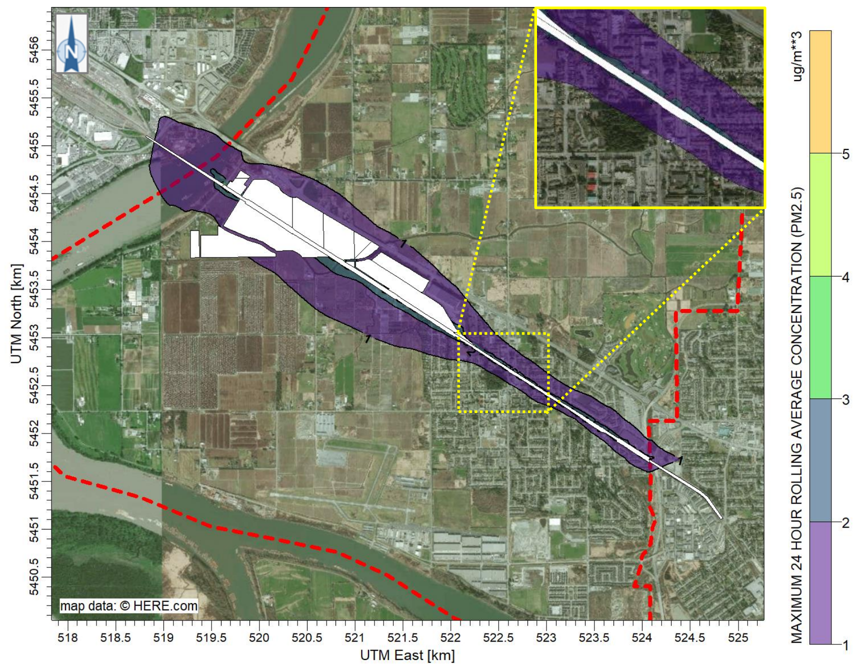
The final report will include results for further air contaminants and further comparison to relevant air quality objectives.

Table 11: Preliminary $PM_{2.5}$ Air Dispersion Modelling Results

Modelled Scenario	Averaging Period	Metro Vancouver AAQO	Maximum Predicted Ground Level Concentration (GLC) *(µg/m³)*						
			MPOI [(a)]	Sensitive Receptors with the Highest GLC in Each Category [(b)]					
				Business	Child Care	Health Care	Residence	School	Senior Care
Scenario 1: *Current Rail Operations*	Max 1 Hour Average	-	22.8	9.0	14.7	10.9	17.8	8.9	7.3
	Max 24-hour Rolling Average	25	2.8	1.4	1.9	1.1	2.4	1.2	0.7
	Annual Average	8 (6) [(c)]	1.0	0.3	0.5	0.3	0.8	0.3	0.2
Scenario 2: *Forecasted 2030 Operations*	Max 1 Hour Average	-	45.4	14.6	26.3	17.8	30.2	15.0	12.4
	Max 24-hour Rolling Average	25	5.3	2.2	3.5	2.0	4.3	2.1	1.3
	Annual Average	8 (6) [(c)]	1.9	0.5	0.9	0.5	1.2	0.5	0.3
Scenario 3: *Scenario 2 with the Addition of the LPV*	Max 1 Hour Average	-	49.7	20.9	27.0	19.1	30.5	15.3	12.8
	Max 24-hour Rolling Average	25	6.0	3.1	3.5	2.0	4.3	2.1	1.3
	Annual Average	8 (6) [(c)]	2.1	0.6	0.9	0.5	1.2	0.5	0.3

[a)] *Maximum Point of Impingement outside of CP Owned Lands (i.e., at a publicly accessible location).*
[b)] *Maximum concentration of contaminants for the sensitive receptors which were predicted to have the highest GLC among that receptor category are presented for each scenario and averaging period.*
[c)] *Annual objective of 6 µg/m³ is a longer-term aspirational target to support continuous improvement.*

Table 12: Preliminary Dispersion Model Predicted Ground Level $PM_{2.5}$ Concentrations for Each Emissions Scenario

