

February 15, 2019

Jocelyne Beaudet
Panel Chair, Roberts Bank Terminal 2 Project
C/O Cindy Parker, Panel Manager, Roberts Bank Terminal 2 Project
Canadian Environmental Assessment Agency
22nd Floor, Place Bell, 160 Elgin Street
Ottawa, ON K1A 0H3

Dear Mme. Beaudet,

From the Vancouver Fraser Port Authority re: Information Requests from the Review Panel for the Roberts Bank Terminal 2 Project Environmental Assessment: Responses (Package 14 – February 15, 2019 Submission)

The Vancouver Fraser Port Authority (VFPA) is pleased to submit to the Review Panel responses to Information Request Package 14 related to the Roberts Bank Terminal 2 Project Environmental Impact Statement.

We are making available the document *Information Requests from the Review Panel for the Roberts Bank Terminal 2 Project Environmental Assessment: Responses (Package 14 – February 15, 2019 Submission)*, which addresses information requests IR14-01 through -06.

Compilation of Panel Information Requests and Vancouver Fraser Port Authority Responses documents, which combine all available responses to the Review Panel's Information Requests, will be updated shortly.

Yours sincerely,
<Original signed by>

Cliff Stewart, P.Eng., ICD.D
Vice President, Infrastructure

cc Cindy Parker, Panel Manager, Roberts Bank Terminal 2 Project
Douw Steyn, Panel Member
David Levy, Panel Member
Gina Delimari, BC Environmental Assessment Office
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Encl. (1)

1. *Information Requests from the Review Panel for the Roberts Bank Terminal 2 Project Environmental Assessment: Responses (Package 14 – February 15, 2019 Submission)*

IR14-01 Wave Environment – Current Use of Lands and Resources for Traditional Purposes – Access to Preferred Locations

Information Source(s)

Marine Shipping Addendum, Appendix 7.2-A

Review Panel Information Requests IR7-21, IR7-22, & IR7-23 (CEAR Doc#1000)

Proponent Response to Information Requests IR7-21, IR7-22, & IR7-23 (CEAR Doc#1141)

Review Panel Information Requests IR10-08, IR10-13 and IR10-15 (CEAR Doc#1130)

Review Panel Information Requests IR13-20 & IR13-25 (CEAR Doc#1228)

Submissions from Indigenous groups (CEAR Doc#384, CEAR Doc#672, CEAR Doc#1150, CEAR Doc#1292, CEAR Doc#1298, CEAR Doc#1310, CEAR Doc# 1314, CEAR Doc#1321)

Context

Various Indigenous groups have expressed concerns about the wave environment and safety to small vessels, especially in open water, and specifically while engaged in fishing and other traditional activities in the Marine Shipping Area and on Swiftsure Bank.

Information requests and responses on this topic have focused on ship wake wave height in relation to the spectrum of wind-driven wave height as a standard for assessment of environmental effect.

For example, the Proponent stated that “ship wake from Project-associated vessels is not expected to be distinguishable from existing wave action on vessels engaged in commercial or recreation activities except in calm conditions, ... given that ship-related wake is within the wave-height spectrum of wind-generated waves.”

Wave height is appropriately used to determine environmental effects arising from wave energy and is important when considering erosion at coastlines. However, an assessment of ship wake wave effects on safety and security of small vessels at sea, based on wave structure (including period, wavelength, steepness and direction) in relation to wave structure of wind driven waves has not been provided.

A consideration of the effects of ship wake waves on small vessels in open water based on wave structure, in addition to wave height alone is required

Information Request

Provide a discussion of the effects of ship wake wave **structure**, rather than wave **height** alone, on small craft of various sizes and the associated effects on safety and security for

fishing and other traditional activities. The discussion should address both rough and calm sea states.

In light of the foregoing discussion, review and reassess ship wake wave effects on fishing and recreational vessels operating in the Marine Shipping Area by Indigenous groups, including those passing through and crossing the shipping lanes. The reassessment should consider relevant information contained in responses to IR7-21, IR7-22, IR7-23, IR10-13, IR13-20 & IR13-25.

VFPA Response

Background and Supporting Information

As noted in the context to this information request, the VFPA has previously responded to IR7-21, IR7-22, and IR7-23 (CEAR Document #934¹), providing additional information regarding interactions between wake generated by container vessels and small craft of various sizes operating and engaging in fishing and other traditional activities in the marine shipping area and on Swiftsure Bank². Both wind-generated and wake-related waves are described in terms of wave height in order to be consistent with the information that was presented in the Marine Shipping Addendum (MSA), Appendix 7.2-A, which refers to wave height or significant wave height³ when describing wind-generated waves and vessel wake. The wave environment assessment presented in the MSA was undertaken using existing information that describes the wind-generated wave climate and empirical relationships that describe the height of waves generated by passing vessels at a known distance from the ship's course.

This information request specifies that wave *structure*, rather than wave *height* alone should be used to quantify the effects of vessel wake. Wave structure includes wave period, wavelength, wave steepness, and wave direction. As context to support the VFPA's response to this information request, key terms referred to in this response are defined as follows:

Calm Seas – as described in the MSA, calm seas are defined by the Douglas Sea Scale as periods of time when the significant wave height is 0.1 m or smaller (WMO 2015).

Rough Seas – rough seas are defined by the Douglas Sea Scale as periods of time when the significant wave height is 2.5 m and 4.0 m (WMO 2015).

¹ CEAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (NOTE: Updated November 30, 2018).

² The marine shipping area and Segments A to D within the area are shown in Marine Shipping Addendum (MSA) Figure 1-1. The area of Swiftsure Bank, as per the area described by the Canadian Environmental Assessment Agency in CEAR Document #1073, is shown in Figure IR14-01-A1 (**Appendix IR14-01-A**).

³ The significant wave height is defined as the average of the largest third of the waves in the wave spectra.

Wave Period – as described in the response to IR7-20 (CEAR Document #934), wave period is defined as the time between wave crests. (The reciprocal of wave period is frequency, which is the number of waves that pass per second.)

Wavelength – as described in the response to IR7-20 (CEAR Document #934), wavelength is the distance between wave crests.

Wave Steepness – as defined by the United States Army Corps of Engineers Coastal Engineering Manual (US Army Corps of Engineers 2002), wave steepness is the ratio between wave height and wavelength.

Wave Direction – the direction in which the wave is travelling (as opposed to when describing wind direction, which is described as the direction from which it is blowing).

Small Vessels and Fishing Activities – with respect to the need to consider in the response “small craft of various sizes and the associated effects on safety and security for fishing and other traditional activities”, the response to IR7-21 (CEAR Document #934) outlines the following:

Small vessels, as defined under various Transport Canada regulations, include pleasure craft, passenger vessels (non-pleasure craft), and fishing vessels. For instance, small commercial (non-pleasure craft) vessels fall into two main categories: 0-15 gross tons and 15-150 gross tons (Transport Canada 2011), and the Safe Boating Guide for pleasure craft (Transport Canada 2014) considers a number of classes of vessels from human-powered paddleboats and sit-on-top kayaks, to sail and power boats exceeding 24 m. Construction and design standards applicable to boats built or sold in Canada dictate environmental operating limits (such as wind force and wave height) for small craft stability and buoyancy. For small commercial vessels, Transport Canada references International Standard Organization (ISO) Standard 12217, which specifies the wave height environmental limits for vessels in four design categories as exceeding 4 m, up to 4 m, up to 2 m, and 0.5 m (Transport Canada 2015).

The effects of ship wake wave structure on small craft of various sizes and the associated effects on safety and security for fishing and other traditional activities is dependent on a range of factors, including the existing sea state, the skill and experience of the vessel operator and crew, the specific activity that the crew is engaged in, the condition and maintenance history of the vessel, and the vessel design. Guidance is not provided in the above-mentioned documents that relates vessel design or vessel safety to wave structure; however, the regulations do provide guidance and outline expectations regarding minimum safety standards in terms of safety-related appliances and equipment, as well as operator competency and duty (see *Small Vessel Regulations*, SOR/2010-91; Transport Canada 2010).

In the context of the above information, the VFPA provides information in response to this information request that describes the wave structure of the existing wind-generated wave

climate and relates this to the expected wave structure of wake-generated waves from container vessels.

Also relevant are the conclusions of a recent container vessel call forecast study by Mercator International (CEAR Document #1362⁴, Mercator Study). The Mercator Study projects that there will be no increase in the number of container ship transits in the marine shipping area in the future with RBT2. In other words, the same number of container ships will call (i.e., 15 ships per week) to the Port of Vancouver regardless of whether or not RBT2 is constructed, and therefore, the previously assumed increase of five additional ships per week (260 calls or 520 movements per year) associated with the Project is no longer envisioned. The Mercator Study also concluded that larger ships will be arriving sooner than originally predicted in the MSA and that the size of the ships will be slightly larger on average if RBT2 proceeds. When RBT2 is operating at capacity, it was assumed for the MSA assessment that the representative container ship calling at RBT2, on average, had 9,034 to 9,580 TEU (twenty-foot equivalent unit) capacity (MSA Table 4-4), while the average vessel in the future without and with RBT2 at Roberts Bank would be 12,143 TEUs and 12,944 TEUs, respectively, on average, based on the vessel size distribution for Roberts Bank terminals presented in the Mercator Study (see CEAR Document #1362, Ship Traffic Information Sheet). As indicated in the response to IR4-02 (CEAR Document #934), newer, larger vessels are expected to have lower design speed; hence, the increase in average ship size is not expected to alter previously stated conclusions of the wave environment assessment. Hence, this response is provided on the basis of wave structure from container vessels in the 9,000 to 13,000 TEUs vessel capacity range, on average, with vessel lengths ranging from 335 m to 366 m in length.

Existing Wave Environment – Wave Spectra

To the casual observer, waves on the ocean appear as individual entities, but detailed measurements of the water surface demonstrate that there are waves of different heights, periods, and directions. The wave spectra is a way of representing all of the various wave energy that is present in a body of water, and in particular for areas exposed to the open ocean, for separating the occurrence of ocean swell⁵ from local wind-waves.

Two wave buoys that measure and record the wave spectra are relevant to this information request⁶: i) Neah Bay wave buoy (Station 46087) is located 11 km north of Cape Flattery, Washington and approximately 19 km southeast of the middle of Swiftsure Bank, and ii) New Dungeness wave buoy (Station 46088) is located in Segment B 14 km southeast of Victoria, B.C. The Neah Bay station is assumed to be representative of wave conditions in the vicinity of Swiftsure Bank and the western portion of Segment D, while the New Dungeness station is assumed to be representative of wave conditions within Segment C and the southern portion

⁴ CEAR Document #1362 From the Vancouver Fraser Port Authority to the Review Panel re: 2018 Container Vessel Call Forecast Study and Ship Traffic Information Sheet.

⁵ As described in the response to IR7-16 (CEAR Document #934), swell refers to waves generated in the open ocean in response to winds outside the local area.

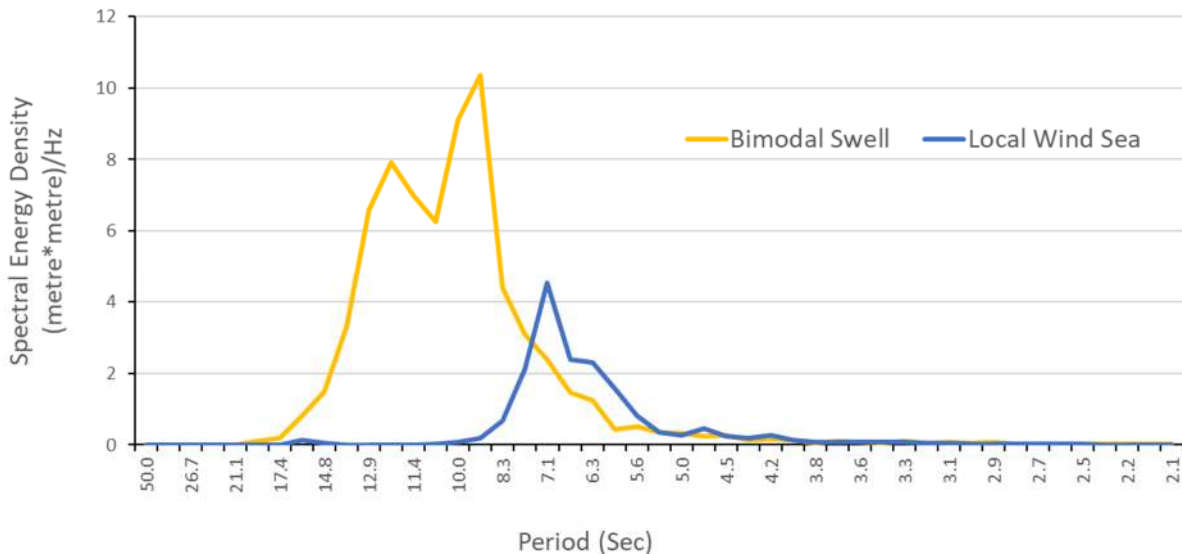
⁶ The Halibut Bank wave buoy (Station 46146) was also referenced in MSA Section 7.2, but is relatively far removed from the shipping lanes in the marine shipping area (station location shown in Figure 2 of MSA Appendix 7.2-A).

of Segment B, and reasonably representative of conditions at the eastern portion of Segment D. Waves are not measured within the northern portion of Segment B or in Segment A.

The location of these stations is shown in Figure IR7-15-4 in the response to IR7-15 (CEAR Document #934) and observed wave statistics, in the form of significant wave height (H_s), were previously tabulated for Neah Bay in Table IR7-22-1 in the response to IR7-22 (CEAR Document #934) and shown graphically as a wave rose in Figure 6 of MSA Appendix 7.2-A.

Spectral wave data for the year 2012 was obtained from the NOAA NDBC website⁷. (The spectral wave density plot for the Neah Bay wave buoy is shown in **Figure IR14-01-1**, which illustrates the signature of a typical bimodal swell with two peak spectral energy periods occurring at 12.1 seconds and at 9.1 seconds (as measured on January 3, 2012), and the signature of the local wind sea (wave spectra occurring in response to local winds) with a peak spectral energy occurring at 7.1 seconds (as measured on August 3, 2012). An analysis of the Neah Bay buoy spectral data for 2012 was used to calculate statistics for the median, average, maximum, and minimum significant wave heights, period, wavelength, and steepness, as derived for this buoy from the spectral data. These statistics are provided in **Table IR14-01-1**. As expected for an area exposed to open ocean, there is a relatively high average wave height that is associated with long period swells (greater than 10 seconds), long wavelength, and relatively low steepness. For the frequency analysis, local wind seas were defined as wave spectral energy at a higher frequency than 0.13 Hz (or peak period below 7.7 seconds).

Figure IR14-01-1 Spectral Wave Density Plot for Neah Bay (Station 46087) Observations



⁷ https://www.ndbc.noaa.gov/station_page.php?station=46087.

Table IR14-01-1 Statistics for Wave Heights for Neah Bay and New Dungeness Stations for 2012 Based on Spectral Energy Analysis

Wave Statistics	Significant Wave Height (H _{s all}) (m)	Wave Period T _{p all} (sec)	Wave Length Lo (m)	Wave Steepness ^a (m/m)
Neah Bay (Station 46097)				
Median	1.67	10.00	151	0.012
Average	1.89	10.40	163	0.013
Max	7.68	21.05	431	0.060
Min	0.32	3.45	19	0.001
New Dungeness (Station 46088)				
Median	0.30	4.55	32.26	0.014
Average	0.41	5.96	67.81	0.015
Max	2.71	17.39	342.29	0.063
Min	0.00	2.06	6.64	0.000

Note: a. Wave steepness is calculated for each time point in the data series to generate median, average, maximum, and minimum wave steepness.

Table IR14-01-1 also presents wave statistics measured at the New Dungeness wave buoy for 2012. As would be expected of a less exposed location, the median wave height is much smaller (0.30 m) and is comprised of shorter period waves (4.55 seconds). The median and average waves are somewhat steeper than those at Neah Bay, and while the maximum wave height is quite small compared to the largest waves at Neah Bay, the period is quite long, indicating periods of time when swell from the open ocean reaches this location.