<table>
<tr><th></th><th>Scenario 1 – Current Operations</th><th>Scenario 2 – Future 2030 Operations</th><th>Scenario 3 – Future 2030 Operations Including the LPV</th></tr>
<tr><td>Maximum 24-hour Rolling Average</td>
<td>
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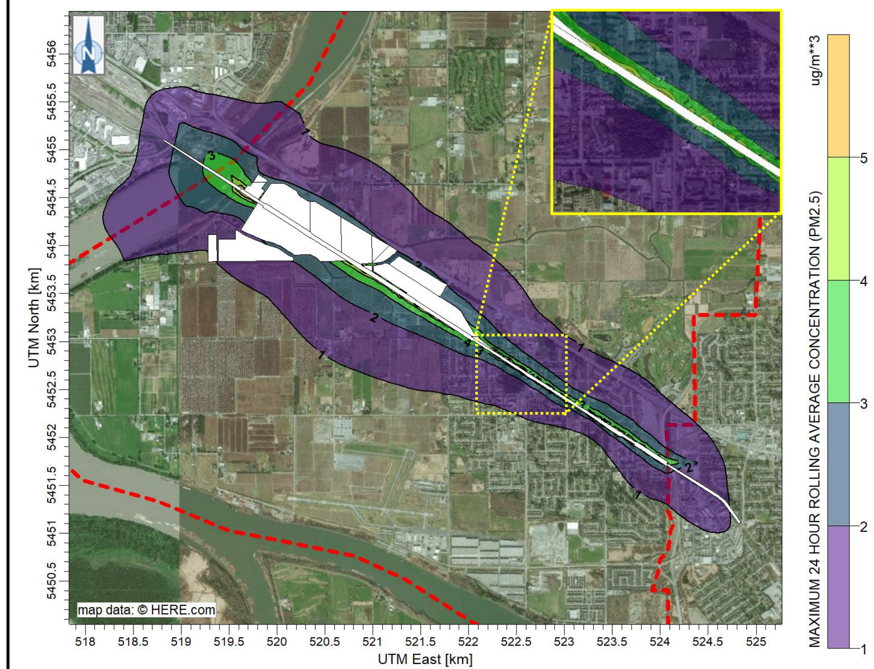
<td>
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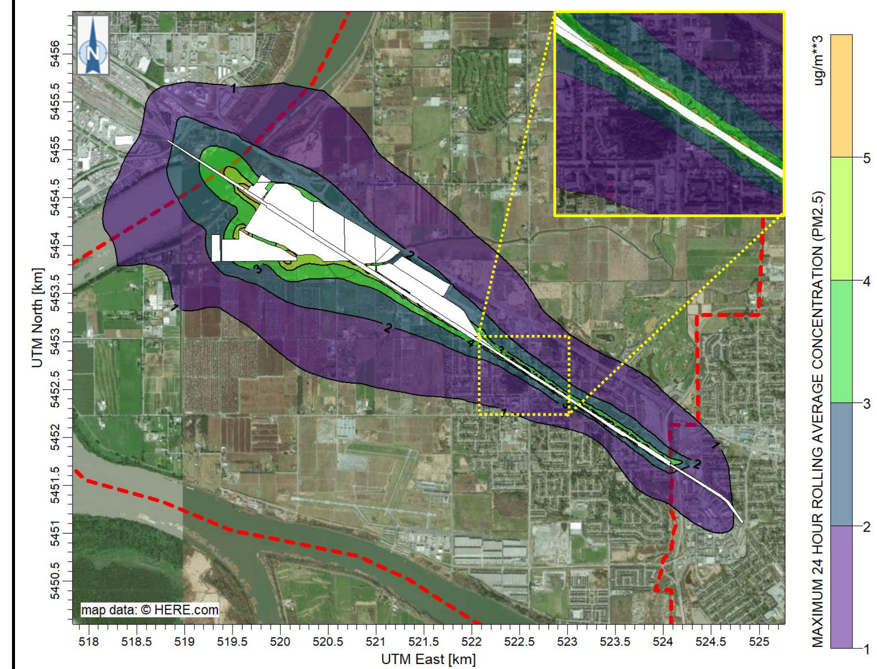
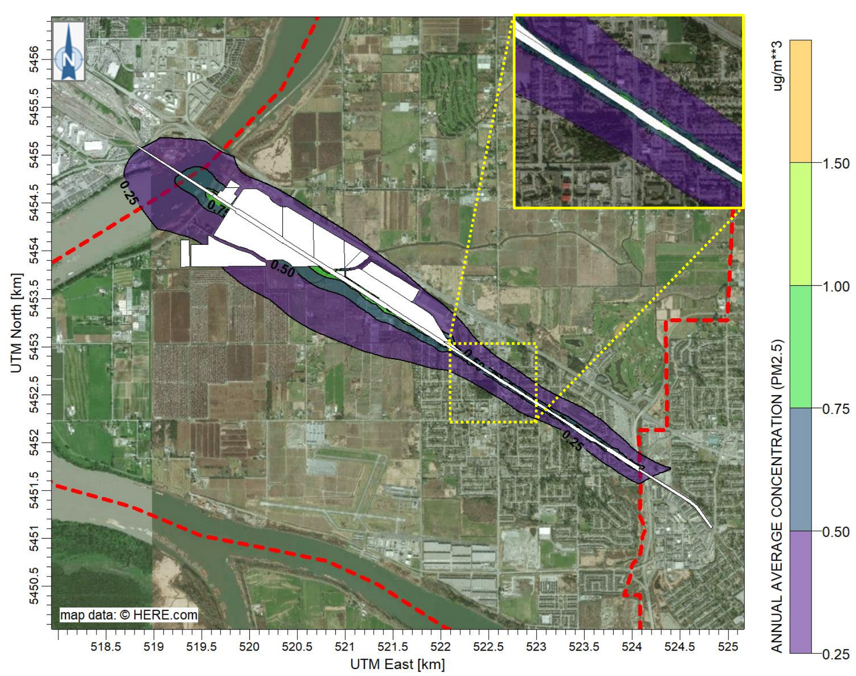
<td>
</td></tr>
<tr><td>Annual Average</td>
<td>
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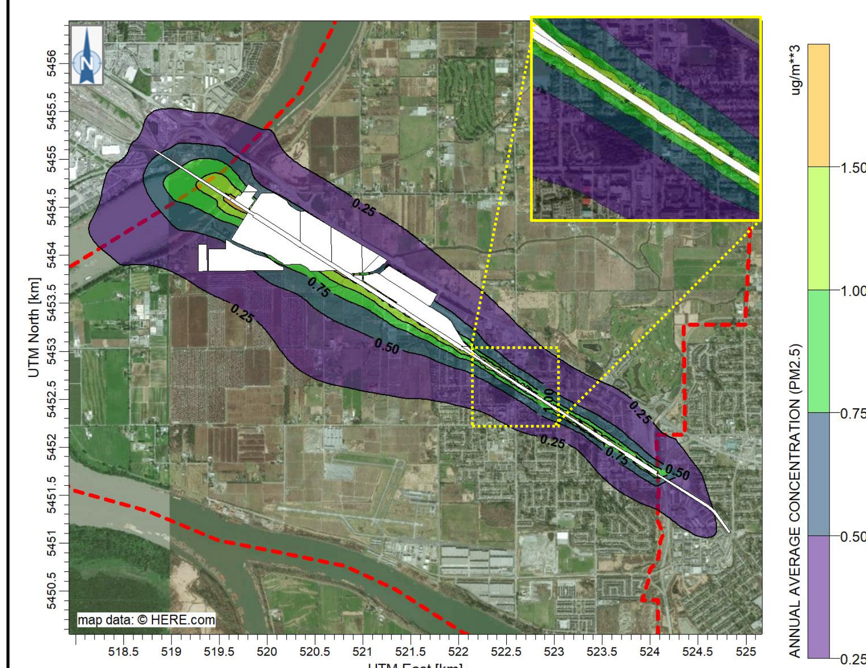
<td>
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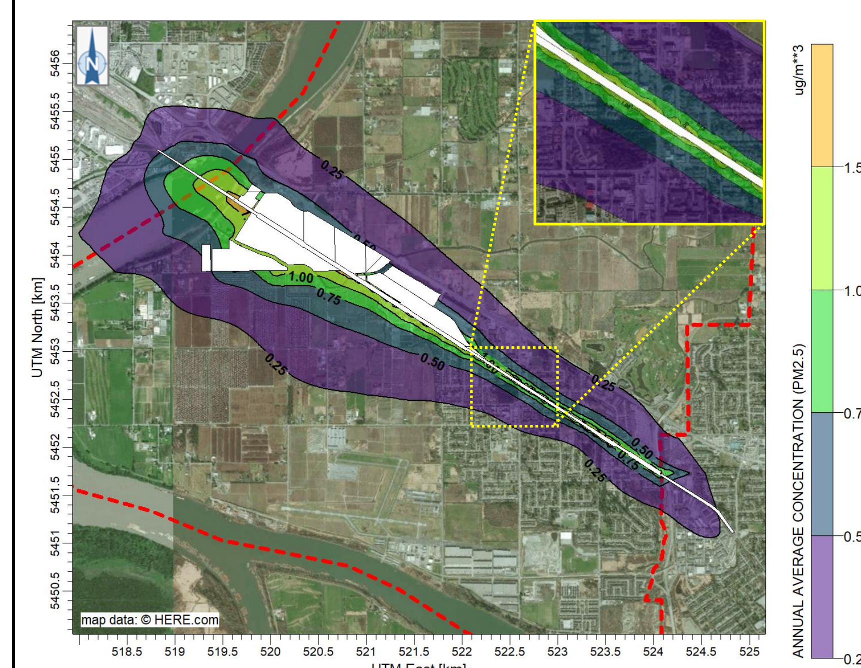
<td>
</td></tr>
</table>

***NOTE**: Model predicted $PM_{2.5}$ concentrations shown here are based on emissions from rail activities within the City of Pitt Meadows municipal boundary (shown as a red dashed line) with the addition of a 1km buffer on the mainlines to the east and west of the city boundary. Inset figures show model predicted concentrations around the Harris Road rail crossing. White areas show CP lands and the rail right of way where there is no public access.*
– – – – = The City of Pitt Meadows Boundary

5.0 PRELIMINARY HUMAN HEALTH RISK ASSESSMENT

5.1 Risk Assessment Approach

The potential for human health risks exist due to the presence of chemical constituents in environmental media is predicated on the co-existence of three components: 1) chemicals must be present at hazardous levels, 2) receptors (people) must be present, and 3) exposure pathways must exist between the chemicals and receptors. In the absence of any one of the three components, human health risks do not exist. The presence of all three elements indicates a potential for risks but does not indicate the magnitude of risk. A risk assessment is conducted to determine if these three essential elements of risk are present, and whether the magnitude of risk is acceptable or unacceptable.