As described in the MSA Section 7.2, wave direction was analysed using a numerical model for each zone within the marine shipping local assessment area, as well as from data recorded at New Dungeness. Wave direction at New Dungeness is dominantly from the west and west-southwest, while further north in Zone 3 (Segment B) the wave direction is dominantly from the southwest. In Zone 1 (Segment B) near Saturna Island, wave direction is from the northwest and southeast, while at Zone 2 (Segment B) near Stuart Island, wave direction comes from many points south of east-west with no obvious dominant direction.

Similarly, periods of calm (defined as a sea state with significant wave height of 0.1 m or smaller) were analysed for these zones, as well as from the data recorded at Neah Bay and New Dungeness. In Zones 1, 2, and 3, periods of calm account for approximately 40%, 46%, and 26% of the time, respectively (as shown in MSA Figures 7.2-3 to 7.2-6). There were no periods of calm recorded at New Dungeness or Neah Bay. Rough seas, as defined by the Douglas Scale (WMO 2015) as a sea state with waves between 2.5 m and 4.0 m, are relatively rare within the marine shipping area.

Provide a discussion of the effects of ship wake wave structure, rather than wave height alone, on small craft of various sizes and the associated effects on safety and security for fishing and other traditional activities. The discussion should address both rough and calm sea states.

Information about wake heights at various offset distances from the sailing line of a container vessel within each segment of the marine shipping area was previously provided in Table IR7-22-2 (CEAR Document #934). This table has been updated in **Table IR14-01-2** to include wave period from the following formula from PIANC (1987):

$$T = 0.82 * V_s * \frac{2\pi}{g}$$

Where V_s = vessel speed

The standard function relating wave period and water depth was used to calculate wavelength (Dean and Dalrymple 1991), which was in turn used to derive wave steepness of the wake generated by container vessels using existing published empirical relationships (**Table IR14-01-2**).

Table IR14-01-2 Wave Height at Various Distances from the Container Vessel Sailing Line and Wave Structure (Period, Wavelength, and Wave Steepness) Based on Segment Average Vessel Speed and Average Channel Depth

Segment	Average Vessel Speed (Kn) ^a	Channel Depth (m)	Initial Wave Period (sec)	Wavelength ^c (m)	Wave Steepness ^c (m/m)	Wake Height (m) at Distance from the Sailing Line					
						150 m	300 m	500 m	1,000 m	1,500 m	2,000 m
A	9.0	106	2.4	9.0	0.002	0.03	0.02	0.02	0.02	0.01	0.01
B ^b	15.5	41	4.2	27.5	0.011	0.47	0.37	0.31	0.25	0.22	0.20
C	15.0	117	4.1	26.2	0.005	0.20	0.16	0.14	0.11	0.10	0.09
D	20.0	73	5.4	45.5	0.003	0.88	0.70	0.59	0.47	0.41	0.37

- Notes:** a. Data sourced from MSA Table 4-5.
b. Information for Segment B is also illustrated in MSA Figure 7.2-2.
c. Calculated on wave height at 500 m distance from sailing line.

Vessel wake wave direction can be inferred from the sailing course. As shown in Figure 2.2 of the Moffatt and Nichol (2011) study (previously submitted to the Panel as Appendix IR7-17-A (CEAR Document #934)), wake waves propagate at an angle of 19°28' from the sailing line. Within Segments A to D, the sailing line is defined as the shipping lanes; however, once vessels pass seaward of the channel separation marker, there are no regulatory controls over vessel course. Figure IR14-01-A1 (**Appendix IR14-01-A**) shows vessel tracks for Category 1 vessels (320 to 367 m in length) transiting the marine shipping area and a portion of the Pacific Ocean offshore of Vancouver Island and northern State of Washington. Category 1 vessels include container vessels and the ship tracks are based on VTOSS⁸ data for 2010. For illustrative purposes, the Crown developed a map of Swiftsure Bank that was included in CEAR Document #1073⁹ (a letter from the Canadian Environmental Assessment Agency to Pacheedaht First Nation dated October 17, 2017). This representation of the boundary of Swiftsure Bank is included in Figure IR14-01-A1 (**Appendix IR14-01-A**) to show its position relative to the inbound and outbound shipping lanes, as well as actual vessel tracks for the representative period. The outbound shipping lane corresponds with the southern half of Swiftsure Bank and the vessel tracks are mostly confined to the shipping lane; however, some vessel tracks are shown to travel to the north of Swiftsure Bank. Based on this information, it is reasonable to conclude that the majority of the wake waves generated by transiting container vessels would travel in a direction that is sub-parallel with the long-axis of the Swiftsure Bank boundary. Based on the density of shipping traffic that was within the outbound shipping lane, wake waves would be travelling in an approximately northerly direction to cross Swiftsure Bank or in a southerly direction towards the southern boundary of Swiftsure Bank. The small number of vessels that chose to travel north of Swiftsure Bank would have generated wake travelling southwesterly towards Swiftsure Bank.

The structure of wake waves generated by container vessels is not dissimilar from the wave structure of the spectra of local wind-generated waves currently recorded at Neah Bay and New Dungeness. In the context of the existing wind-driven wave environment, wake from these vessels would not pose a different hazard than those generated by other passing vessels of various sizes. As noted above, there is no guidance provided by federal regulations governing small vessels that relates wave period, wavelength, or wave steepness to vessel safety. Since waves with similar structure to those generated by container vessels are already a feature of the environment, operators and crew of small vessels would need to continue to practice adequate vigilance to avoid impacts from wake generated by all passing vessels. In light of the recent container vessel call forecast study by Mercator International (CEAR Document #1362), additional container vessel traffic arising from the Project is not anticipated.

⁸ Vessel Traffic Operational Support System - a longstanding tool for monitoring vessel traffic on the West Coast of Canada that was discontinued in 2011 to standardise the use of the Information System on Marine Navigation (INNAV) for all of Canada (Canadian Coast Guard Agency 2011).

⁹ CEAR Document #1073 From the Canadian Environmental Assessment Agency to the Pacheedaht First Nation re: Preliminary Depth Reassessment for Pacheedaht First Nation.

In light of the foregoing discussion, review and reassess ship wake wave effects on fishing and recreational vessels operating in the Marine Shipping Area by Indigenous groups, including those passing through and crossing the shipping lanes. The reassessment should consider relevant information contained in responses to IR7-21, IR7-22, IR7-23, IR10-13, IR13-20 & IR13-25.

Recognising that Indigenous groups have described periods of calm conditions at Swiftsure Bank (e.g., CEAR Document #384¹⁰), the VFPA undertook additional analysis of the spectral wave data. Although calm conditions (e.g., significant wave height of 0.1 m or smaller) are not present in the record at Neah Bay for 2012, local boaters may experience 'quasi calm' conditions when local wind-generated waves in the short wavelength of the wave spectra are largely absent and the sea is comprised of long, even swell. Taking a 'calm' period as being defined as the significant wave height (Hs) of local seas is less than 0.5 m and also that swell heights are less than 2.5 m and swell periods are greater than 11 seconds, the amount of time in the record that satisfies this criteria is 4.9% of the total time at Neah Bay. By comparison, at New Dungeness the waves are less than 0.5 m for about 73% of the time. During such times, unanticipated vessel wake from passing container ships could be superimposed on the otherwise quasi calm sea state. Per the information on ship wake presented in **Table IR14-01-2**, the presence of the passing vessel would presumably provide warning of the imminent arrival of wake (wake-generated waves within 500 m of the vessel are expected to be 0.59 m, for instance).

Considering the findings of the foregoing discussion and the Mercator Study findings (CEAR Document #1362), container ship wake wave effects on fishing and recreational vessels passing through and crossing the shipping lanes in the marine shipping area and in the vicinity of Swiftsure Bank are expected to decrease from current conditions with or without the Project.

The VFPA has acknowledged in responses to information requests in Packages 10 and 13 (CEAR Document #934) that Indigenous groups have said that any additional Project-related effects on their current use of lands and resources for traditional purposes (Current Use) would further degrade already unacceptable conditions. In the responses to IR10-13, IR13-20, and IR13-25 (among others; CEAR Document #934), the VFPA reiterated the predictions presented in the MSA with regard to the potential effects of changes in the wave environment on Current Use, including, but not only, at Swiftsure Bank. As noted in these responses, the VFPA assessed potential effects on Current Use access and experience as a result of Project-associated ship pass-bys as negligible-to-minor (or 'up to minor'), assuming an increase of three movements every two days on average per year over current conditions; however, as the Mercator Study findings indicate that container ships are expected to decrease from current conditions with or without the Project, the conclusions of the Current Use assessment are now even more conservative than previously reiterated in the responses to IR10-13, IR13-20, and IR13-25 (CEAR Document #934) as there will be no Project-related increase in shipping traffic through the marine shipping area.

¹⁰ CEAR Document #384 From Pacheedaht First Nation to the Canadian Environmental Assessment Agency re: Comment on the Completeness of the Marine Shipping Addendum.

References

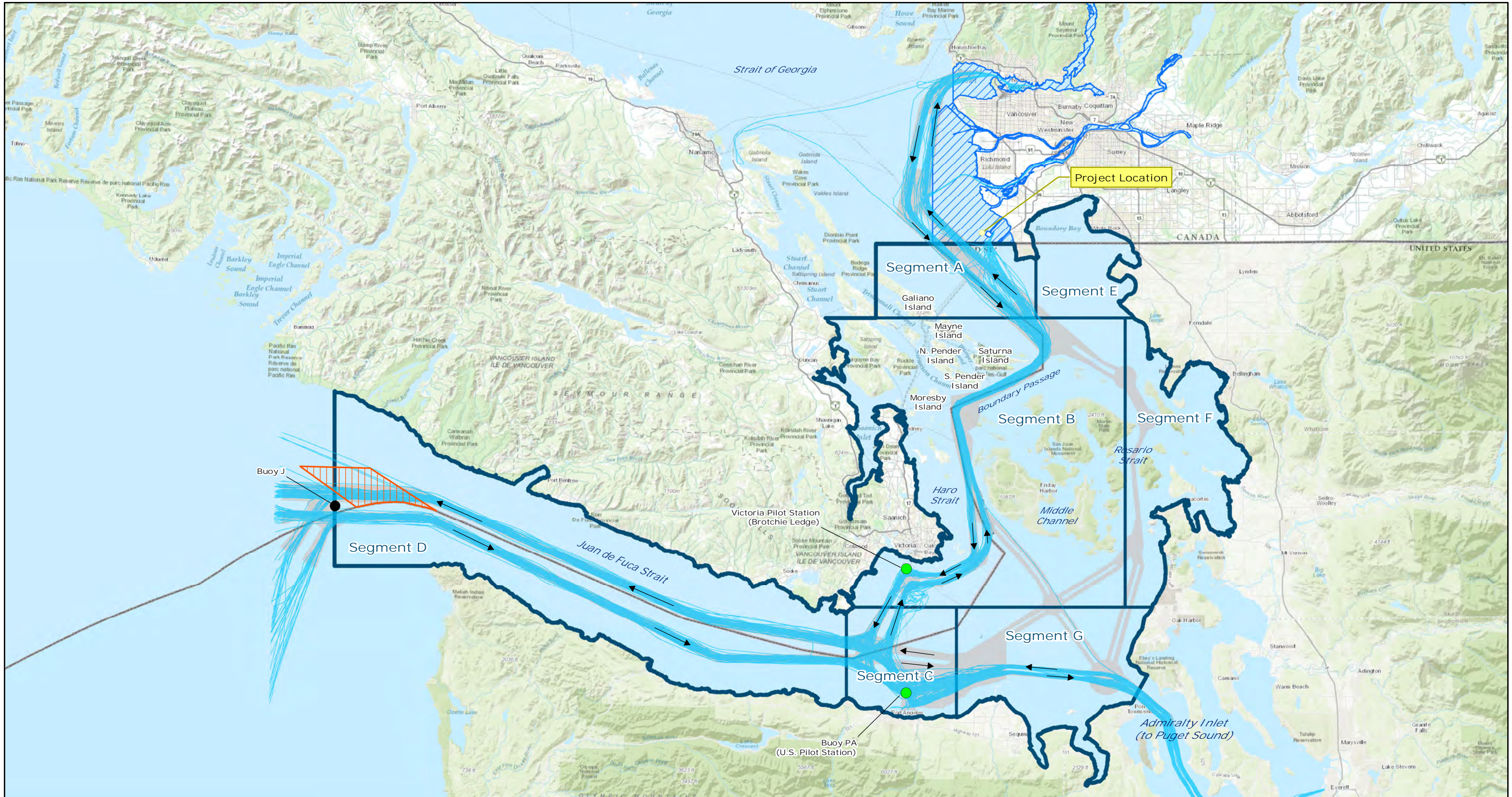
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Appendices

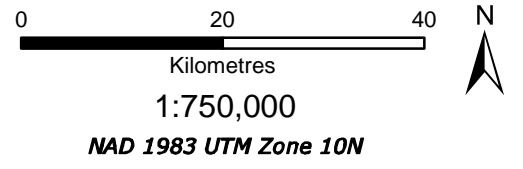
Appendix IR14-01-A Supporting Figure

APPENDIX IR14-01-A
SUPPORTING FIGURE

Path: S:\Geomatics\Projects\102738\EIS_IRs\IR4_01.mxd\IR4-01-A1_ContainerVesselTracks_MSA_SwiftsureBank_July2015_190212.mxd



- Legend**
- MARINE SHIPPING AREA
 - VFPA NAVIGATIONAL JURISDICTION AREA
 - SWIFTSURE BANK AREA
 - U.S.A.-CANADA BORDER
 - PILOT STATION
 - CONTAINER SHIP AUTOMATIC IDENTIFICATION SYSTEM (AIS) VESSEL TRACK, JULY 2015
 - DIRECTION OF TRAVEL
 - INTERNATIONAL SHIPPING LANES



Note:
International shipping lanes provided by NOAA, at <http://encdirect.noaa.gov/>. Accessed May 20, 2015.



ROBERTS BANK TERMINAL 2	
CONTAINER VESSEL TRACKS WITHIN THE MARINE SHIPPING AREA AND IN THE VICINITY OF SWIFTSURE BANK FOR THE PERIOD JULY, 2015	
DATE: 02/12/2019	FIG No. IR4-01-A1

IR14-02 Air Quality – Ferry Emissions Estimates

Information Source(s)

EIS Appendix 9.2-A, Attachments 2 & 8.

Review Panel Information Request IR6-13 (CEAR Doc#991)

Metro Vancouver Submission MV-23 (CEAR Doc#1319)

Context

EIS Appendix 9.2-A states that: "... based on recent history, traffic levels for the B.C. Ferries terminal are not expected to increase from 2010 to 2025", and therefore that the number of ferry vessel movements and ferry-related vehicle movements in the local study area would stay constant.

According to Metro Vancouver (CEAR Doc#1319), recent data reported by B.C. Ferries show increasing traffic volumes, with record traffic volumes in 2018. Therefore, some of the potential emissions reductions associated with the deployment of Liquid Natural Gas (LNG) vessels into the ferry fleet may be offset by increasing ferry vessel movements.

Information Request

Using the most recent ferry-related vehicle traffic trends for the B.C. Ferries terminals, as reported by Metro Vancouver, assess the projected ferry traffic in 2025.

In light of this assessment, revise Appendix 9.2-A, Appendix A, Section 2.8 of the EIS concerning ferry-related vehicle traffic levels, and hence ferry traffic, from 2010 to 2025.

Based on this reassessment, revise the Appendix 9.2-A, Appendix A, Attachment 2 of the EIS for ferries and the estimated NO_x and PM_{2.5} emissions from "Ferry at Berth", "Ferry Causeway" and "Ferry Transit" in Appendix 9.2-A, Appendix A, Attachment 8 of the EIS (Modelled Emission Rates).

If the change in emission rates of NO_x and PM_{2.5} associated with ferries are more than 10% greater than estimates in the EIS, reassess the contribution of ferry emissions on the expected and future scenarios (NO_x and PM_{2.5}) and their effects on ambient concentrations.

VFPA Response

Using the most recent ferry-related vehicle traffic trends for the B.C. Ferries terminals, as reported by Metro Vancouver, assess the projected ferry traffic in 2025.