The risk assessment framework applied for the project is consistent with provincial and federal guidance and consists of four steps: 1) Problem Formulation; 2) Exposure Assessment; 3) Effects Assessment; and 4) Risk Characterization. In Problem Formulation, a conceptual exposure model is developed which identifies the contaminants of potential concern, the human receptors of potential concern, and potentially complete exposure pathways between the contaminants and receptors. In Exposure Assessment, the frequency, magnitude and duration of contaminant exposure is estimated for each receptor. In Effects Assessment, the adverse effects that exposures to the contaminants could cause are identified, and toxicity reference values (TRVs) are selected. During the Risk Characterization step, the results of the Exposure and Effects Assessments are integrated and interpreted into descriptions of human health risk.

The guidance documents used in the human health risk assessment are:

- Protocol 1 for Contaminated Sites - Detailed Risk Assessment, Version 3.0. ENV, May 13, 2021.
- Human Health Risk Assessment for Diesel Exhaust. Health Canada, March 2016.
- Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Version 3.0. Health Canada, March 2021.
- Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs), Version 3.0. Health Canada, March 2021.

For the purposes of this interim report, only the following key elements of the four steps described above are discussed:

- Conceptual Exposure Model (i.e., scenarios, contaminants, receptors, and exposure pathways)
- Exposure Estimation
- Toxicity Reference Values
- Preliminary Risk Estimates

A comprehensive risk assessment will be provided in the final study report.

5.1.1 Conceptual Exposure Model

The three scenarios for which dispersion modelling was conducted and that the HHRA considers are as follows. It should be noted that the emissions modelling in this study includes worst-case activity levels (based on current understanding of rail operations in Pitt Meadows) to identify the maximum potential health impacts. Comparison of the results for each scenario is reasonable with the understanding that background concentrations from other emissions sources in the region will also impact potential risks identified below.

- **Scenario 1:** Current rail operations
- **Scenario 2:** Forecasted 2030 rail operations
- **Scenario 3:** Scenario 2 with the addition of the proposed CP Logistics Park: Vancouver

The contaminants of potential concern (COPCs) associated with diesel emissions for which dispersion modelling was conducted include CO, NO_x, $PM_{2.5}$, SO_2 and various VOCs. While multiple air contaminants are emitted from diesel engines and are under evaluation in this study, diesel emissions particulate (DEP) has typically received the greatest attention from health authorities in Canada and abroad for its potential health risks and results for this air contaminant were therefore focused on at this interim stage of this project. Dispersion modelling and HHRA is in progress for the remaining COPCs.

The human receptors of potential concern (ROPCs) with respect to exposures to diesel emissions from rail activities are members of the general public that live, work and recreate within the City of Pitt Meadows and the region in general. In particular, dispersion modelling predicted COPC concentrations for the following locations within the study area to which people could be exposed: Businesses, Child Care Facilities, Health Care Facilities, Residences, Schools, Senior Care Facilities, and the Maximum Point of Impingement (MPOI). The ROPCs for the preliminary HHRA are people that spend time at these locations. The location with the highest predicted concentration within each category was assessed (i.e., the school with the highest predicted concentration of the school locations included in the model).

Inhalation of COPCs attached to air-borne particles and/or in the vapour phase is expected to be the primary exposure pathway of concern with respect to human exposure and health effects and therefore is the focus of the preliminary HHRA. Exposure to diesel emission related COPCs via other exposure pathways (e.g., ingestion of settled dust, dermal contact with settled dust, ingestion of food grown in contaminated soils, etc.) is possible but expected to be a less important contributor to exposure and risk.

5.1.2 Exposure Estimation

The following equation from Health Canada (2021a[6]) was used to estimate $PM_{2.5}$ exposures for each location and scenario:

$$TDCA\ or\ TLACA = \frac{CA \times RAF_{Inh} \times D_1 \times D_2 \times D_3 \times D_4}{LE}$$

Where:

- TDCA = time-adjusted average daily air concentration (µg/m^3) – to assess non-cancer risk
- TLACA = time-adjusted lifetime average air concentration (µg/m^3) – to assess cancer risk
- CA = concentration of $PM_{2.5}$ in air (µg/m^3)
- RAF_{Inh} = relative absorption factor for inhalation (unitless)
- D_1 = hours per day exposed/24 hours
- D_2 = days per week exposed/7 days
- D_3 = weeks per year exposed/52 weeks
- D_4 = number of years exposed (used in exposure estimation for cancer risk only)
- LE = life expectancy (year; used in exposure estimation for cancer risk only)

The parameters used in the exposure estimation equation are defined below.

Maximum predicted 1-hour average concentrations at each location and scenario were assumed to represent the concentration of $PM_{2.5}$ in air (CA) for the purposes of estimating short term exposures (see **Table 11**). To estimate chronic $PM_{2.5}$ exposures, predicted annual average concentrations at each location and scenario were assumed to represent the CA term (see **Table 11**).

A relative inhalation absorption factor (RAF_{Inh}) of one (1) was assumed when estimating $PM_{2.5}$ exposure, per Health Canada (2021b[7]) guidance.

The duration and frequency (D_1, D_2, D_3, D_4) that ROPCs were assumed to be exposed to $PM_{2.5}$ and assumed ROPC life expectancies were based on preliminary human health risk assessment guidance from Health Canada (2021a) and are presented below in **Table 13**.

[6] Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Version 3.0. Health Canada, March 2021.

[7] Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs), Version 3.0. Health Canada, March 2021.

Table 13: Assumed Exposure Duration and Frequency

Location	Hours Per Day Exposed	Days Per Week Exposed	Weeks Per Year Exposed	Years Exposed	Life Expectancy *(Years)*
MPOI [(a)]	2	7	52	80	80
Business	10	5	48	35	80
Child Care	10	5	48	35	80
Health Care[(b)]	10	5	48	35	80
Residence	24	7	52	80	80
School	10	5	48	35	80
Senior Care	24	7	52	35	80

(a) Maximum predicted model result at an outdoor space near the rail operations
(b) The health care facilities within the study area are clinics without overnight care.

5.1.3 Toxicity Reference Values

For the purposes of the preliminary HHRA it is assumed that $PM_{2.5}$ is equivalent to diesel emissions particulate (DEP). The uncertainties with this assumption are described by Health Canada (2016[8]) and are acknowledged. However, this assumption is considered reasonable and appropriate for the preliminary HHRA given that rail operations-related diesel emissions were the only source of particulates included in dispersion modelling.

Health Canada (2016) identified a causal relationship between DEP exposures and lung cancer and a suggestive link to bladder cancers. With regard to non-carcinogenic effects, short term and chronic exposures to DEP have been linked to adverse respiratory, reproductive, developmental, cardiovascular, immunological and neurological effects (Health Canada, 2016).