This response provides a re-assessment of ferry emissions based on updated information from BC Ferries, including information contained in British Columbia Ferry Services Inc.'s

Performance Term Five (PT5) submission (April 1, 2020 to March 31, 2024) to the BC Ferries Commissioner (BC Ferries 2018a). As indicated in the response to IR6-13 (CEAR Document #934¹) and the PT5 submission, BC Ferries has and continues to transition their vessel fleet to alternative fuels (i.e., dual-fuel² or diesel-electric), which is expected to significantly decrease carbon, sulphur oxide, and nitrogen oxide emissions³.

This response incorporates current information on historical and forecast traffic for Tsawwassen Terminal Routes 1, 9, and 30, which serve Swartz Bay, Southern Gulf Islands, and Duke Point, respectively. As acknowledged by Metro Vancouver in CEAR Document #1319⁴ (dated on October 5, 2018), and indicated in **Table IR14-02-1**, actual vessel and vehicle traffic records indicate an increase in 2018 to record levels. Growth is expected to continue at a slowing rate and then flatten after 2022, as shown in **Table IR14-02-1**. BC Ferries has limited ability to expand capacity, as all available vessels are in service during peak periods, and therefore, traffic growth is constrained. Taking these factors into consideration along with indications that economic activity is plateauing and the econometric modelling results, BC Ferries has assumed that it will experience flat traffic growth through PT5, and beyond⁵.

Table IR14-02-1 Historical (2010 to 2018) and Forecast Vessel and Vehicle Traffic (2019 to 2030) for Tsawwassen Terminal Routes 1, 9, and 30

	Fiscal Year (April - March)	Tsawwassen Terminal Vessel Traffic ^a	Tsawwassen Terminal Vehicle Traffic ^b
Actual Traffic	2010		
	2011	-2%	-2%
	2012	-4%	-3%
	2013	-1%	-1%
	2014	-2%	-1%
	2015	1%	1%
	2016	6%	5%
	2017	2%	3%
	2018	5%	5%

¹ CEAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (NOTE: Updated November 30, 2018).

² Dual-fuel capable vessels are designed to run primarily on liquified natural gas (LNG), with marine diesel fuel as a backup (BC Ferries 2018a). The Salish Class vessels are capable of running as dual-fuel on either LNG or ultra-low sulphur diesel fuel.

³ BC Ferries (2018a) reports that carbon, sulphur oxide, and nitrogen oxide emissions will decrease by 25%, almost 100%, and 85%, with the use of LNG, respectively, compared to use of ultra-low sulphur diesel fuel.

⁴ CEAR Document #1319 From Metro Vancouver to the Review Panel re: Comments on the Sufficiency of Information.

⁵ BC Ferries acknowledges that the actual traffic experience in PT5 could be higher or lower, depending somewhat on factors that are beyond its control, such as the economy and tourism.

	Fiscal Year (April - March)	Tsawwassen Terminal Vessel Traffic ^a	Tsawwassen Terminal Vehicle Traffic ^b
Forecast Traffic	2019	2%	3%
	2020	2%	2%
	2021	2%	1%
	2022	1%	1%
	2023	0%	0%
	2024	0%	0%
	2025	0%	0%
	2026	0%	0%
	2027	1%	1%
	2028	-1%	-1%
	2029	0%	0%
	2030	0%	0%

Source: a. BC Ferries 2018a; b. BC Ferries 2018b

As assessed and explained further below, the potential emission reductions associated with the deployment of dual-fuel vessels into the ferry fleet are expected to more than offset the recent increases in traffic.

In light of this assessment, revise Appendix 9.2-A, Appendix A, Section 2.8 of the EIS concerning ferry-related vehicle traffic levels, and hence ferry traffic, from 2010 to 2025.

By the time RBT2 is operational in the late 2020s, ferry emissions are not anticipated to be higher than the conservative RBT2 Air Quality Study predictions provided in EIS Appendix 9.2-A. As context for the updates that are presented below, the RBT2 Air Quality Study incorporated the following conservative assumptions regarding emissions from the operation of ferries at the Tsawwassen Ferry Terminal (based on available information at the time of commencing the RBT2 Study):

- Two large diesel-fuel powered ferries (i.e., Spirit Class vessels) were assumed to be at berth under load 100% of the time both in 2010 for existing conditions and in 2025 for expected (i.e., without RBT2) and future (with RBT2) conditions;
- Ferry vehicular (on causeway) and ferry vessel emissions along with other emission sources at Roberts Bank were calculated for each scenario, even though ferry-related emissions are captured in background concentrations (which were added to predicted concentrations, essentially double-counting ferry-related emissions); and
- Future vehicular emissions were assumed to not change from existing conditions, as any emissions from traffic-related increases in the future would be offset by vehicle turnover to newer, lower-emitting vehicles (e.g., electric cars).

For additional explanation regarding the use of conservative assumptions, refer to the response to IR6-13 (CEAR Document #934).

The requested updates to Section 2.8 in Appendix A of EIS Appendix 9.2-A are provided below. To reiterate, ferries running from the Tsawwassen Ferry Terminal were assessed using the following emission estimation methodology⁶:

$$\text{Emissions (g/period)} = [\text{Emission Factor (g/kW-h)} * \text{Traffic Count (ferries/period)} * \text{Ferry Engine Size (kW/ferry)} * \text{Load Factor} * \text{Activity time (h)}]$$

As outlined in the response to IR6-13 (CEAR Document #934) and recent BC Ferries documents (2018a and 2018b), BC Ferries has converted the Spirit Class vessels on Routes 1 and 30 to dual-fuel and the Salish Class vessels now operate on Route 9. **Table IR14-02-2** updated information on vessels previously documented in EIS Appendix 9.2-A with information for vessels currently used on these routes⁷, as well as other information relevant to this response. Considering the information in **Table IR14-02-2**, the updated ferry emissions analysis presented below includes or assumes the following:

- Ferry sailings to and from the Tsawwassen Terminal have been projected to increase from 7,617 in 2010 to 8,500⁸ in 2025, an increase of 11.6% over the 15 year period;
- Vehicle traffic on the causeway is also projected to increase by 12.7%;
- LNG is assumed to be used as the primary fuel (80% of the time) and the remaining time (20%) marine diesel oil is used; and
- Main engine (ME) power is 14,126 kW on average for the three routes.

The proportional power for each vessel was based on the ME size and percentage of sailings in 2018. As shown in **Table IR14-02-2**, the average proportional power rating for the three routes has increased from approximately 13,000 kW in 2010 to approximately 14,000 kW in 2025 due to the vessel replacements.

⁶ Note that all ship emissions were calculated, not modelled, based on this equation, contrary to the title of Attachment 8 of Appendix A in EIS Appendix 9.2-A. The title of Attachment 8 should have stated "Calculated Emission Rates" not "Modelled Emission Rates".

⁷ <http://www.bcferrries.com/onboard-experiences/fleet/>

⁸ Based on the number of sailings in 2018 (7,931) from BC Ferries PT5 Submission (BC Ferries 2018a) plus the projected annual increases (provided in **Table IR14-02-1**) to 2025.

Table IR14-02-2 BC Ferries Tsawwassen Ferry Terminal – Summary of EIS Fleet Assumptions and Updated Information for 2025 Considered for IR14-02 Assessment

Ferry Vessel	EIS Assumptions for 2010 and Future Conditions in 2025					IR14-02 Updated Information for Future Conditions in 2025 (based on 2018 BC Ferries operational data)					
	Total No. of Sailings	Percent of Total Sailings	ME Power (kW)	Proportional ME Power (kW)	Year of Replacement	Ferry Vessel Update	Total No. of Sailings	Percent of Total Sailings	ME Power (kW)	Proportional ME Power (kW)	Comments
Route 1 Tsawwassen – Swartz Bay											
<i>Spirit of British Columbia</i>	1,242	16.30%	15,600	2,544	2043 ^d	Operating on dual-fuel since June 2018 ^a	1,494	18%	15,600	2,742	No change in power rating, but lower EFs due to LNG fuel use
<i>Coastal Celebration</i>	937	12.30%	15,600	1,919	2057	No current changes announced by BC Ferries	1,494	18%	15,600	2,742	
<i>Coastal Renaissance</i>	16	0.20%	15,600	33	2055	Vessel no longer on this route ^f	n/a	n/a	n/a	n/a	Not included in updated analysis
<i>Queen of New Westminster</i>	471	6.20%	12,528	775	2022	To be retired by 2023 ^b	n/a	n/a	n/a	n/a	Future vessel likely to include alternative fuels/ technologies ^e . Not included in updated analysis due to retirement date and other upgraded vessels on this route are representative.
<i>Spirit of Vancouver Island</i>	1,210	15.90%	15,600	2,478	2044 ^d	Dual-fuel conversion underway ^a	1,494	18%	15,600	2,742	No change in power rating, but lower EFs due to LNG fuel use
Total No. Sailings	3,876						4,482				

	EIS Assumptions for 2010 and Future Conditions in 2025					IR14-02 Updated Information for Future Conditions in 2025 (based on 2018 BC Ferries operational data)					
Ferry Vessel	Total No. of Sailings	Percent of Total Sailings	ME Power (kW)	Proportional ME Power (kW)	Year of Replacement	Ferry Vessel Update	Total No. of Sailings	Percent of Total Sailings	ME Power (kW)	Proportional ME Power (kW)	Comments
Route 9 Tsawwassen – Southern Gulf Islands											
<i>Bowen Queen</i>	102	1.30%	671	9	2019	To be replaced in 2022, assumed with <i>Salish Class</i> -type vessel ^b	364	4%	4,438	190	ME power of 4,438 ^c and lower EFs due to LNG fuel use
<i>Queen of Burnaby</i>	156	2.00%	4,412	90.4	2017	Replaced by <i>Salish Orca</i> in May 2017 ^a	364	4%	4,438	190	
<i>Queen of Nanaimo</i>	737	9.70%	4,414	427	2017	Replaced by <i>Salish Eagle</i> in June 2017 ^a	364	4%	4,438	190	
Total No. Sailings	995						1,093				
Route 30 Tsawwassen – Duke Point											
<i>Queen of Alberni</i>	1,240	16.30%	8,606	1,401	2021	New dual-fuel vessel anticipated in mid 2020's	1,462	17%	15,600	2684	Future vessel likely to include alternative fuels/ technologies ^e ; assume same ME and EFs as <i>Coastal Inspiration</i> , although likely to have lower EFs.
<i>Coastal Inspiration</i>	1,185	15.60%	15,600	2,427	2056	No current changes announced by BC Ferries	1,462	17%	15,600	2684	

	EIS Assumptions for 2010 and Future Conditions in 2025					IR14-02 Updated Information for Future Conditions in 2025 (based on 2018 BC Ferries operational data)					
Ferry Vessel	Total No. of Sailings	Percent of Total Sailings	ME Power (kW)	Proportional ME Power (kW)	Year of Replacement	Ferry Vessel Update	Total No. of Sailings	Percent of Total Sailings	ME Power (kW)	Proportional ME Power (kW)	Comments
<i>Coastal Renaissance</i>	180	2.40%	15,600	367	2055	Vessel no longer on this route ^f	n/a	n/a	n/a	n/a	Not included in updated analysis
<i>Queen of Cowichan</i>	7	0.10%	8,602	8	2024	Vessel no longer on this route ^f	n/a	n/a	n/a	n/a	
<i>Queen of New Westminster</i>	134	1.80%	15,600	274	2022	Vessel no longer on this route ^f	n/a	n/a	n/a	n/a	
Total No. Sailings	2,746						2,925				
Total No. Sailings – all 3 Routes	7,617	Average Proportional Power Rating – all 3 Routes		12,754		Updated Total No. Sailings – all 3 Routes in 2025	8,500	Average Proportional Power Rating – all 3 Routes		14,164	

Sources: a. BC Ferries 2018c; b. BC Ferries 2018d; c. Documented in response to IR6-13; d. After completion of upgrades, 25 year life anticipated (BC Ferries 2018c). e. Various propulsion options are being considered for the replacement vessel, including dual-fuel and battery power (the latter of which would be used during departure and arrival in port, as well as in-port operations (BC Ferries 2018a)); f. <http://www.bcferrries.com/onboard-experiences/fleet/>

Note: Proportional power ratings for 2010 and 2025 are calculated as the vessel power rating multiplied by the percentage of total sailings from the Tsawwassen Ferry Terminal for that particular year.

Table IR14-02-3 provides updated information on ferry engine power assumed for the ME and auxiliary engine (AE), as well as load factors (LF) for in transit, and standby and power down activities. Information is presented alongside information from Table 2-23 in Section 2.8 of Appendix A in EIS Appendix 9.2-A for ease of comparison.

Table IR14-02-3 Ferry Engine Power (kW) and Load Factors –RBT2 Air Quality Study and Updated Assumptions for 2025 (Updated Table 2-23 from Section 2.8 in Appendix A of EIS Appendix 9.2-A)

Engine Type	RBT2 Air Quality Study			IR14-02 Updated Ferry Emissions		
	Engine Power (kW)	In Transit Load Factor (LF)	Standby and Power Down LF	Engine Power (kW)	In Transit LF	Standby and Power Down LF
Main Engine	13,000	0.405	0.343	14,164	0.405	0.343
Auxiliary Engine	1,285	0.427	0.353	1,533	0.427	0.353

Table IR14-02-4 provides updated information on ferry emission factors (EFs) for NO_x and PM_{2.5} for 2025 for main and auxiliary engines, based on a vessel with assumed ME and AE power of 14,164 kW and 1,533 kW, respectively. The NO_x and PM_{2.5} were updated based on the last part of this information request pertaining to changes in emission rates of NO_x and PM_{2.5} only, and not all parameters listed in Table 2-24 in Section 2.8 of Appendix A in EIS Appendix 9.2-A. The updated EFs are presented alongside information presented in the RBT2 Air Quality Study (i.e., Table 2-24 in Section 2.8) for ease of comparison. Note that only EFs for future conditions in 2025 is presented, as the assumptions used in the RBT2 Air Quality Study for existing conditions (2010) are still valid, albeit conservative.

EFs for LNG were taken from Marine Emission Factors Study (National Research Council Canada 2016). As shown in **Table IR14-02-4**, the replacement of old ferries with newer or converted vessels that use LNG result in lower NO_x and PM_{2.5} EFs. The 2025 NO_x and PM_{2.5} EFs are weighted averages that take into account the fact that 65% of the ferries will be replaced or upgraded by 2025 compared to 2010.

Table IR14-02-4 RBT2 Air Quality Study and Updated Ferry Emission Factors for NO_x and PM_{2.5} (g/kW-h) (Updated Table 2-24 in Section 2.8 in Appendix A of EIS Appendix 9.2-A)

Horizon Year	Engine	RBT2 Air Quality Study		IR14-04 Updated Ferry Emissions	
		NO _x	PM _{2.5}	NO _x	PM _{2.5}
2025	ME	10.3	0.23	6.13	0.13
	AE	7.3	0.23	4.66	0.13

Based on this reassessment, revise the Appendix 9.2-A, Appendix A, Attachment 2 of the EIS for ferries and the estimated NO_x and PM_{2.5} emissions from "Ferry at Berth", "Ferry Causeway" and "Ferry Transit" in Appendix 9.2-A, Appendix A, Attachment 8 of the EIS (Modelled Emission Rates).

Table IR14-02-5 provides information on existing ferry activity levels (for 2010, as documented in Attachment 2), as well as updated annual average ferry activity levels for future conditions in 2025. Since information that has informed this response is available on an annual cycle, only annual activity levels have been updated and provided in this response, because this period can be used as a proxy for the direction of change expected for hourly and daily averaging periods. The number of sailings in 2025 (shown by route in **Table IR14-02-2**) is based on the projected increase in 2018 sailings and the forecast annual changes presented in **Table IR14-02-1**.

Table IR14-02-5 Existing Conditions (2010) and Updated Future Conditions (2025) Annual Average Activity Level Assumptions For Tsawwassen Terminal Ferries

Case	Ship Quantity/Type	Activity Time
Existing Conditions (2010)	<u>Standby</u> (all 3 Routes): 7,617 ferry trips <u>Powerdown</u> : 3 ferries <u>In Transit</u> (Route 30): 2,746 ferry trips <u>In Transit</u> (Routes 1 & 9): 4,871 ferry trips	<u>Standby</u> : 1 h per trip <u>Powerdown</u> : 6 h per night <u>In Transit</u> (Route 30): 2 h per trip <u>In Transit</u> (Routes 1 & 9): negligible ^a
Future Conditions (2025)	<u>Standby</u> (all 3 Routes): 8,500 ferry trips <u>Powerdown</u> : 3 ferries <u>In Transit</u> (Route 30): 2,925 ferry trips <u>In Transit</u> (Routes 1 & 9): 5,575 ferry trips	<u>Standby</u> : 1 h per trip <u>Powerdown</u> : 6 h per night <u>In Transit</u> (Route 30): 2 h per trip <u>In Transit</u> (Routes 1 & 9): negligible ^a

Note: a. Ferries travelling Routes 1 and 9 are in transit for less than 3 minutes prior to crossing the U.S. border and being beyond the modelling boundary—emissions were calculated and determined to be negligible during this period. Refer to the response to IR6-13 (CEAR Document #934) for more information.

Estimated NO_x and PM_{2.5} annual emission rates (in g/s) from the activities 'Ferry at Berth', 'Ferry Causeway,' and 'Ferry Transit' in EIS Appendix 9.2-A, Appendix A, Attachment 8 have been updated for expected and future conditions (2025) and are presented in **Table IR14-02-7**. For 'Ferry at Berth' emission calculations, it was assumed that the ME and the AE are operational at terminals for 1 hour duration. For 'Ferry Causeway' emissions (i.e., emissions from diesel buses, heavy-duty diesel or gasoline vehicles, light duty (passenger)

vehicles, and motorcycles travelling on the causeway⁹), it was assumed that vehicle traffic increases by 12.7% from 2010 to 2025, based on BC Ferries (2018b). For 'Ferry Transit' emissions, the annual traffic volume was increased to 8,500 sailings based on the ferry traffic forecast to 2025.

Table IR14-02-7 Existing Conditions (2010) and Updated Expected and Future Conditions (2025) Ferry Annual Emission Rates (g/s) for NO_x and PM_{2.5}

Annual Emission Rates (g/s)				
Parameter and Case		Ferry at Berth	Ferry Causeway	Ferry Transit
NO _x	Existing Conditions (2010)	18.1	0.343	13.7
	Expected Conditions (2025)	9.23	0.087	7.81
	Future Conditions (2025)	9.23	0.087	7.81
PM _{2.5}	Existing Conditions (2010)	0.295	0.0123	0.224
	Expected Conditions (2025)	0.2	0.0045	0.16
	Future Conditions (2025)	0.2	0.0045	0.16

Based on the calculation of ferry emissions using the updated information presented above, and comparing the updated emission rates to the RBT2 Air Quality Study emission rates, it is projected that there would be an overall decrease in NO_x and PM_{2.5} emissions from ferries on Tsawwassen Terminal routes of approximately 24% and 30% per year, respectively, as shown in **Table IR14-02-8**.

There may be additional ferry emission reductions by the time RBT2 is operational, as BC Ferries (2018a) notes that they are exploring additional options for the propulsion systems for vessels, with a view to adopting a lower carbon technology to reduce emissions and increase fuel efficiency. Future vessels may also feature very large energy storage systems, which could allow departure and arrival in port (as well as in-port operations) to be performed on battery power. BC Ferries has stated its goal is ultra-clean emissions with ultra-low fuel consumption (BC Ferries 2018a).

⁹ For more information of BC Ferries Terminal vehicles and emission calculations, refer to Section 5.1.3 in Appendix A of EIS Appendix 9.2-A.

Table IR14-02-8 Comparison of Updated and RBT2 Air Quality Study NO_x and PM_{2.5} Annual Emissions (t/y) for BC Ferries Tsawwassen Terminal Sources

Source	NO _x Emissions (t/y)			PM _{2.5} Emissions (t/y)		
	RBT2 AQ Study	Updated IR14-02	Percent Change	RBT2 AQ Study	Updated IR14-02	Percent Change
Ships	704	537.5	-23.7%	16.4	11.4	-30.4%
Vehicles	2.45	2.76	12.7%	0.13	0.14	12.7%
Total Emissions	706.45	540.2	-23.5%	16.53	11.6	-30.0%

If the change in emission rates of NO_x and PM_{2.5} associated with ferries are more than 10% greater than estimates in the EIS, reassess the contribution of ferry emissions on the expected and future scenarios (NO_x and PM_{2.5}) and their effects on ambient concentrations.

As shown in the comparison provided in **Table IR14-02-8**, the change in total annual emissions of NO_x and PM_{2.5} is projected to decrease, not increase, from those presented in the EIS. Therefore, a reassessment of the contribution of ferry vessel and on-causeway vehicle traffic emissions on expected and future scenarios and their effects on predicted ambient NO₂ and PM_{2.5} concentrations is not required.

References

- BC Ferries. 2018a. British Columbia Ferry Services Inc. Performance Term Five Submission, September 28, 2018. Available at <http://www.bcferrycommission.ca/wp-content/uploads/2018/10/2018-09-28-PT5-Submission-to-the-Commissioner.pdf>. Accessed January 2019.
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National Research Council Canada. 2016. Automotive and Surface Transportation, Marine Emission Factors Study. Prepared for Transportation Division, Environment Canada, by T. McWha. July 2016.

IR14-03 Air Quality – Modelling – Uncertainty and Bias

Information Source(s)

EIS Volume 2: Appendix 9.2-A, Appendix C, Section 2.2, Figures 2-3, 2-4 and 2-5.

Review Panel Information Request IR6-04; CEAR Doc#991.

Proponent Response to Information Request IR6-04; CEAR Doc#1188.

Metro Vancouver submission; CEAR Doc#1319, MV-27.

Environment and Climate Change Canada submission; CEAR Doc#1346

Context

The Proponent used meteorological data from 2010 to base their assessment of the Air Quality effects of the proposed Project (EIS Figures 2-3, 2-4, and 2-5).

In IR6-04, the Review Panel noted that these results do not support the Proponent's assertion that 2010 was deemed to be a representative year for meteorological conditions and that differences between the model year 2010 and 1980-2010 climatology could potentially result in modelling biases.

In their submission to the Review Panel, Metro Vancouver asserted that the year 2010 was not representative of regional meteorology and Environment and Climate Change Canada stated that it is difficult to determine if the year selected for the assessment accurately represents the typical meteorology of the study area.

The use of meteorological data from 2010 may have introduced uncertainty, and possible bias in the assessment of air quality effects of the Project.

Information Request

Provide a quantitative assessment of possible bias and level of uncertainty in modelled ambient air pollutant concentrations introduced by the use of 2010 meteorological data provided in the EIS.

VFPA Response

Section 2.2 in Appendix C of EIS Appendix 9.2-A explained that modelled meteorological outputs for 2010 were considered representative of typical meteorological conditions in the local study area, based on comparisons of meteorological outputs from the WRF-NMM model used in the RBT2 Air Quality Study to 30-year climate normals for Vancouver International

Airport¹. In addition, statistical comparisons provided in the response to IR6-04 (CEAR Document #934²) for WRF-NMM results (based on 2010 meteorology) to climate normal data indicate that 2010 was a representative year for meteorological conditions.

While there may be some variation in 2010 WRF-NMM model output data when compared with climate normals, these variances do not increase any uncertainties associated with the performance of the CALPUFF air quality dispersion model used for the RBT2 Air Quality Study. This is because the purpose of the air quality dispersion modelling for the Project was to evaluate and compare existing conditions and future conditions, both with and without the Project, and the same WRF-NMM outputs are used for all conditions assessed. Therefore, as concluded in Appendix C of EIS Appendix 9.2-A and the response to IR6-05 (CEAR Document #934), the WRF-NMM model provides a reasonably accurate measure of the atmospheric state through the modelling domain and does not add to uncertainty in predicting air pollutant concentrations.

With respect to dispersion modelling, as stated in the response to IR6-05 (CEAR Document #934), it has been demonstrated in numerous air quality assessments that the CALPUFF dispersion model is conservative in estimating maximum concentrations and, therefore, can accommodate some disparity between meteorological model-predicted parameters and surface meteorological observations without compromising output results. For more information on the evaluation of meteorological data for use in dispersion modelling analyses, refer to the response to IR6-05.

To further evaluate the appropriate use of 2010 meteorological data for dispersion modelling conducted as part of the RBT2 Air Quality Study, as per this information request, quantitative analyses of possible bias and level of uncertainty in modelled ambient air pollutant concentrations were conducted for the 2010 model predictions of 1-hour and 24-hour NO₂ at Station T39 (in Pebble Hill Park in Tsawwassen). This contaminant was selected for these analyses due to its relevance to human health effects and stringent air quality criteria (i.e., see response to IR14-04).

Statistical Analyses

There are numerous performance measure statistics that can be used to validate models in a comprehensive manner. A model's ability to predict air pollution levels is normally evaluated by comparing field observations for the same time period. In order to quantitatively assess the reliability of the predictions generated by the model at Station T39 compared to observations measured at Station T39, two statistical performances measures were used in

¹ A climate normal is defined as the arithmetic average of a climate element (e.g., temperature) over a prescribed 30-year interval. The 30-year interval is selected since it is long enough to filter out inter-annual variation or anomalies but also short enough to show longer climatic trends. The Vancouver International Airport station is the only station in the vicinity of the Roberts Bank terminals that meets Environment Canada and World Meteorological Organization station siting requirements and has a long record of climate parameters.

² CEAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (NOTE: Updated November 30, 2018).

the evaluations: model bias and fractional bias. For model-predicted concentrations for 2010 at Station T39, comparisons have been conducted with annual observed concentrations obtained from Station T39 for 2010, as well as for observed concentrations for 2011 to 2015. The methods and results of these evaluations are presented below.

Model Bias

Model bias (MB) is the mean error that is defined as the arithmetic difference between the observed concentration (C_o) and the predicted concentration (C_p) (i.e., $MB = C_o - C_p$). For this evaluation, MB was determined from the average difference between the highest ten observed concentrations and the highest ten model-predicted concentrations to determine the difference in the mean state. **Table IR14-03-1** presents the MB values for 2010 average observed to 2010 average predicted 1-hour and 24-hour NO₂ concentrations, as well as the MB values for average observed concentrations for 2011 to 2015 and 2010 average predicted concentrations. The MB values are presented both without and with the inclusion of 98th percentile background concentration (i.e., 44.7 µg/m³ for 1-hour NO₂ and 34.9 µg/m³ for 24-hour NO₂) for predicted concentrations at Station T39. A negative model bias value (expressed in µg/m³) means that model predictions are on average higher than the observations. The closer to zero the MB value, the better the prediction. All model bias data is presented in Table IR14-03-A1 of **Appendix IR14-03-A**.

Table IR14-03-1 Model Bias Values for 1-hour and 24-hour NO₂ (µg/m³) for 2010 to 2015 Average Observed Concentrations and 2010 Model-Predicted Average Concentration for Station T39

	2010	2011	2012	2013	2014	2015
Model Bias Values from Average 10 Highest Concentrations for 1-Hour NO₂						
Without Background	-47.92	-28.68	-40.01	-42.65	-44.12	-32.89
With Background	-92.62	-73.38	-84.71	-87.35	-88.82	-77.59
Model Bias from Average 10 Highest Concentrations for 24-Hour NO₂						
Without Background	5.71	14.68	10.12	12.82	13.81	10.72
With Background	-29.19	-20.22	-24.78	-22.08	-21.09	-24.18

In reviewing the MB results presented in Table IR14-03-A1 (**Appendix IR14-03-A**), it should be noted that the NO_x emissions from marine terminal operations at Roberts Bank are not a unique source of NO_x emissions in the local study area (i.e., emissions from the operation of marine terminals do not account for all of the observed NO₂ concentrations measured at Station T39). Consequently, a direct comparison between predicted and observed concentrations cannot be made without some degree of *a priori* uncertainty.

In addition, conservative bias was introduced to the RBT2 Air Quality Study for 2010 by assuming that all three berths at Deltaport Terminal and the two berths at Westshore Terminals were occupied 100% of the time as a hypothetical worst-case emission scenario, and that two vessels (i.e., one arriving and one departing within the same hour) were in manoeuvring mode for maximum 1-hour average emissions, and up to 10 vessels (i.e., five

arriving and five departing on the same day) was assumed for maximum daily emissions. While hypothetically possible, such intense vessel activity does not correspond to actual operations at these two terminals, and the variability in NO_x emissions associated with less intense vessel activity has not been accounted for in the modelling analysis, resulting in a bias to over-predict. Similarly, highly conservative assumptions were used for the dispersion modelling of expected and future marine terminal operations in 2025 (i.e., all eight berths at the three terminals³ occupied 100% of the time by the largest vessels, with one vessel arriving and one departing in the same hour every hour, and eight vessels arriving with eight vessels departing on the same day, every day).

Finally, it should be noted that there is a difference between dispersion modelling of NO_x emissions with respect to 1-hour and 24-hour averages. For both the predicted 1-hour and 24-hour average NO₂ concentrations, the dispersion modelling analysis assumes there is a unidirectional conversion of NO_x to NO₂ as the plume is transported from the source to Station T39. While this may be a reasonable assumption with respect to predicted 1-hour average NO₂ concentrations, it may be a less reasonable assumption with respect to 24-hour average NO₂ concentrations because these concentrations would be subject to both formation and destruction of NO₂ over the 24-hour period, and the destruction of NO₂ is not considered in the modelling analysis. Therefore, the comparison between predicted and observed 24-hour average NO₂ concentrations would be biased by the absence of any chemical mechanism in the analytical techniques utilised to account for this process of formation and destruction.

While the modelling analysis assumed that the observed 98th percentile background NO₂ levels at Station T39 were representative of all other sources of NO₂ in the local study area, such an assumption cannot account for the actual variability in hourly or daily emissions of these sources that contribute to the observed variability in measured NO₂ concentrations at Station T39. Using a static estimate of observed NO₂ concentrations at the higher end of the statistical distribution of observations automatically introduces a bias towards conservative (i.e., over predicted) estimates of background levels. In particular, those observations include contributions from marine terminal sources that are then added to the modelled contributions from those very same sources, essentially double counting the emissions from operations at the marine terminals.

The MB values listed in **Table IR14-03-1** illustrate a trend of model over-prediction for NO₂ for both the 1-hour and 24-hour averages. For the 1-hour average NO₂ analyses, model bias values are negative for all years compared, which indicates that average predicted concentrations are higher than average observed concentrations (when considering the average highest 10 predicted and observed concentrations, and average predicted concentrations both with and without the inclusion of background). The difference (or more negative bias value) for the 'with background' case is to be expected because there are additional local sources of NO₂ that were not included in the dispersion model and may not

³ The eight berths in the future conditions with the Project case include three berths at RBT2, three berths at Deltaport Terminal, and two berths at Westshore Terminals.

have been entirely accounted for in the defined background air quality level⁴. The 2010 year appears to be more conservative (based on a half year of 2010 Station T39 data⁵) than comparisons of other years, as shown by the more negative bias value.

For the 24-hour average NO₂ analyses, MB values (based on the average highest 10 predicted and observed concentrations) are positive when predicted concentrations without background concentrations are considered, and negative when predicted concentrations include background concentrations. This illustrates that the model-predicted NO₂ concentrations for sources at the marine terminals alone do not fully account for the observed NO₂ levels at Station T39, even when using the conservative estimates of NO_x to NO₂ conversion derived from the Ozone Limiting Method, as discussed in the response to IR6-22 (CEAR Document #934)⁶. Other sources contribute to those observed NO₂ levels, and their inclusion in the MB analyses using the defined background level from Station T39 results in a negative model bias (i.e., over-prediction) of the predicted 24-hour average NO₂ concentrations.