Health Canada (2016) recommended the following tolerable concentrations for DEP for non-cancer effects:

- Chronic Exposure – 5 $\mu g/m^3$
- Short-term Exposure (up to 2 hours) – 10 $\mu g/m^3$

These health-based values were used to assess the risk of non-cancer health effects due to $PM_{2.5}$/DEP exposure within the study area.

In the absence of a recommended Toxicity Reference Value (TRV) for cancer effects from Health Canada, an inhalation unit risk of 3E-04 $(\mu g/m^3)^{-1}$ recommended by the California Environmental Protection Agency[9] was used to evaluate cancer risks.

The regional air quality objectives and federal standards identified in **Section 2.2** are not purely health-based and therefore were not used to estimate risk.

[8] Human Health Risk Assessment for Diesel Exhaust. Health Canada, March 2016.
[9] California OEHHA. Toxicity Criteria Database Available. California Office of Environmental Health Hazard Assessment. Sacramento, California.

5.2 Preliminary Risk Estimates

The health risks for each human receptor were estimated based on worst-case air dispersion modelling presented in **Section 4.2**, exposure assumptions presented in **Section 5.1.2** and TRVs presented in **Section 5.1.3**. Since CP's rail operations are federally regulated, federal risk guidelines were used to interpret the acceptability of the estimated risks.

5.2.1 Non-Cancer Health Risks

Non-cancer health risks were estimated for each receptor location and scenario by the following formula:

$$HQ = \frac{TDCA}{TC}$$

Where:

- HQ = hazard quotient
- TDCA = time-adjusted average daily air concentration (µg/m^3)
- TC = tolerable concentration (µg/m^3)

Health Canada (2021a) considers a hazard quotient of greater than 0.2 to indicate a potential unacceptable non-cancer health risk in preliminary human health risk assessments that do not account fully for background exposures to chemicals (i.e., from sources at a site and away from a specific site). In other words, an exposure exceeding 20% of the tolerable daily intake of a chemical is unacceptable in a preliminary HHRA. Health Canada (2021) does however indicate that a risk assessor may chose to use a threshold of acceptability other than 0.2 with rationale.

This preliminary HHRA does not fully account for background exposures to $PM_{2.5}$/DEP and focusses on inhalation exposures only. The media to which people could theoretically be exposed to $PM_{2.5}$/DEP include air (inhalation), soil/settled dust (ingestion/dermal contact), water (ingestion/dermal contact), food (ingestion), and consumer products (dermal contact). It is highly unlikely that people would be exposed to $PM_{2.5}$/DEP through consumption or contact with water or consumer products. If the tolerable daily intake of $PM_{2.5}$/DEP is apportioned equally to the three remaining media (i.e. air, soil/settled dust and food), an allowable HQ of 0.33 from exposure to each medium can be derived. Accordingly, an HQ of 0.33 was used as the threshold of acceptability for the air inhalation risk estimates presented below. This is expected to be conservative since air exposures to $PM_{2.5}$/DEP are likely to be much higher and hazardous than exposures to soil/settled dust and food.

Non-cancer hazard quotients for each scenario and location (the receptors with the maximum predicted ground level concentrations in each receptor category) are presented below in **Table 14** to **Table 16**.

Table 14: Hazard Quotients: $PM_{2.5}$ Concentration in Air – Scenario 1: Current Operations

	MPOI	Sensitive Receptor with Maximum Predicted Ground Level Concentration in each Category					
		Business	Child Care	Health Care	Residence	School	Senior Care
Short Term HQs	0.19	0.25	**0.40**	0.30	**1.8**	0.24	**0.73**
Chronic HQs	0.02	0.02	0.02	0.01	0.15	0.01	0.04

MPOI – maximum point of impingement
***Bold** – exceeds threshold of acceptable risk (0.33)*

Estimated short-term HQs for residential, child care and senior care locations exceeded 0.33 under Scenario 1 indicating a potentially unacceptable risk at these locations. Short term and chronic HQs for the remaining locations under Scenario 1 were less than 0.33 indicating an acceptable risk.

Table 15: Hazard Quotients: $PM_{2.5}$ Concentrations in Air – Scenario 2: Forecasted 2030 Operations

	MPOI	Sensitive Receptor with Maximum Predicted Ground Level Concentration in each Category					
		Business	Child Care	Health Care	Residence	School	Senior Care
Short Term HQs	**0.38**	**0.40**	**0.72**	**0.49**	**3.0**	**0.41**	**1.2**
Chronic HQs	0.03	0.03	0.04	0.03	0.25	0.03	0.07

MPOI – maximum point of impingement
***Bold** – exceeds threshold of acceptable risk (0.33)*

Estimated short-term HQs exceeded 0.33 for each location under Scenario 2 indicating a potentially unacceptable risk at these locations. Estimated short-term HQs were up to 99% higher under Scenario 2 compared to Scenario 1.

Chronic HQs for all locations under Scenario 2 were less than 0.33 indicating an acceptable risk.

Table 16: Hazard Quotients: $PM_{2.5}$ Concentrations in Air – Scenario 3: Scenario 2 With the Addition of the Proposed CP Logistics Park

	MPOI	Sensitive Receptor with Maximum Predicted Ground Level Concentration in each Category					
		Business	Child Care	Health Care	Residence	School	Senior Care
Short Term HQs	**0.41**	**0.58**	**0.74**	**0.52**	**3.1**	**0.42**	**1.3**
Chronic HQs	0.03	0.04	0.04	0.03	0.25	0.03	0.07

MPOI – maximum point of impingement
***Bold** – exceeds threshold of acceptable risk (0.33)*

Estimated short-term HQs exceeded 0.33 for each location under Scenario 3 indicating a potentially unacceptable risk at these locations. Estimated short-term HQs up to 43% higher under Scenario 3 compared to Scenario 2 at receptors close to the proposed LPV.

Chronic HQs for all locations under Scenario 3 were less than 0.33 indicating an acceptable risk.

Example Calculation – Non-Cancer Hazard Quotient

- Scenario: 1
- Receptor: Business
- Exposure Type: Chronic

$$HQ = \frac{TDC_A}{TC}$$

$$HQ = \frac{0.32\ \mu g/m^3 \times 10\ hours/24\ hours \times 5\ days/7\ days \times 48\ weeks/52\ weeks}{5\ \mu g/m^3}$$

HQ = 0.02

5.2.2 Cancer Risks

The incremental lifetime cancer risks posed by $PM_{2.5}$/DEP exposure were estimated for each location and scenario by the following formula:

$$ILCR = TLAC_A \times UR$$

Where:

- ILCR = Incremental Lifetime Cancer Risks
- $TLAC_A$ = time-adjusted lifetime air concentration ($\mu g/m^3$)
- UR = inhalation unit risk $(\mu g/m^3)^{-1}$

Health Canada's guideline of acceptability for incremental lifetime cancer risk is 1 additional cancer case in 100,000 people than would otherwise be expected in an average sample population of 100,000 people. ILCRs for each scenario and location are presented in **Table 17** to **Table 19**.