One would expect that the ratio of C_p to C_o (C_p/C_o) of a good model would not exhibit any trend with meteorological variables and would not exhibit any large deviations from unity (i.e., 1:1 ratio, implying a perfect match between the model and observations). The C_p to C_o ratios for 2010 to 2015 are presented in Table IR14-03-A1 of **Appendix IR14-03-A**. Compared to observed concentrations for 1-hour NO₂, the model overpredicts concentrations by 1.4 to 1.8 times (as shown by the ratios of the average ten highest modelled to observed concentrations presented in Table IR14-03-A1 in **Appendix IR14-03-1**) even without inclusion of the other local emission sources. When the observed background NO₂ concentration is considered in the analyses, the overprediction by the model increases to 1.9 to 2.5 times. For 24-hour NO₂ predictions without background added, the model underpredicts by 0.64 to 0.82 times average monitored concentration, but the model overpredicts by 1.5 to 1.9 times the average monitored concentration when background is added.

These estimates of overprediction are based on RBT2 Air Quality Study results that incorporated the 98th percentile ozone concentration in the Ozone Limiting Method for the conversion of NO_x emissions to ambient NO₂ concentrations. The bias would have been even greater (i.e., increased disparity between predicted and observed NO₂ concentrations) if the 100th percentile ozone value was used, as recommended in the B.C. modelling guidelines (MOE 2008 and 2015). Refer to IR6-22 (CEAR Document #934) for more information on the use of the 98th percentile ozone concentration.

⁴ Defined background level means the 98th percentile of measured concentrations as defined by the 2008 Guidelines for Air Quality Dispersion Modelling in British Columbia (MOE 2008) and the 2015 British Columbia Air Quality Dispersion Modelling Guideline (MOE 2015).

⁵ As reiterated in the response to IR6-37 (CEAR Document #934), Station T39 was specifically established in June 2010 to monitor air quality in relation to the operation of marine terminals at Roberts Bank, stemming from the 2005 air quality assessment conducted for the Deltaport Third Berth Project.

⁶ As outlined in the response to IR6-22 (CEAR Document #934), an overprediction of maximum NO₂ concentrations by a factor 1.7 to 2.0 is documented in Podrez 2013 and 2015.

For both averaging periods when background is added to predicted concentrations, the overprediction is greatest for 2010 (based on a half year of 2010 Station T39 data), indicating that the modelling was conservative based on 2010 meteorological inputs.

Fractional Bias

Fractional bias (FB), a performance measure used to determine if a model meets the performance expectations (i.e., predictions within a factor of two), is calculated according to the following equation:

$$FB = \frac{2 * (Co - Cp)}{(Co + Cp)}$$

Values for FB range between +2 (extreme underprediction) and -2 (extreme overprediction). Model predictions with a FB of zero (0) are relatively free from bias. FB values that are equal to -0.67 are equivalent to an overprediction by a factor-of-two, while FB values that are equal to +0.67 are equivalent to an under-prediction by a factor-of-two.

For this analysis, FB was calculated twice. First, using average values, where Co and Cp were equal to the average of the highest 25 observed and predicted concentrations, respectively, and the second time using standard deviation, where Co and Cp were equal to the standard deviation of the highest 25 observed and predicted concentrations, respectively.

Similar to the MB calculations, FB values were calculated for each year of observed NO₂ data from 2010 to 2015, and Cp concentrations both with and without background concentrations from Station T39 (i.e., 44.7 µg/m³ for 1-hour and 34.9 µg/m³ for 24-hour) were considered.

Table IR14-03-2 presents the FB values for 1-hour and 24-hour NO₂ predictions considering 2010 average predicted concentrations, both with and without the inclusion of 98th percentile background concentrations, and average annual observed concentrations for 2010 to 2015. **Table IR14-03-2** also presents the FB values based on standard deviation considering the same data. The results from the fractional bias show that the model is performing within the expected standards.

Table IR14-03-2 Fractional Bias Values for 1-hour and 24-hour NO₂ at Station T39 for 2010 to 2015 Observed Concentrations and 2010 Model-predicted Concentrations (with and without Background)

	2010	2011	2012	2013	2014	2015
FB Values (Without Background) from Average 25 Highest Concentrations for 1-Hour NO₂						
FB Average	-0.59	-0.43	-0.50	-0.51	-0.54	-0.44
FB StDev	-0.06	1.25	0.34	0.06	0.07	0.75
FB Values (With Background) from Average 25 Highest Concentrations for 1-Hour NO₂						
FB Average	-0.90	-0.75	-0.82	-0.83	-0.85	-0.77
FB StDev	-0.06	1.25	0.34	0.06	0.07	0.75
FB Values (Without Background) from Average 25 Highest Concentrations for 24-Hour NO₂						
FB Average	0.23	0.50	0.39	0.49	0.47	0.45
FB StDev	0.05	0.06	-0.05	-0.01	0.10	-0.41

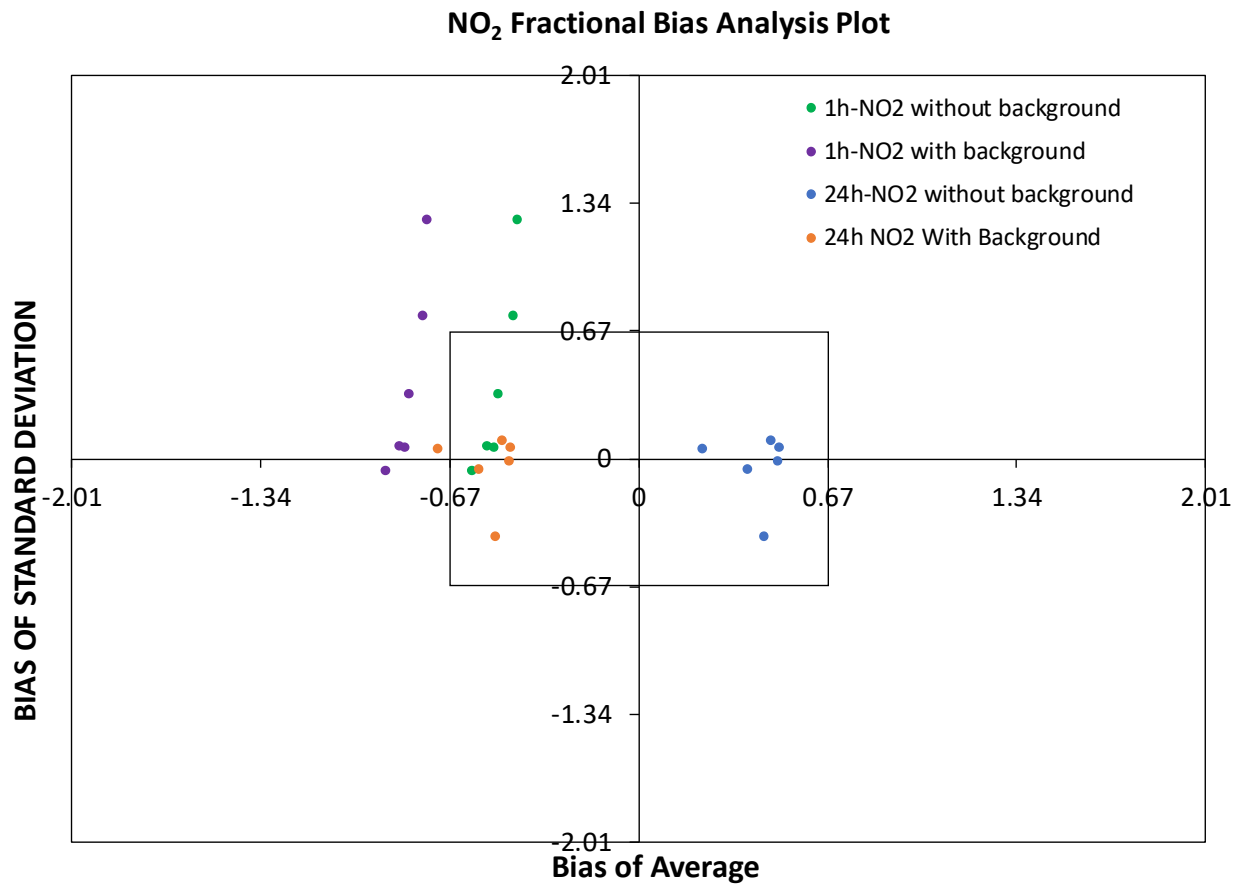
	2010	2011	2012	2013	2014	2015
FB Values (With Background) from Average 25 Highest Concentrations for 24-Hour NO₂						
FB Average	-0.71	-0.46	-0.56	-0.46	-0.48	-0.51
FB StDev	0.05	0.06	-0.05	-0.01	0.10	-0.41

The resulting two values for each of the four scenarios listed in **Table IR14-03-2** for each year were then plotted (see **Figure IR14-03-1**), with FB values of average on the x-axis and FB of standard deviation values on the y-axis.

For 1-hour average NO₂ FB values, the plots illustrate that the model overpredicts concentrations of 1-hour NO₂ without background concentrations added to the average of the highest 25 predicted concentrations in each of the six years (represented by green dots in **Figure IR14-03-1**), and the overprediction increases when the background concentration is added (purple dots). Station T39 had a wider standard deviation of measured concentrations than the model-predicted concentrations because the modelled emission scenarios do not vary hour to hour like actual operations do. In other words, the observed data had greater variation in measured concentrations than the variation in the model-predicted concentrations (i.e., the model is more consistent at predicting higher concentrations than the monitor exhibited due to non-varying assumptions). This is consistent with the noted conservative bias introduced to the modelling through the use of hypothetical worst-case scenarios for estimating emissions from the marine terminals (emissions assumed to be constant or static throughout the averaging period) and the use of a static 98th percentile background concentration for estimating contributions from other NO_x emission sources.

For 24-hour NO₂ FB values, the plots illustrate that the model underpredicts concentrations of 24-hour NO₂ without the background concentration added (represented by blue dots in **Figure IR14-03-1**), and overpredicts concentrations of 24-hour NO₂ when the background concentration is added (orange dots). As there are also other local sources of emissions that contribute to observed concentrations at Station T39 (i.e., local traffic, home heating, landscaping equipment at the park where Station T39 is located, backyard barbeques, etc.), in addition to the emission sources from operating marine terminals at Roberts Bank that were included in the dispersion model, an under prediction of dispersion modelled NO₂ concentrations without background would be expected.

Figure IR14-03-1 1-hour and 24-hour NO₂ Fractional Bias Analysis Plot



Detailed FB data are provided in Table IR14-03-A2 of **Appendix IR14-03-A**.

Summary

A quantitative assessment of possible bias and level of uncertainty in modelled ambient air pollutant concentrations introduced by the use of 2010 meteorological data was assessed by comparing modelled concentrations for 2010 to ambient observation data monitored at Station T39 for each of the six years for the period of 2010 to 2015. The statistical methods included model bias and fractional bias for the evaluation of 1-hour and 24-hour averaging periods for NO₂.

The analysis demonstrated that the prediction of worst-case concentrations of air pollutants (i.e., NO₂) when other sources from the airshed are included (as defined background concentrations) reduces uncertainty in the model with an overall tendency to overpredict air pollutant concentrations. Considering that hypothetical worst-case emissions were modelled for the operating marine terminals at Roberts Bank, as per direction from the Air Quality Scoping Study process representatives (see response to IR6-04 (CEAR Document #934) for more information), and defined background levels include emissions from these terminals, one would expect that the modelled emissions for existing conditions would be higher than measured emissions.

Overall, the comparisons above based on air dispersion model predictions for 2010 indicate the following when using 2010 meteorological inputs:

- An increase in possible bias and level of uncertainty in CALPUFF modelled ambient air pollutant concentrations is not expected;
- The RBT2 Air Quality Study approach was reasonable and the modelling generated conservative predictions; and
- Dispersion model output results have not been compromised.

Therefore, 2010 data is considered adequately conservative for predicting air pollutant concentrations for existing conditions, expected conditions, and future conditions with the Project because similarly conservative assumptions were used for modelling expected and future emissions from the marine terminal operations in 2025.

References

British Columbia Ministry of Environment (MOE). 2008. Guidelines for Air Quality Dispersion Modelling in British Columbia. Environmental Protection Division, Environmental Quality Branch, Air Protection Section, Victoria, BC.

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Podrez, M. 2013. Ambient Ratio Method Version 2 (ARM2) for AERMOD 1-hr NO₂ NAAQS Analyses. Presented at the Regional, State, and Local Dispersion Modelers' Workshop, April 22-25, 2013 in Dallas, TX.

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Appendices

Appendix IR14-03-A Statistical Analysis Tables

APPENDIX IR14-03-A
STATISTICAL ANALYSIS TABLES

Appendix IR14-03-A Statistical Analysis Tables

Model bias and fractional bias analyses of 1-hour and 24-hour NO₂, with and without the 98th percentile background concentration, are presented in **Tables IR14-03-A1** and **IR14-03-A2**, respectively.

Table IR14-03-A1 1-hour and 24-hour NO₂ data and Model Bias Values without and with Background Concentrations

Using Highest 10 Concentrations	2010	2011	2012	2013	2014	2015
1-hr NO₂ data without Background						
Model: Average (Cp)	107.87	107.87	107.87	107.87	107.87	107.87
Observed: Average (Co)	59.94	79.18	67.86	65.22	63.75	74.97
Model Bias (Co-Cp)	-47.92	-28.68	-40.01	-42.65	-44.12	-32.89
Ratio of Cp:Co	1.80	1.36	1.59	1.65	1.69	1.44
1-hr NO₂ data with Background						
Model: Average (Cp)	152.57	152.57	152.57	152.57	152.57	152.57
Observed: Average (Co)	59.94	79.18	67.86	65.22	63.75	74.97
Model Bias (Co-Cp)	-92.62	-73.38	-84.71	-87.35	-88.82	-77.59
Ratio of Cp:Co	2.55	1.93	2.25	2.34	2.39	2.03
24-hr NO₂ data without Background						
Model: Average (Cp)	26.19	26.19	26.19	26.19	26.19	26.19
Observed: Average (Co)	31.91	40.88	36.31	39.01	40.01	36.91
Model Bias (Co-Cp)	5.71	14.68	10.12	12.82	13.81	10.72
Ratio of Cp:Co	0.82	0.64	0.72	0.67	0.65	0.71
24-hr NO₂ data with Background						
Model: Average (Cp)	61.09	61.09	61.09	61.09	61.09	61.09
Observed: Average (Co)	31.91	40.88	36.31	39.01	40.01	36.91
Model Bias (Co-Cp)	-29.19	-20.22	-24.78	-22.08	-21.09	-24.18
Ratio of Cp:Co	1.91	1.49	1.68	1.57	1.53	1.66

Table IR14-03-A2 1-hour and 24-hour NO₂ data and Average and Standard Deviation Fractional Bias Values without and with Background Concentrations

Using Highest 25 Concentrations	2010	2011	2012	2013	2014	2015
1-hr NO₂ data without Background						
Model: Average (Cp)	104.83	104.83	104.83	104.83	104.83	104.83
Observed: Average (Co)	57.01	67.76	62.92	61.98	60.37	66.73
Model: StDev (Cp)	3.61	3.61	3.61	3.61	3.61	3.61
Observed: StDev (Co)	3.41	15.73	5.11	3.84	3.86	7.98
FB Average	-0.59	-0.43	-0.50	-0.51	-0.54	-0.44
FB StDev	-0.06	1.25	0.34	0.06	0.07	0.75
1-hr NO₂ data with Background						
Model: Average (Cp)	149.53	149.53	149.53	149.53	149.53	149.53
Observed: Average (Co)	57.01	67.76	62.92	61.98	60.37	66.73
Model: StDev (Cp)	3.61	3.61	3.61	3.61	3.61	3.61
Observed: StDev (Co)	3.41	15.73	5.11	3.84	3.86	7.98
FB Average	-0.90	-0.75	-0.82	-0.83	-0.85	-0.77
FB StDev	-0.06	1.25	0.34	0.06	0.07	0.75
24-hr NO₂ data without Background						
Model: Average (Cp)	21.27	21.27	21.27	21.27	21.27	21.27
Observed: Average (Co)	26.69	35.29	31.43	35.14	34.27	33.45
Model: StDev (Cp)	5.06	5.06	5.06	5.06	5.06	5.06
Observed: StDev (Co)	5.33	5.39	4.79	5.00	5.58	3.35
FB Average	0.23	0.50	0.39	0.49	0.47	0.45
FB StDev	0.05	0.06	-0.05	-0.01	0.10	-0.41
24-hr NO₂ data with Background						
Model: Average (Cp)	56.17	56.17	56.17	56.17	56.17	56.17
Observed: Average (Co)	26.69	35.29	31.43	35.14	34.27	33.45
Model: StDev (Cp)	5.06	5.06	5.06	5.06	5.06	5.06
Observed: StDev (Co)	5.33	5.39	4.79	5.00	5.58	3.35
FB Average	-0.71	-0.46	-0.56	-0.46	-0.48	-0.51
FB StDev	0.05	0.06	-0.05	-0.01	0.10	-0.41

IR14-04 Human Health Risk Assessment – Air Quality – exposure limits

Information Source(s)

Review Panel Information Request IR13-02, IR13-03 & IR13-04; CEAR Doc#1228.