Table 17: Incremental Lifetime Cancer Risks – Scenario 1: Current Operations

	MPOI	Sensitive Receptor with Maximum Predicted Ground Level Concentration in each Category					
		Business	Child Care	Health Care	Residence	School	Senior Care
ILCR[(a)]	**2.5**	**1.2**	**1.8**	**0.9**	**23**	**1.1**	**2.5**

(a) – Number of additional cancer cases per 100,000 people exposed
MPOI – maximum point of impingement
***Bold** – exceeds threshold of acceptable risk (1 in 100,000)*

ILCRs estimated for each location, except health care, exceeded 1 additional cancer case per 100,000 people exposed indicating a potential unacceptable risk under Scenario 1 at these locations.

Table 18: Incremental Lifetime Cancer Risks – Scenario 2: Forecasted 2030 Operations

	MPOI	Sensitive Receptor with Maximum Predicted Ground Level Concentration in each Category					
		Business	Child Care	Health Care	Residence	School	Senior Care
ILCR[(a)]	4.7	1.8	3.3	1.7	37	1.9	4.5

(a) – Number of additional cancer cases per 100,000 people exposed
MPOI – maximum point of impingement
***Bold** – exceeds threshold of acceptable risk (1 in 100,000)*

ILCRs estimated for each location exceeded 1 additional cancer case per 100,000 people exposed indicating a potential unacceptable risk under Scenario 2. Estimated ILCRs were up to 91% higher under Scenario 2 compared to Scenario 1.

Table 19: Incremental Lifetime Cancer Risks - Scenario 3: Scenario 2 With the Addition of the Proposed CP Logistics Park

	MPOI	Sensitive Receptor with Maximum Predicted Ground Level Concentration in each Category					
		Business	Child Care	Health Care	Residence	School	Senior Care
ILCR[(a)]	5.2	2.3	3.3	1.7	37	1.9	4.5

(a) – Number of additional cancer cases per 100,000 people exposed
MPOI – maximum point of impingement
***Bold** – exceeds threshold of acceptable risk (1 in 100,000)*

ILCRs estimated for each location exceeded 1 additional cancer case per 100,000 people exposed indicating a potential unacceptable risk under Scenario 3. Estimated ILCRs were up to 28% higher under Scenario 3 compared to Scenario 2.

Example Calculation – Incremental Lifetime Cancer Risk

- Scenario: 1
- Receptor: Business

$$HQ = \frac{TDC_A}{TC}$$

ILCR = 0.32 µg/m^3 x 10 hours/24 hours x 5 days/7 days x 48 weeks/52 weeks x 35 years/80 years x 3E-04 (µg/m^3)$^{-1}$

ILCR = 1.2 in 100,000

6.0 SUMMARY

A preliminary air quality Human Health Risk Assessment (HHRA) of the current and future predicted air emissions from rail operations within the City of Pitt Meadows boundary is underway including emissions inventory, air dispersion modelling, and preliminary human health risk assessment. This study is considering both current operations and future predicted operations that include various proposed projects.

Preliminary results (that may be subject to change) have been presented here for the emissions inventory, air dispersion modelling results of $PM_{2.5}$/DEP and associated preliminary risk estimates. It should be noted that the emissions modelling in this study includes estimated worst-case activity levels (based on current understanding of rail operations in Pitt Meadows), to identify the maximum potential health impacts and locations where they may occur.

Further and more detailed results will be presented in the final study report. The second part of the study aims to collect baseline air quality data from specific locations (identified by the air quality dispersion modelling) if possible, for further investigation.

File Path: 2021-11-15 Pitt Meadows - Rail Emissions Air Quality Review - Interim Report

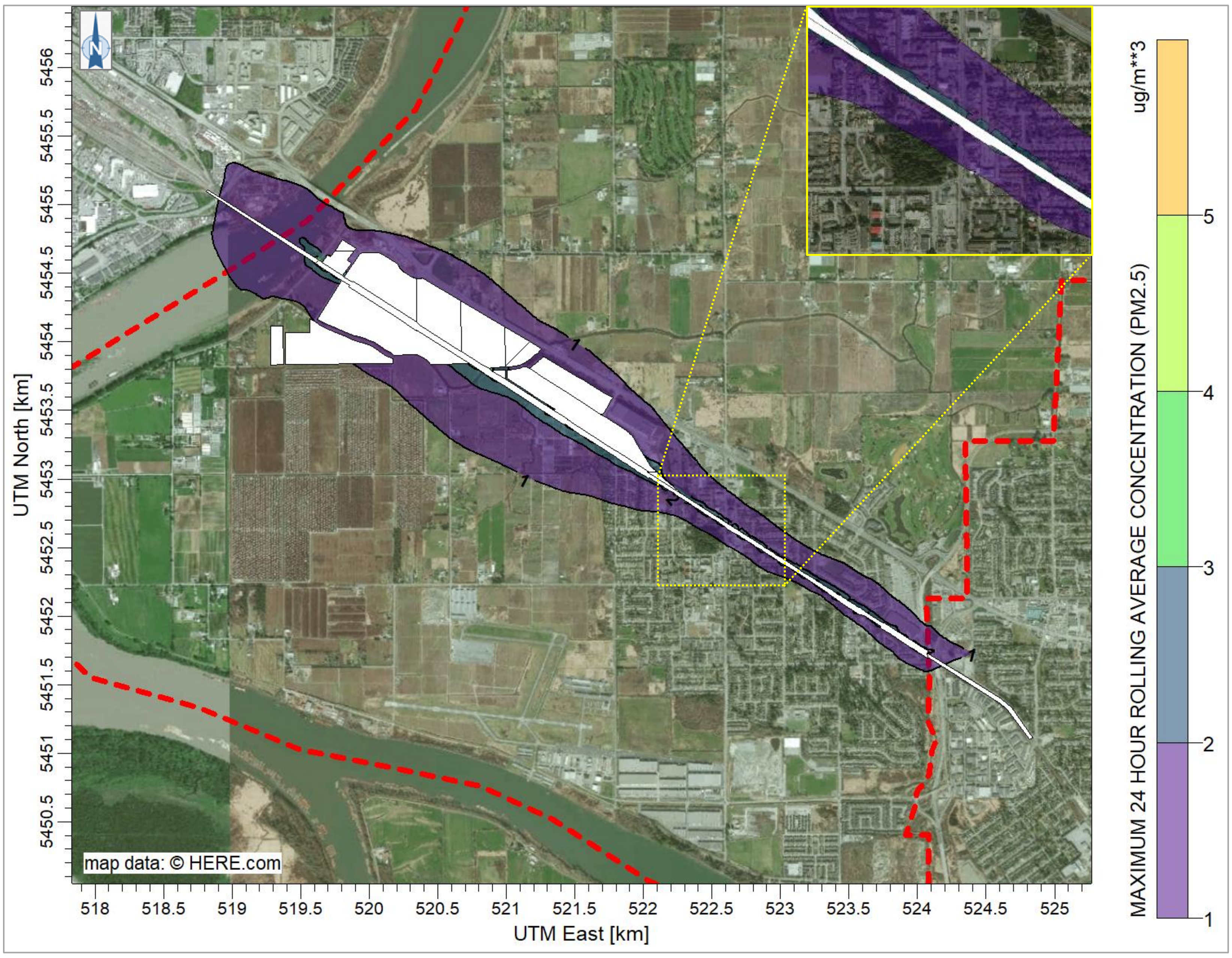
7.0 GLOSSARY OF TERMS

Acronym	Definition
AAQOs	Ambient Air Quality Objectives
CAAQs	Canadian Ambient Air Quality Standards
CACs	Criteria Air Contaminants
COPCs	Contaminants of Potential Concern
DE	Diesel Emissions
DEP	Diesel Emissions Particulate
DPM	Diesel Particulate Matter
GLC	Ground-level Concentration
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risks
LPV	Logistics Park Vancouver
MPOI	Maximum Point of Impingement
RAC	Railway Association of Canada
ROPCs	Receptors of Potential Concern
TC	Tolerable Concentration
TDCA	Time-adjusted average daily air concentration
TLACA	Time-adjusted lifetime air concentration
TRV	Toxicity Reference Value
UR	Inhalation Unit Risk
VFPA	Vancouver Fraser Port Authority
VIF	Vancouver Intermodal Facility
VOCs	Volatile Organic Compounds
WCE	West Coast Express

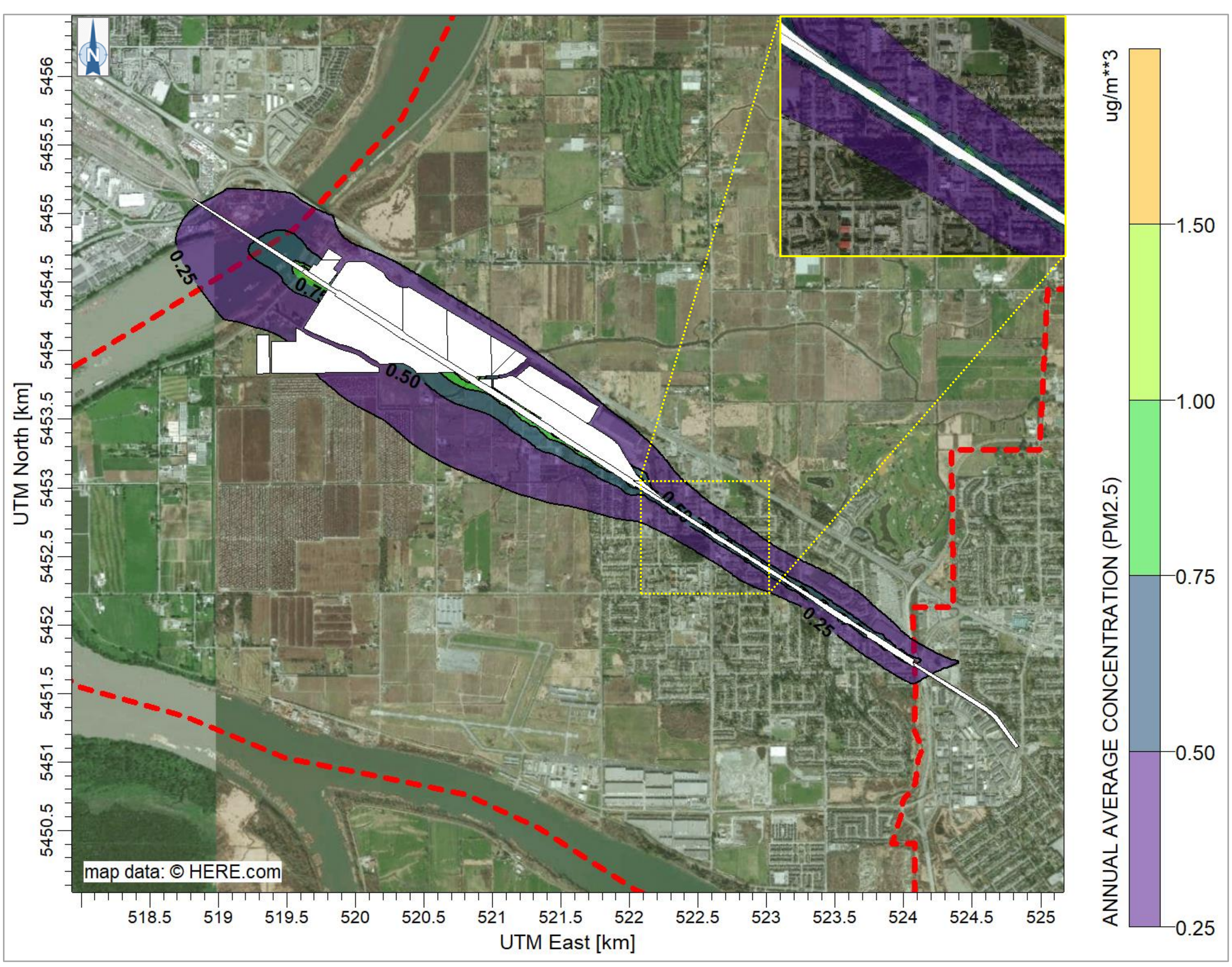
APPENDIX A: LARGE FORMAT MODEL PREDICTED ISOPLETHS

***NOTE**: Model predicted $PM_{2.5}$ concentrations shown here are based on emissions from rail activities within the City of Pitt Meadows municipal boundary (shown as a red dashed line) with the addition of a 1 km buffer on the mainlines to the east and west of the city boundary. Inset figures show model predicted concentrations around the Harris Road rail crossing. White areas show CP lands and the rail right of way where there is no public access.*