Proponent Response to Information Request IR13-02, IR13-03 & IR13-04; CEAR Doc#1333 & Doc#1345.

Environment and Climate Change Canada submission; CEAR Doc#1346

Health Canada submission: CEAR Doc#1286.

Metro Vancouver submission; CEAR Doc#1319, MV-34 & MV-35.

Context

The Proponent, in subsection 3.6 of Appendix 27-A of the EIS, stated that “the most stringent exposure limit from the list of values recommended by authoritative health agencies was used in the Human Health Risk Assessment (HHRA), provided that the derivation of the value was adequately documented, not outdated, and scientifically defensible. The adopted exposure limits all include uncertainty factors which further reduced the presumed acceptable exposure limit for the protection of individuals who may be more sensitive to chemical exposure”.

Table IR6-23-1, provided in responses to information request IR6-23 (CEAR Doc#1188), presented up to date or upcoming applicable ambient air quality standards for Canadian and U.S. Over Land and Over Water Locations for CO, NO₂, SO₂, formaldehyde and particulate matter. The 1-hour NO₂ standard used in the HHRA is not the most up-to-date Canadian Ambient Air Quality Standard (CAAQS) published in the Canadian Gazette, December 9, 2017.

In their sufficiency analysis, Environment and Climate Change Canada recommended the Proponent assess the potential for the Project to contribute to ambient concentrations of NO₂ that exceed the 1-hour and annual NO₂ based on the new CAAQS for 2025, and replace the Metro Vancouver 1-hour objective for NO₂ with the new CAAQS for 1-hour NO₂ for 2025 for all Canadian portions of the modelling domain.

In their sufficiency analysis, Health Canada requested the Proponent provide further discussion of the potential for Project-related emissions to contribute to future NO₂ exceedances in the area relative to the CAAQS for NO₂. Furthermore, it is Health Canada's view that the single most stringent, applicable air quality objective(s) be applied to receptors uniformly throughout the air quality study area, irrespective of whether they are located over land or over water.

In their sufficiency analysis, Metro Vancouver recommended that the CAAQS for NO₂ that come into effect in 2020 should be incorporated into the HHRA.

The use of the most recent and the most stringent exposure limits is required when responding to information requests related to the human health risk assessment for air quality in "Future Conditions".

An updated HHRA that reflects the CAAQS 1-hour and annual standards for NO₂ that will come into effect in 2020 and 2025, as presented below, is required.

Table IR14-04: NO₂ Air Quality Standard/Objective (in µg m⁻³) 1-hour/annual

	Table IR6-23-1	CAAQS	CAAQS
		2020	2025
Over land	200/40	113/32	79/23
Over water	188/60	113/32	79/23

Information Request

Provide an updated 'future conditions' HHRA that reflects the new CAAQs standards that will come into effect in the year 2020 and 2025 for 1-hour NO₂ and annual NO₂.

This update should include updated Figures, Tables and a discussion that will allow an assessment of the risk to human health due to exposure to NO₂ (annual and 1-hour average concentrations) under the Future Conditions scenarios (with and without the Project).

Provide Figures and Tables as follows:

- Updated Figure IR13-02-B2 (left panel): Predicted 98th Percentile 1-Hr NO₂ Concentrations (µg m⁻³) for RBT2 Construction alone.
- Updated Figure IR13-02-B2 (right panel): Predicted 98th Percentile 1-Hr NO₂ Concentrations (µg m⁻³) for RBT2 Construction, and Operations at Westshore Terminals, Delta port and B.C. Ferries Terminal.
- New Figure: Predicted 98th Percentile 1-Hr NO₂ Concentrations (µg m⁻³) for Future Conditions with RBT2 Operation alone.
- New Figure: Predicted 98th Percentile 1-Hr NO₂ Concentrations (µg m⁻³) for RBT2 Operation, and Operations at Westshore Terminals, Delta port and B.C. Ferries Terminal.
- New Figure IR13-02-B2: Predicted annual average NO₂ Concentrations (µg m⁻³) for RBT2 Construction alone.
- New Figure: Predicted annual average NO₂ Concentration (µg m⁻³) for RBT2 Construction, and Operations at Westshore Terminals, Delta port and B.C. Ferries Terminal.
- New Figure: Predicted annual average NO₂ Concentration (µg m⁻³) for Future Conditions for RBT2 Operation alone.
- New Figure: Predicted annual average NO₂ Concentration (µg m⁻³) for Future Conditions with RBT2 Operation, and Operations at Westshore Terminals, Delta port and B.C. Ferries Terminal.
- New Table: Tabulated Summary of NO₂ Concentrations (µg m⁻³), (including background) for 70 discrete receptors for all eight cases in requested Figures.

All Figures and Tables must include an expanded set of receptors, as listed in Table IR13-02-A1 and mapped in Figure IR13-02-B1.

NO₂ criteria must be applied uniformly over entire map area.

The Tables contents must be determined from existing model runs as for Table IR13-02-B1.

All tabulated quantities must be given as estimated values and not as an upper limited range (for example <100 µg m⁻³).

VFPA Response

In this response, the VFPA has provided the requested information to the extent practicable, with an explanation provided for any exceptions. Background information is presented at the beginning of the response to provide context for the results that are presented in the subsequent sections. As per the information request, the tables and figures provided below:

- Include the 70 receptors listed in Table IR13-02-A1 and shown in Figure IR13-02-B1 in the response to IR13-02 (CEAR Document #934¹);
- Apply the Canadian Ambient Air Quality Standard (CAAQS) for nitrogen dioxide (NO₂) uniformly over the local study area for all receptors, including those located in the U.S.A. (which are not subject to Canadian standards);
- Present concentrations for upper-limit NO₂ concentrations (previously presented in Table IR13-02-B1 of Appendix IR13-02-C (CEAR Document #934)) based on quantitative methods (i.e., dispersion modelling); and
- Present concentrations inclusive of model-predicted concentrations from contributing sources and background concentrations (as measured at air quality monitoring Station T39 in Tsawwassen). For 1-hour NO₂ concentrations, the statistical form for this numerical standard is provided as the 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations, and for annual concentrations it is the average of a single calendar year of all 1-hour average concentrations², as specified by the Canadian Council of Ministers of the Environment (CCME).

Background Information

As background information, the CAAQS are intended as an air zone or airshed management tool to facilitate the management of air quality at the regional (e.g., Western Canada) and local levels³. The national Air Quality Management System (AQMS) defines the comprehensive approach to reducing air pollution and public reporting on air quality in Canada. The CAAQS are developed under the AQMS to drive action to protect human health and the environment². The RBT2 Project is in the 'Lower Fraser Valley Air Zone' as defined in the CAAQs. The CAAQS are supported by four colour-coded Management Levels, with each management level being determined by the amount of a pollutant within an air zone and recommended air quality management actions being provided. If the amount of a pollutant within an air zone increases, the management actions become more stringent, which helps to ensure that the CAAQS are

¹ CEAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (NOTE: Updated November 30, 2018).

² <http://airquality-qualitedelair.ccme.ca/en/>

³ <https://www.ccme.ca/en/resources/air/aqms.html>

not treated as pollute-up-to levels and actions will be taken to maintain clean areas. **Table IR14-04-1** summarises the management levels and goals for NO₂ CAAQS.

Table IR14-04-1 November 2017 CAAQS (in parts per billion) for NO₂

Air Quality Management Levels and Goals	Range of Ambient Air Pollutant Concentrations			
	1-hour average NO ₂ (ppb) ^a		Annual Average NO ₂ (ppb) ^b	
	2020	2025	2020	2025
Reduce ambient pollutant concentrations below the CAAQS	>60	>42	>17	>12
Prevent CAAQS exceedance	>31-≤60	>31-≤42	>7-≤17	>7-≤12
Prevent air quality deterioration	>21-≤31		>2-≤7	
Keep clean areas clean	≤20		≤2	

Notes: a. 1-hour NO₂ concentrations are based the 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations.

b. Annual concentrations are based on the average of a single calendar year of all 1-hour average concentrations⁴.

Provinces and territories, with assistance from the federal government, are responsible for monitoring in the air zones and reporting to the general public in their jurisdictions on air quality and the measures taken to implement AQMS. Annual air zone reports are produced that include information on achievement of the CAAQS, air quality issues and trends, and the air management level in each air zone. The B.C. Ministry of Environment (MOE), in their document *Guidance on Application of Provincial Air Quality Objectives for SO₂*⁵, has stated that “the reporting of CAAQS achievement is focused on those monitoring sites that are located beyond the industrial fenceline and in proximity to populated areas or other sensitive receptors such as sensitive ecosystems.” The B.C. MOE also indicates that provincial ambient air quality objectives (AAQOs) are non-statutory limits used to assess air quality and guide air management decisions, including those related to environmental assessments and authorisations. To date, B.C. MOE and Metro Vancouver have not adopted the CAAQS for NO₂, and hence guidance documentation on the application of the NO₂ CAAQS in either of these jurisdictions has not been released.

Air quality criteria was selected for the RBT2 Air Quality Study based on the most stringent of federal and provincial AAQOs in place at the time the assessment was undertaken (prior to November 2014), and Metro Vancouver AAQOs were presented alongside these non-statutory limits for comparison purposes, as outlined in the response to IR6-23 (CEAR Document #934). The transition to the new NO₂ CAAQS for 2020 and 2025 has not yet been facilitated by B.C. or Metro Vancouver. Nevertheless, in this response, the VFPA has provided the requested information, noting that the new CAAQS for NO₂ for 2025 (79 µg/m³ or 42 ppb) have been used as criteria for both the RBT2 construction and operation phase predictions to align with

⁴ <http://airquality-qualitedelair.ccme.ca/en/>

⁵ https://www2.gov.bc.ca/assets/gov/environment/air-land-water/air/reports-pub/so2_aqo-implementation_guide.pdf

the current Project schedule that indicates the construction activities will extend into the mid-late 2020s (as documented in the Project Construction Update (CEAR Document #1210⁶).

It is important to note that although air quality is predicted to improve in the future compared to existing conditions⁷, exceedances of the NO₂ CAAQS are predicted in the context of existing conditions in the local study area. That is, the 98th percentile background level for 1-hour NO₂ based on measurements taken at Station T39 (i.e., 23.4 ppb in 2010-2012) is approximately 56% of the future 42 ppb CAAQS for 2025; existing 98th percentile levels measured at Station T39 (e.g., 23.6 ppb in 2013-2015) are within the yellow management zone shown on **Figure IR14-04-1**⁸. The relative contribution from RBT2 to the concentrations presented in this response must be considered in interpreting the results. As explained further below, the results demonstrate that RBT2 would not significantly affect or increase the risk to human health or the environment.

Provide an updated 'future conditions' HHRA that reflects the new CAAQs standards that will come into effect in the year 2020 and 2025 for 1-hour NO₂ and annual NO₂.

This update should include updated Figures, Tables and a discussion that will allow an assessment of the risk to human health due to exposure to NO₂ (annual and 1-hour average concentrations) under the Future Conditions scenarios (with and without the Project).

Appendix IR4-04-A provides the requested figures, as summarised in **Table IR14-04-2**. Where relevant, exceptions are noted and supporting information is provided.

⁶ CEAR Document #1210 From the Vancouver Fraser Port Authority to the Review Panel re: Project Construction Update (See Reference Document #995) (NOTE: Updated June 13, 2018).

⁷ For more details, refer to EIS Section 9.2.7 and the response to IR6-04 and others (i.e., IR6-09, IR6-14; CEAR Document #934).

⁸ As documented in Table IR6-09-1 in response to IR6-09 (CEAR Document #934), the 98th percentile background levels for 1-hour NO₂ based on measurements taken at Station T39 were 44.7 µg/m³ or 23.4 ppb in 2010-2012, and 45.1 µg/m³ or 23.6 ppb in 2013-2015.

Table IR14-04-2 Summary of References for Requested Updated or New NO_x Figures

Requested Update or New Figure	Appendix IR14-04-A Figure Reference for Requested Information
Updated Figure IR13-02-B2 (left panel): Predicted 98 th Percentile 1-Hr NO ₂ Concentrations (µg m ⁻³) for RBT2 Average Day Construction alone.	Figure IR14-04-A1 left panel
Updated Figure IR13-02-B2 (right panel): Predicted 98 th Percentile 1-Hr NO ₂ Concentrations (µg m ⁻³) for RBT2 Average Day Construction, and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal.	Figure IR14-04-A1 right panel
New Figure: Predicted 98 th Percentile 1-Hr NO ₂ Concentrations (µg m ⁻³) for Future Conditions with RBT2 Operation alone.	Figure IR14-04-A2: incremental change from RBT2 (alone) is shown by comparing left panel (for Expected Conditions) and right panel (for Future Conditions with the Project). ^a
New Figure: Predicted 98 th Percentile 1-Hr NO ₂ Concentrations (µg m ⁻³) for RBT2 Operation, and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal.	Figure IR14-04-A2 right panel
New Figure IR13-02-B2: Predicted annual average NO ₂ Concentrations (µg m ⁻³) for RBT2 Average Day Construction alone.	Figure IR14-04-3 left panel
New Figure: Predicted annual average NO ₂ Concentration (µg m ⁻³) for RBT2 Average Day Construction, and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal.	Figure IR14-04-A3 right panel
New Figure: Predicted annual average NO ₂ Concentration (µg m ⁻³) for Future Conditions for RBT2 Operation alone.	Figure IR14-04-A4: incremental change from RBT2 (alone) is shown by comparing left and right panels ^a
New Figure: Predicted annual average NO ₂ Concentration (µg m ⁻³) for Future Conditions with RBT2 Operation, and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal.	Figure IR14-04-A4 right panel

Note: a. RBT2 Operation was not modelled in isolation of other contributing emission sources at Roberts Bank (i.e., realistic approach was taken by considering all sources of emissions from terminals at Roberts Bank).

Appendix IR4-04-B provides the requested tabulated summary of NO₂ concentrations (µg/m³) inclusive of background concentrations for 70 discrete receptors for the eight cases. **Table IR14-04-3** provides the appendix table reference for each of the specific requests.

Table IR14-04-3 Summary of Predicted 1-Hour and Annual Average NO₂ Emissions Contained in Appendix IR4-04-B

Appendix IR4-04-B Table Reference	Description of Tabulated Information
Table IR4-04-B1	Predicted 98 th percentile 1-hour NO ₂ concentrations for RBT2 construction alone (for average day)
Table IR4-04-B2	Predicted 98 th percentile 1-hour NO ₂ concentrations for RBT2 construction (for average day), and operations at Westshore Terminals, Deltaport, and BC Ferries Terminal
Table IR4-04-B3	Predicted 98 th percentile 1-hour NO ₂ concentrations for future conditions with RBT2 operation alone
Table IR4-04-B4	Predicted 98 th percentile 1-hour NO ₂ concentrations for future conditions with RBT2 operation and operations at Westshore Terminals, Deltaport, and BC Ferries Terminal
Table IR4-04-B5	Predicted annual average NO ₂ concentrations for RBT2 average day construction alone
Table IR4-04-B6	Predicted annual average NO ₂ concentrations for RBT2 average day construction, and operations at Westshore Terminals, Deltaport, and BC Ferries Terminal
Table IR4-04-B7	Predicted annual average NO ₂ concentrations for future conditions with RBT2 operation alone
Table IR4-04-B8	Predicted annual average NO ₂ concentrations for future conditions with RBT2 operation and operations at Westshore Terminals, Deltaport, and BC Ferries Terminal

As outlined in the response to IR14-03, the RBT2 Air Quality Study provided highly conservative predictions for NO₂, as a result of the use of hypothetical worst-case assumptions and double counting of terminal emissions with the addition of the 98th percentile background concentration. The dispersion modelling analysis assumed that the hypothetical worst-case emission scenario occurs in every hour of the year in order to capture the maximum potential hourly averaged NO₂ concentration. As such, the 98th percentile 1-hour average NO₂ concentration derived from the distribution of predicted values at any location does not provide a true measure of the actual expected NO₂ concentration that would result from real-world variations in emissions due to actual port operations. The use of the 98th percentile 1-hour average predicted NO₂ concentration further adds to the conservative overprediction of 1-hour average NO₂ concentrations noted in the responses to IR6-22 (CEAR Document #934) and IR14-03.