Scenario 1 – Current Operations

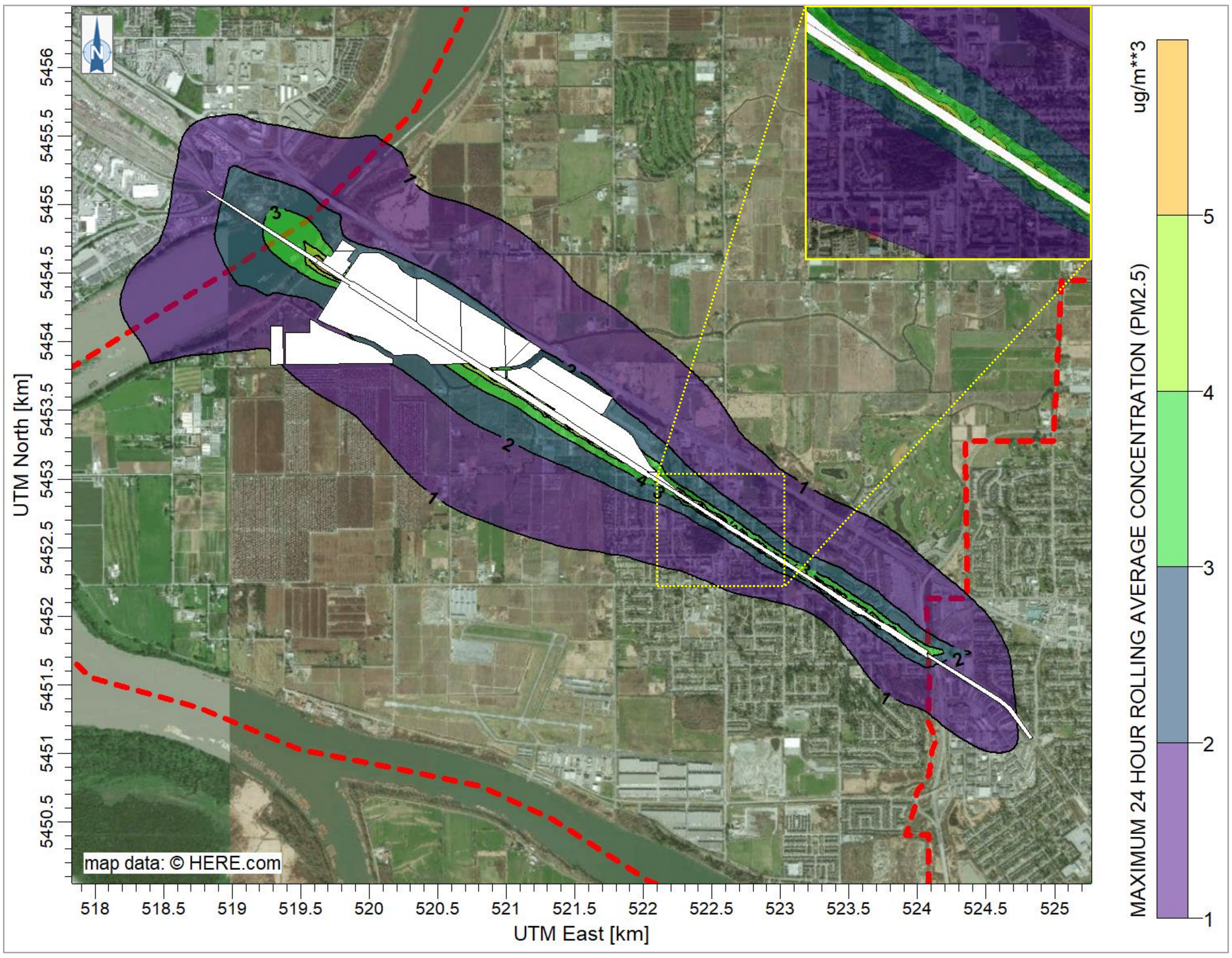


Model Predicted Ground-Level 24-hour Rolling Average $PM_{2.5}$ Concentrations

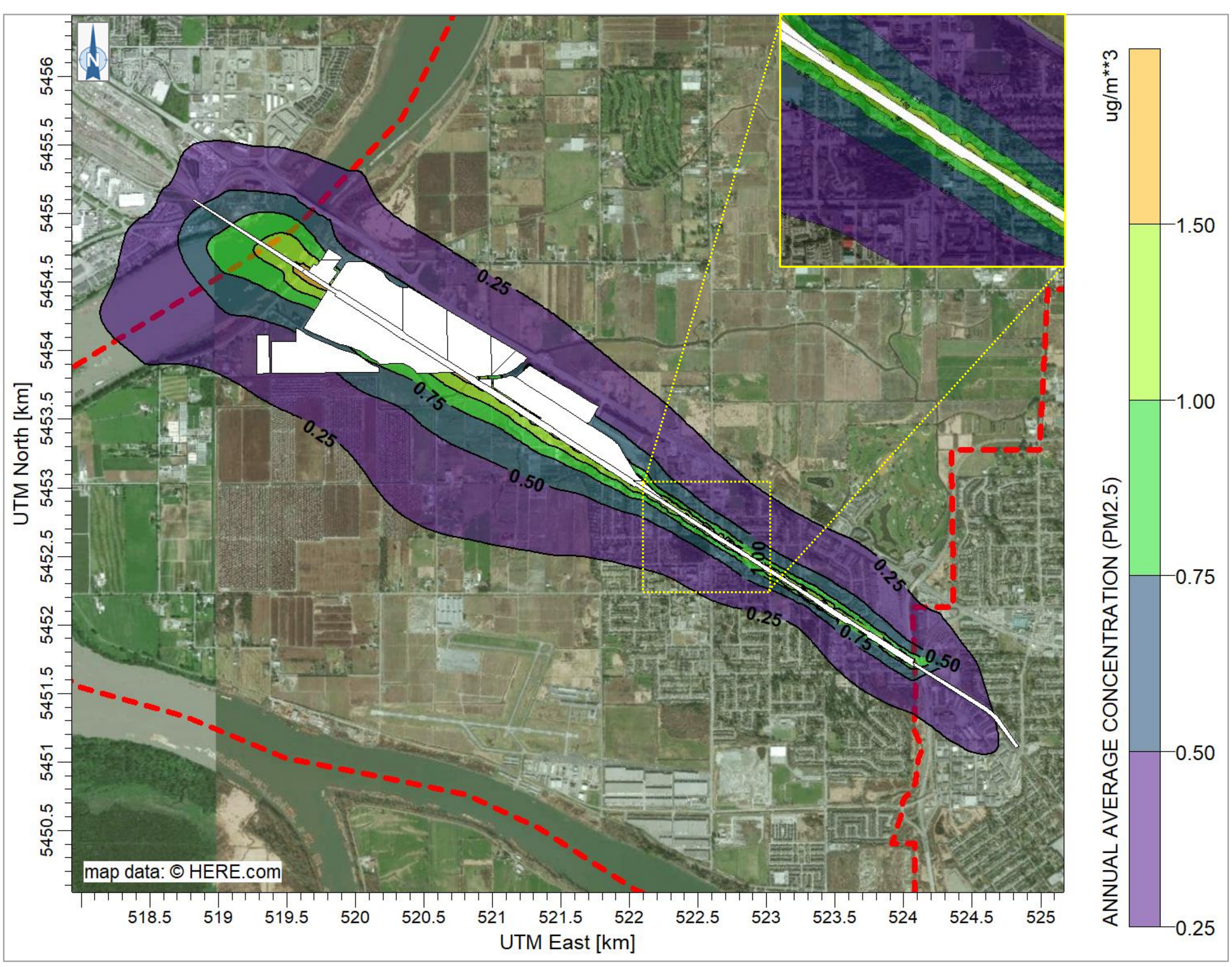


Model Predicted Ground-Level Annual Average $PM_{2.5}$ Concentrations

Scenario 2 – Future 2030 Operations

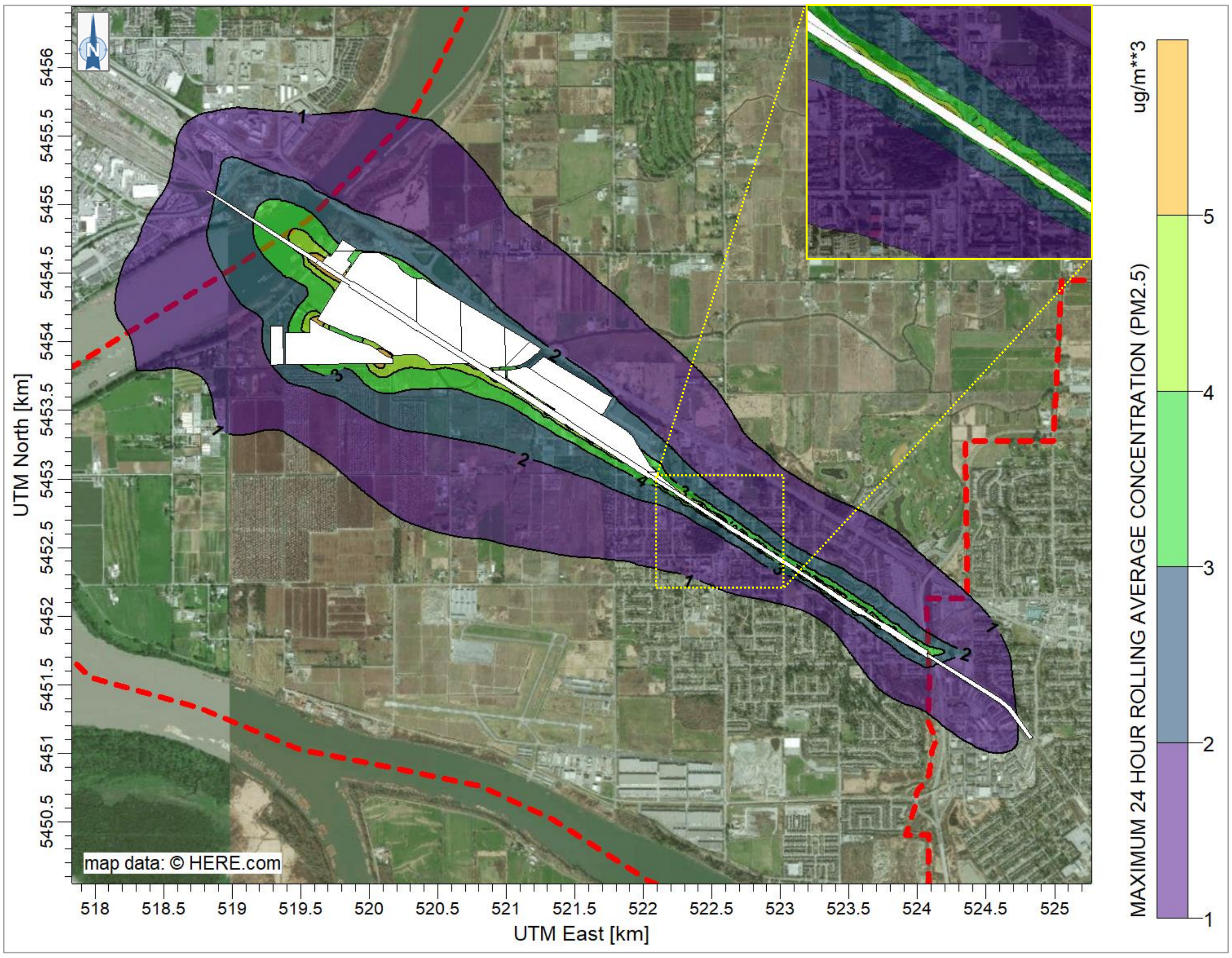