Discussion of Updated HHRA Results

The results of the Air Quality Human Health Risk Assessment (HHRA) presented in EIS Appendix 27-A have been updated to reflect the 1-hour (98th percentile) and annual NO₂ concentrations presented in **Appendix IR4-04-B**⁹ and the 2025 CAAQS for 1-hour NO₂ and annual NO₂. The HHRA results provided in the EIS, as well as results provided in the response to IR13-04 (CEAR Document #934) for updated contaminant criteria, have been revised in this response to consider the following CAAQS, which will come into effect in 2025:

- For the 1-hour averaging period, 79 µg/m³ has replaced the U.S. Environmental Protection Agency National Ambient Air Quality Standards of 188 µg/m³; and
- For the annual averaging period, 23 µg/m³ has replaced the World Health Organization guideline of 40 µg/m³.

As indicated above, the 2025 CAAQS were selected for future conditions with the Project (for both construction and operation phases) over the 2020 CAAQS since these standards are more stringent and reflect the current revised Project schedule outlined in the Figure 4-9 of the Project Construction Update (CEAR Document #1210).

For each of the updated exposure scenarios (Future without Project, Future with Project (operation), and Construction (average day)), the maximum predicted acute (1-hour averaging period) and chronic inhalation risk quotient (RQ) values are provided in **Table IR14-04-4** through **Table IR14-04-6**. RQs are provided for each discrete receptor type considered in the HHRA¹⁰. The location of the maximum NO₂ concentration predicted on land (among the 70 locations considered in response to IR13-02 (CEAR Document #934)) was also included in these tables. This location (R19) represents conditions at the East end of Roberts Bank Causeway¹¹. In addition, RQs are provided for the maximum point of impingement (MPOI), which is a location over water between the existing Westshore Terminal and the proposed RBT2 terminal.

The air concentrations provided in **Appendix IR4-04-B** and used to determine RQ values for the MPOI (over water), include ambient air concentrations measured on land (i.e., background concentrations). This differs from the HHRA approach described in Section 3.5 of EIS

⁹ The 1-hour NO₂ air concentrations provided in **Appendix IR14-04-A** and **Appendix IR14-04-B** are based on the B.C. MOE *Dispersion Modelling Guidance for 1-hour NO₂ and SO₂ Interim Ambient Air Quality Objectives*, which was released in April 2015, after completion of EIS Appendix 27-A in December 2014. The updated predicted concentrations for 1-hour NO₂ and SO₂ are presented in IR-7.31.15-19 (CEAR Document #314).

¹⁰ Receptor types include Tsawwassen First Nation, farmer, Canadian resident, U.S. resident, and recreationist.

⁸ Receptor R19 was incorrectly identified as a residential location in Tsawwassen in the response to IR13-02 (CEAR Document #934), and should have been classified as an 'other' receptor type.

Appendix 27-A, where chemical exposure over water was based on terminal-related emissions and land-based sources of chemical exposure were not considered.

Acute Exposure Risk

The recalculation of acute (1-hour averaging period) inhalation RQ values for NO₂ necessitated an update of the acute inhalation RQ values for the respiratory irritant group, which considers combined exposure to 1-hour concentrations of the following acute respiratory irritants: acetaldehyde, naphthalene, NO₂, and SO₂.

The use of CAAQS as exposure limits for NO₂ results in an increase in the predicted RQ values for NO₂ and the respiratory irritant group across the exposure scenarios. However, the relative contribution of the Project to 1-hour 98th percentile or annual average NO₂ concentrations in air does not change by updating the HHRA with the new CAAQS.

As previously described in the HHRA (Section 3.4.1, EIS Appendix 27-A), dispersion modelling assumptions were such that the acute air concentrations were more likely to be overestimated rather than underestimated. As outlined in the response to IR14-03, the maximum 1-hour average NO₂ concentrations *modelled* for Station T39 (R18) under existing conditions (including background) were approximately 1.9 to 2.5 times higher than the maximum 1-hour average NO₂ concentrations *measured* at Station T39 depending on the monitoring period being compared (i.e., mid 2010 to 2015).

RQ values above 1 indicate that the predicted exposure (i.e., air concentration) exceeds the inhalation exposure limit identified to assess potential human health risk, in this case the 2025 CAAQS for NO₂. For the assessment of health risks associated with acute inhalation exposure to NO₂, RQ values that are above 1 but at or below 2 are considered to be of low consequence to public health based on the approximately two-fold overestimation of the 1-hour NO₂ concentrations predicted by air dispersion modelling (as explained in the response to IR14-03). This is consistent with HHRA methodology as described in Section 5.3.1 in EIS Appendix 27-A.

Revised acute RQ values for NO₂ and respiratory irritants for the Future with Project (operation) and construction scenarios were essentially at or below 2 for all of the discrete receptor type considered in the HHRA (see **Tables IR14-04-4** and **IR14-04-5**). A RQ of 2 was exceeded in some cases at the maximum land based receptor at the east end of Roberts Bank Causeway adjacent to the Tsawwassen Container Examination Facility (R19) as well as at the MPOI (located over water between terminals), as discussed further below. The highest acute RQ value for NO₂ and respiratory irritants predicted for the Maximum Land Based Receptor and the MPOI are presented in **Tables IR14-04-4** and **IR14-04-5**, and these locations are shown in Figures IR14-04-A1 and IR14-04-A2 in **Appendix IR14-04-A**.

Acute NO₂ Exposure

RQs for acute NO₂ exposure are provided in **Table IR14-04-04**. The contribution of Project emissions to acute RQ values for each discrete receptor type considered in the HHRA was low; addition of the Project increased the Future without Project acute RQ values by 0.01 to 0.4.

For land-based receptors, a maximum acute RQ of 3.28 is predicted under the Future with Project scenario at R19, located at the east end of the Roberts Bank causeway, adjacent to the Tsawwassen Container Examination Facility. An acute RQ of 2.02 is predicted at this location for the Future without Project scenario. Further analyses were conducted to determine the frequency of occurrence of an NO₂ concentration at or above 158 µg/m³ at R19 (i.e., predicted acute RQ of 2 or more). An acute RQ of 2 or more was predicted to occur 5% of the year at this location at the end of the causeway.

The highest predicted 98th percentile 1-hour average NO₂ concentrations in air during Project operations or construction (160 µg/m³ or higher) will occur at the MPOI, where public access will be limited, as illustrated in **Figures IR14-04-A1** and **IR14-04-A2**. The predicted acute RQ values for NO₂ at the MPOI are 2.62 for the construction scenario and 3.50 for the Future with Project (operation) scenario.

The predicted acute inhalation RQ value for NO₂ at the MPOI marginally increased in the Future with Project scenario compared to the Future without Project scenario (i.e., RQ value increased by 0.07).

Acute Respiratory Irritant Exposure

RQs for acute exposure to respiratory irritants are provided in **Table IR14-04-5**. At the maximum land-based receptor (R19) a RQ of 3.39 is predicted during Project operation (Future with Project scenario). At the MPOI, slightly higher RQ values for respiratory irritants are predicted during operation (RQ = 3.74) and a RQ of 2.77 is predicted during construction.

In the Future with Project scenario, the predicted acute inhalation RQ value marginally increased at the MPOI for respiratory irritants compared to the Future without Project scenario (i.e., RQ value increase by 0.08).

Table IR14-04-4 Revised Acute Inhalation Risk Quotient Values – 1-hour Nitrogen Dioxide

Receptor (location of maximum RQ)	Maximum Estimated Risk Quotients (RQ)		
	Future without Project	Future with Project Operation	Construction
TFN ^a (R3)	1.52	1.86	1.61
Farmers (R4)	1.59	1.98	1.78 ^b
Canadian Residents (R18)	1.81	1.82	1.81
U.S. Residents (R11)	1.81	1.85	1.82
Recreationists (R16)	1.77	1.84	1.82
Maximum land-based location (R19)	2.02	3.28	1.95
MPOI ^c	3.43	3.50	2.62

Notes: a. TFN = Tsawwassen First Nation.

b. Location of maximum RQ changed to R5 under the construction scenario.

c. MPOI = Maximum Point of Impingement (for location see Figures IR14-04-A1 to IR14-04-A4 in **Appendix IR14-04-A**).

Table IR14-04-5 Revised Acute Inhalation Risk Quotient Values – Respiratory Irritants (1 hour)

Receptor (location of maximum RQ)	Maximum Estimated Risk Quotients (RQ)		
	Future without Project	Future with Project Operation	Construction
TFN ^a (R3)	1.60	1.95	1.69
Farmers (R4)	1.66	2.07	1.89 ^b
Canadian Residents (R18)	1.88	1.90	1.89
U.S. Residents (R11)	1.89	1.93	1.90
Recreationists (R16)	1.85	1.93	1.90
Maximum land-based location (R19)	2.12	3.39	2.05
MPOI ^c	3.67	3.74	2.77

Notes: Respiratory irritants include acetaldehyde, naphthalene, NO₂, and SO₂.

a. TFN = Tsawwassen First Nation.

b. Location of maximum RQ changed to R5 under the construction scenario.

c. MPOI = Maximum Point of Impingement (for location see Figures IR14-04-A1 to IR14-04-A4 in Appendix IR14-04-A).

Chronic Exposure Risk

All revised chronic (annual averaging period) RQ values for NO₂ were less than 1 at the HHRA discrete receptor locations (**Table IR14-04-6**), indicating that predicted annual air concentrations for NO₂ under future conditions (with and without the Project) and during construction were below the 2025 annual CAAQS at these locations, and potential health effects are predicted to be negligible.

A chronic RQ above 1 was predicted for annual NO₂ concentrations at the maximum land-based receptor location (R19) for the Future with Project scenario (chronic RQ=1.18), slightly higher than the chronic RQ for the Future without Project scenario (chronic RQ=0.87).

The chronic inhalation RQ values at the MPOI were the same for future with and without Project scenarios (i.e., chronic RQ = 2.80), indicating that Project emissions do not substantially contribute to annual NO₂ concentrations predicted at the MPOI. The highest RQ value for chronic exposure to NO₂ (i.e., chronic RQ = 4.17) was predicted at the MPOI during Project construction.

Table IR14-04-6 Revised Chronic Inhalation Risk Quotient Values – Annual Nitrogen Dioxide

Receptor (location of maximum RQ)	Maximum Estimated Risk Quotients (RQ)		
	Future without Project	Future with Project Operation	Construction
TFN ^a (R3)	0.61	0.63	0.64
Farmers (R5)	0.62	0.65	0.68
Canadian Residents (R9)	0.61	0.63	0.67
U.S. Residents (R11)	0.64	0.65	0.68
Maximum land-based receptor (R19)	0.87	1.18	0.96
MPOI ^b	2.80	2.80	4.17

Notes: a. TFN = Tsawwassen First Nation.

b. MPOI = Maximum Point of Impingement (for location see Figures IR14-04-A1 to IR14-04-A4 in **Appendix IR14-04-A**).

Summary

In summary, the acute RQ values predicted for NO₂ and respiratory irritants at the HHRA discrete receptor locations were considered to be of low consequence to public health since they were essentially at or below 2 and the air dispersion model was demonstrated to overestimate acute NO₂ concentrations by approximately two-fold. The contribution of Project emissions to acute RQ values at these receptor locations and at the MPOI was low (**Tables IR14-04-4** and **IR14-04-5**).

Based on the analysis using CAAQS in the calculation of RQs, risks for acute exposure to NO₂ and respiratory irritants are predicted to exceed health thresholds during operation at the maximum land-based receptor (R19) (i.e., acute RQ of 3.28 and 3.39, respectively). For acute exposure to NO₂, a RQ of 2 or more (to a maximum of 3.28) was predicted to occur 5% of the year at this location under the Future without Project scenario.

A RQ of 4.17 was determined for the MPOI based on chronic exposure to annual NO₂ concentrations predicted during construction. This RQ could be associated with moderate health risks should chronic exposure at the MPOI occur; however, exposure to the 1-hour and annual NO₂ concentrations predicted for the MPOI will be limited since this area will not be accessible to the public during Project construction or operation.

These conclusions are consistent with those originally provided in the air quality HHRA, which identified potential concern for adverse effects on human health from changes in air quality during Project construction (Section 6.0, EIS Appendix 27-A). Use of the CAAQS for the assessment of NO₂ resulted in higher RQ values across all scenarios; however, the contribution of Project operation or construction emissions to these RQ values did not change.

For all exposure scenarios, the NO₂ acute RQ value was the most significant contributor to the acute RQ value for respiratory irritants (~95%), as illustrated by the results presented in **Tables IR14-04-4** and **IR14-04-5**. Therefore, a reduction in exposure to 1-hour NO₂ air concentrations will also result in a substantial reduction in exposure to acute respiratory irritants.

The VFPA has committed to implementing specific measures to mitigate potential increases in air emissions during Project construction, and the measures for NO₂ will be outlined in an Air Quality and Dust Control Plan (for more information refer to EIS Section 33.3.3 and the responses to IR6-28 and IR13-30 of CEAR Document #934). The intent of implementing such mitigation measures is to reduce emissions and the potential for exposure to acute respiratory irritants during Project construction.

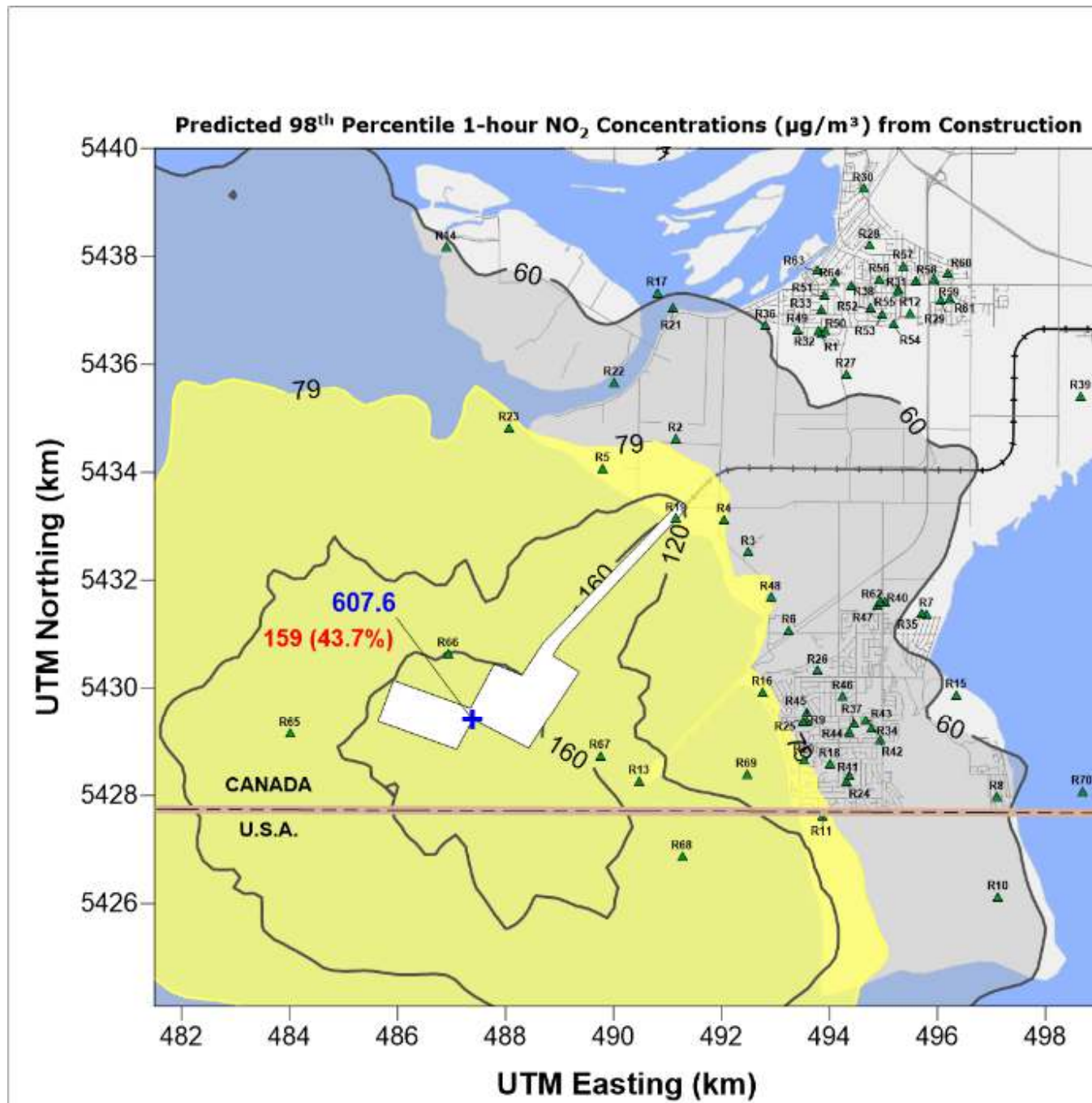
As indicated in the responses to IR6-28 and IR13-30 (CEAR Document #934), the VFPA will conduct air quality monitoring in accordance with the Construction Compliance Monitoring Plan, which will be informed by the requirements outlined in the Air Quality and Dust Control Plan. Should air quality observations reach trigger values, adaptive management measures will be implemented. Adaptive management measures will be specified in the Construction Compliance Monitoring Plan. To verify that applicable air quality criteria are being met during the operation phase, the VFPA has also committed to monitoring with Station T39, which has been shown to be representative of air quality levels for criteria air contaminants (i.e., CO, NO₂, SO₂, O₃, and PM_{2.5}) in overland areas at Roberts Bank as discussed in detail in response to IR6-37 (CEAR Document #934).