Model Predicted Ground-Level 24-hour Rolling Average $PM_{2.5}$ Concentrations

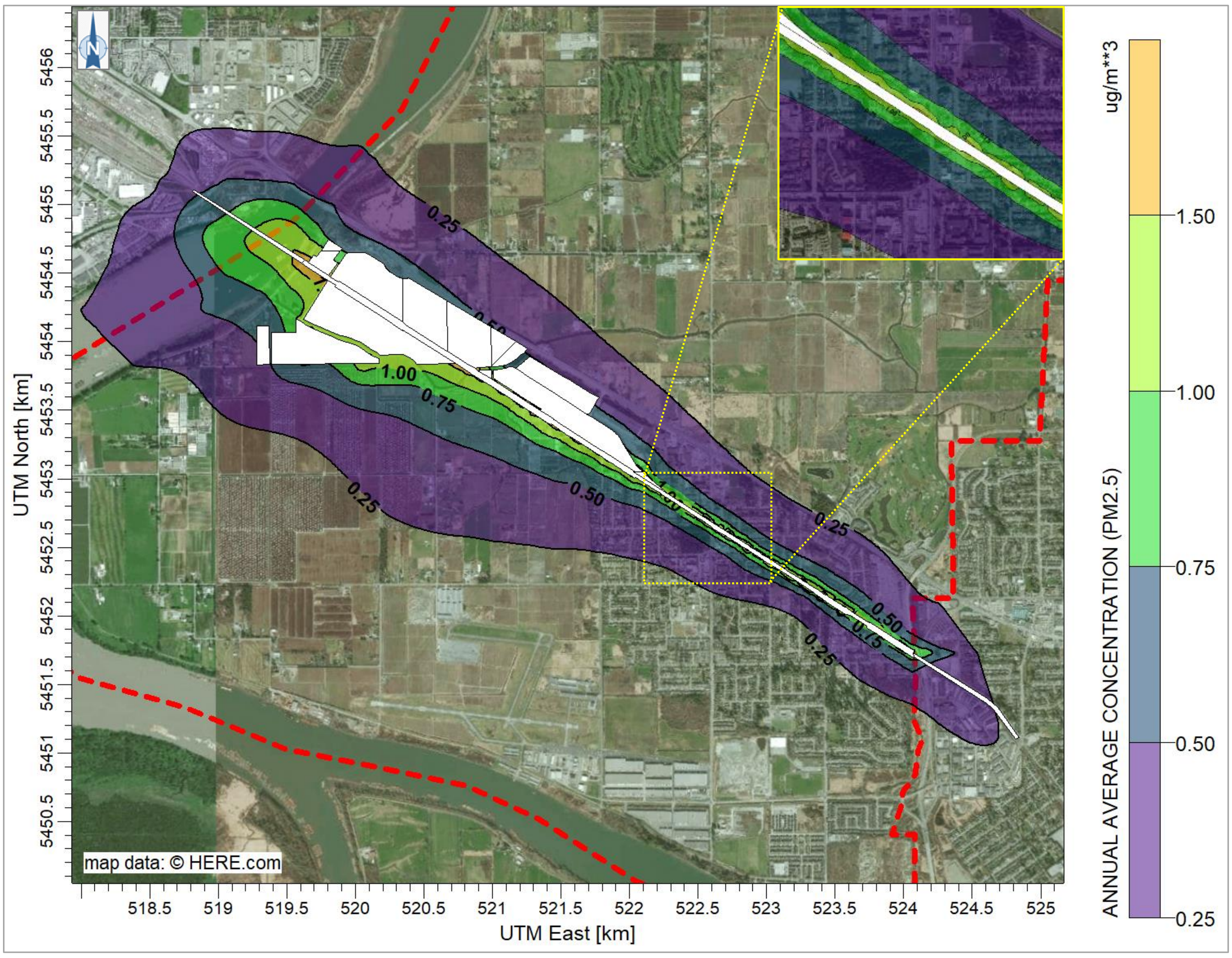


Model Predicted Ground-Level Annual Average $PM_{2.5}$ Concentrations

Scenario 3 – Future 2030 Operations Including the LPV



Model Predicted Ground-Level 24-hour Rolling Average $PM_{2.5}$ Concentrations



Model Predicted Ground-Level Annual Average $PM_{2.5}$ Concentrations