Appendices

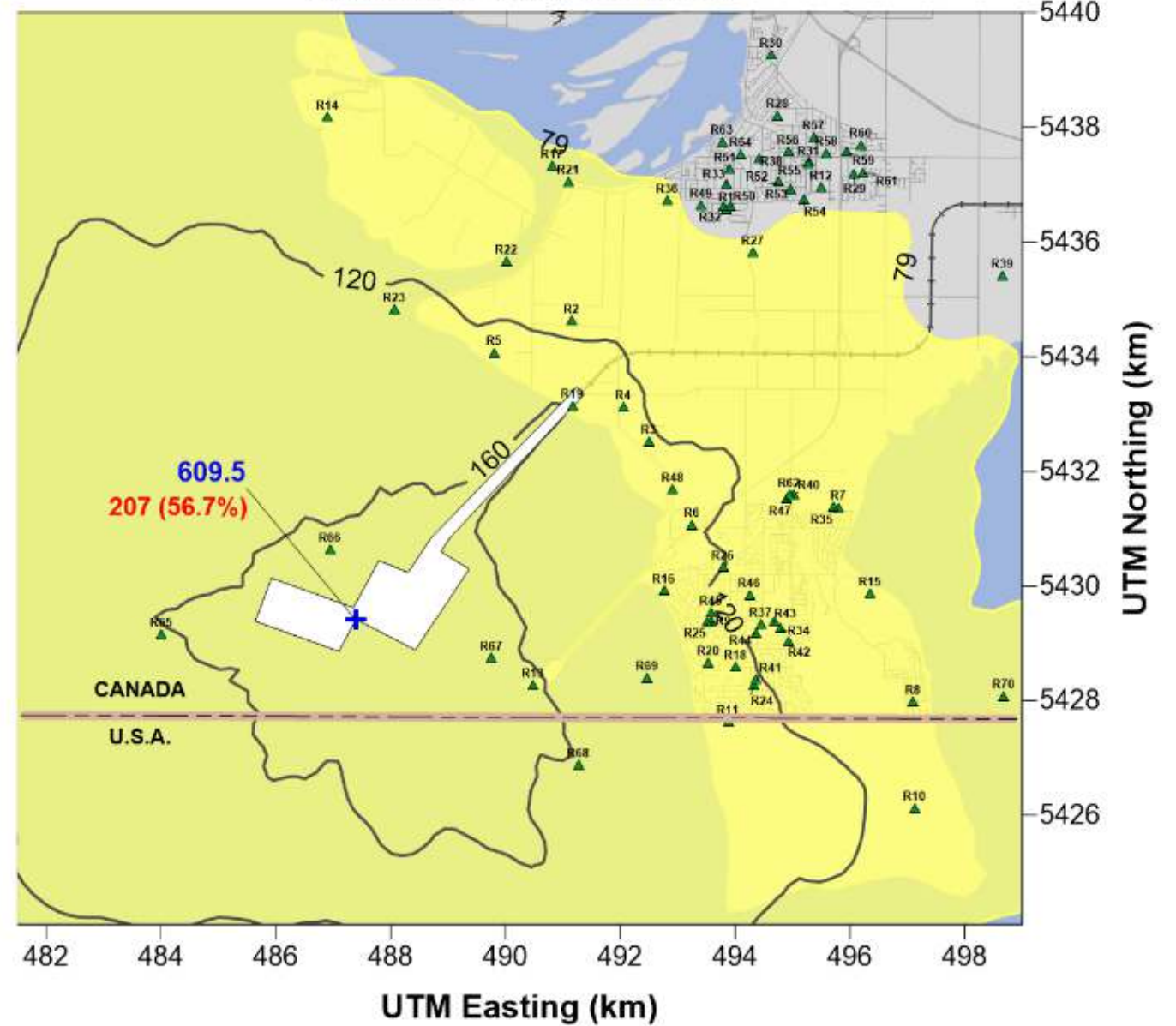
- Appendix IR4-04-A Figures – Predicted NO₂ Concentrations Inclusive of Background Concentrations
- Appendix IR4-04-B Tabulated Predicted NO₂ Concentrations Inclusive of Background Concentrations

APPENDIX IR4-04-A

FIGURES – PREDICTED NO₂ CONCENTRATIONS INCLUSIVE OF BACKGROUND CONCENTRATIONS

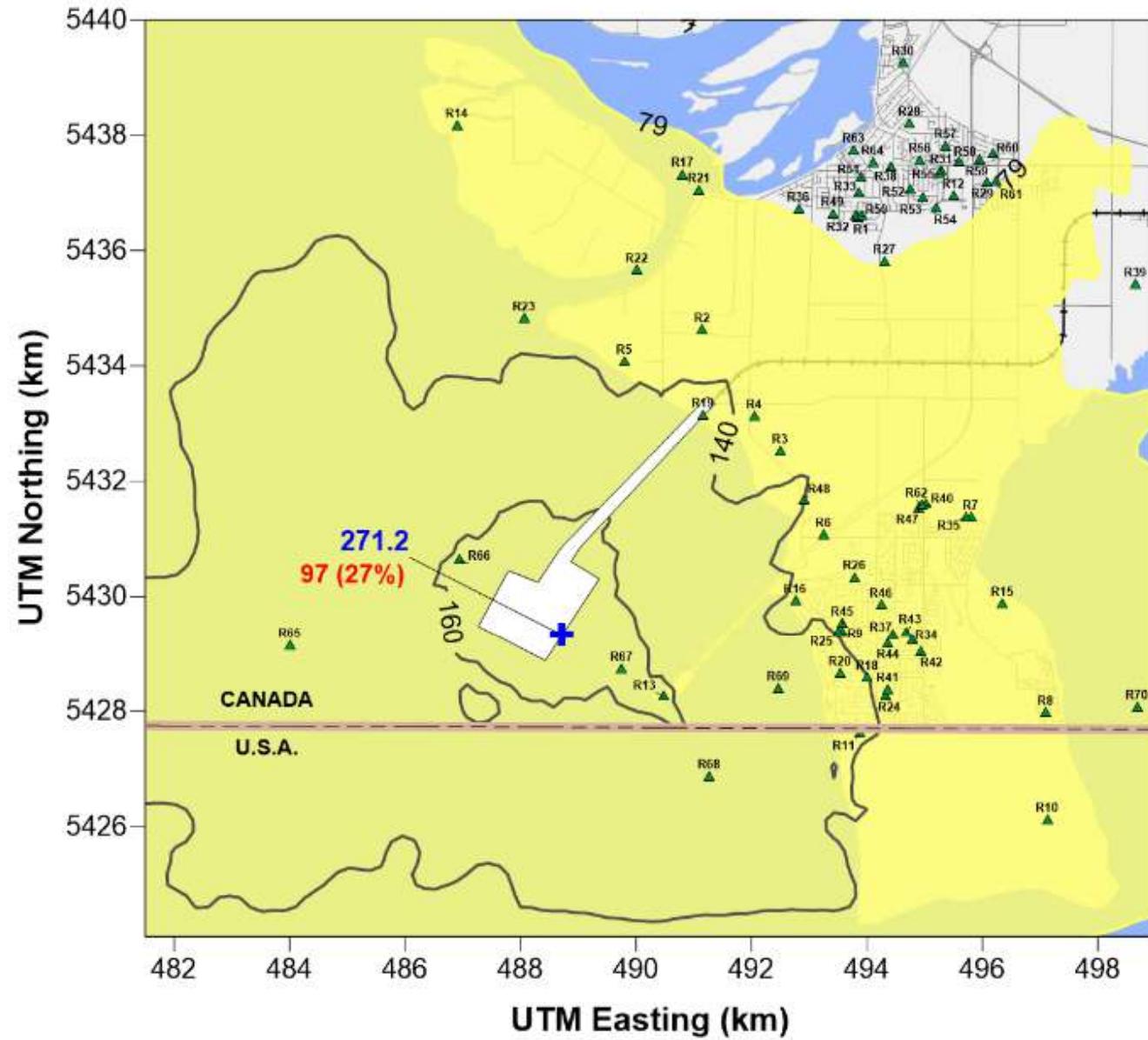


Predicted 98th Percentile 1-hour NO₂ Concentrations (µg/m³) from Construction & Operations at Westshore Terminals, Deltaport and B.C. Ferries Terminal (i.e. Expected Conditions scenario)

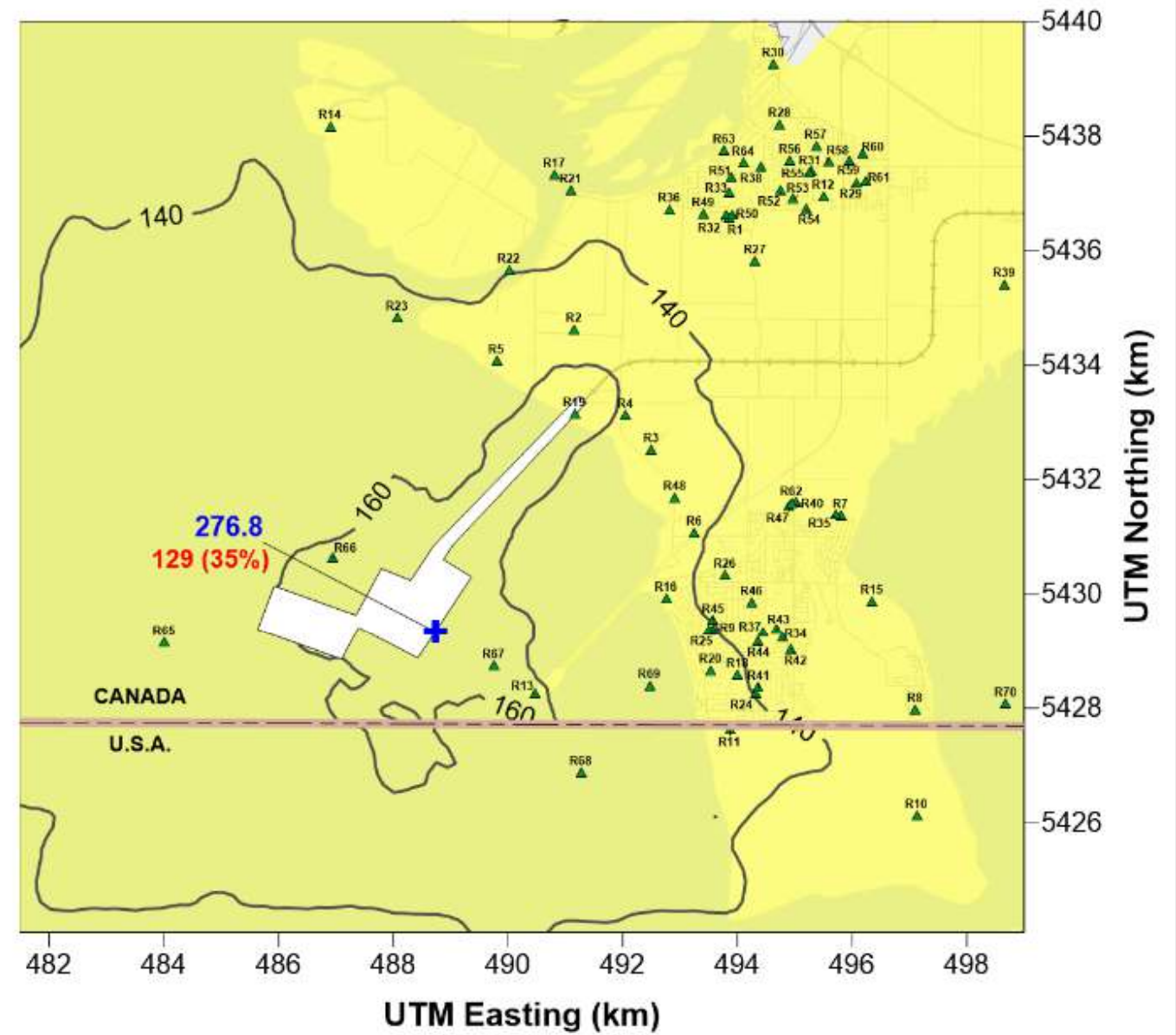


<p>Legend</p> <ul style="list-style-type: none"> □ PROJECT BLANKING BOUNDARY — ROADS — RAILWAYS — CONCENTRATION CONTOURS (µg/m³) — 2025 CAAQS (79 µg/m³) + LOCATION OF MAXIMUM CONCENTRATION (µg/m³) ▲ DISCRETE AIR QUALITY RECEPTOR LOCATIONS — U.S.A. - CANADA BORDER 		<p>Notes:</p> <p>Concentration contour levels include a background concentration of 44.7 µg/m³</p> <p>Frequency of exceedances shown in red as days per year (percentage)</p>		<p>0 2 4 Kilometres</p> <p>N</p> <p>PORT of vancouver</p>		<p>ROBERTS BANK TERMINAL 2</p> <p>CONSTRUCTION PHASE AVERAGE DAY SCENARIO - 98TH PERCENTILE 1-HOUR NO₂ CONCENTRATIONS (µg/m³)</p>	
<p>Sources: PMV, GeoGratis "CANVEC"</p>		<p>DATE: January 2019</p>		<p>FIG No. Revised IR14-04-A1</p>			

2025 EXPECTED CONDITIONS



2025 FUTURE CONDITIONS WITH PROJECT



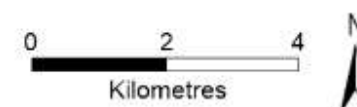
Legend

- PROJECT BLANKING BOUNDARY
- ROADS
- RAILWAYS
- CONCENTRATION CONTOURS ($\mu\text{g}/\text{m}^3$)
- 2025 CAAQS ($79 \mu\text{g}/\text{m}^3$)
- LOCATION OF MAXIMUM CONCENTRATION ($\mu\text{g}/\text{m}^3$)
- DISCRETE AIR QUALITY RECEPTOR LOCATIONS
- U.S.A. - CANADA BORDER

Notes:

Concentration contour levels include a background concentration of $44.7 \mu\text{g}/\text{m}^3$

Frequency of exceedances shown in red as days per year (percentage)



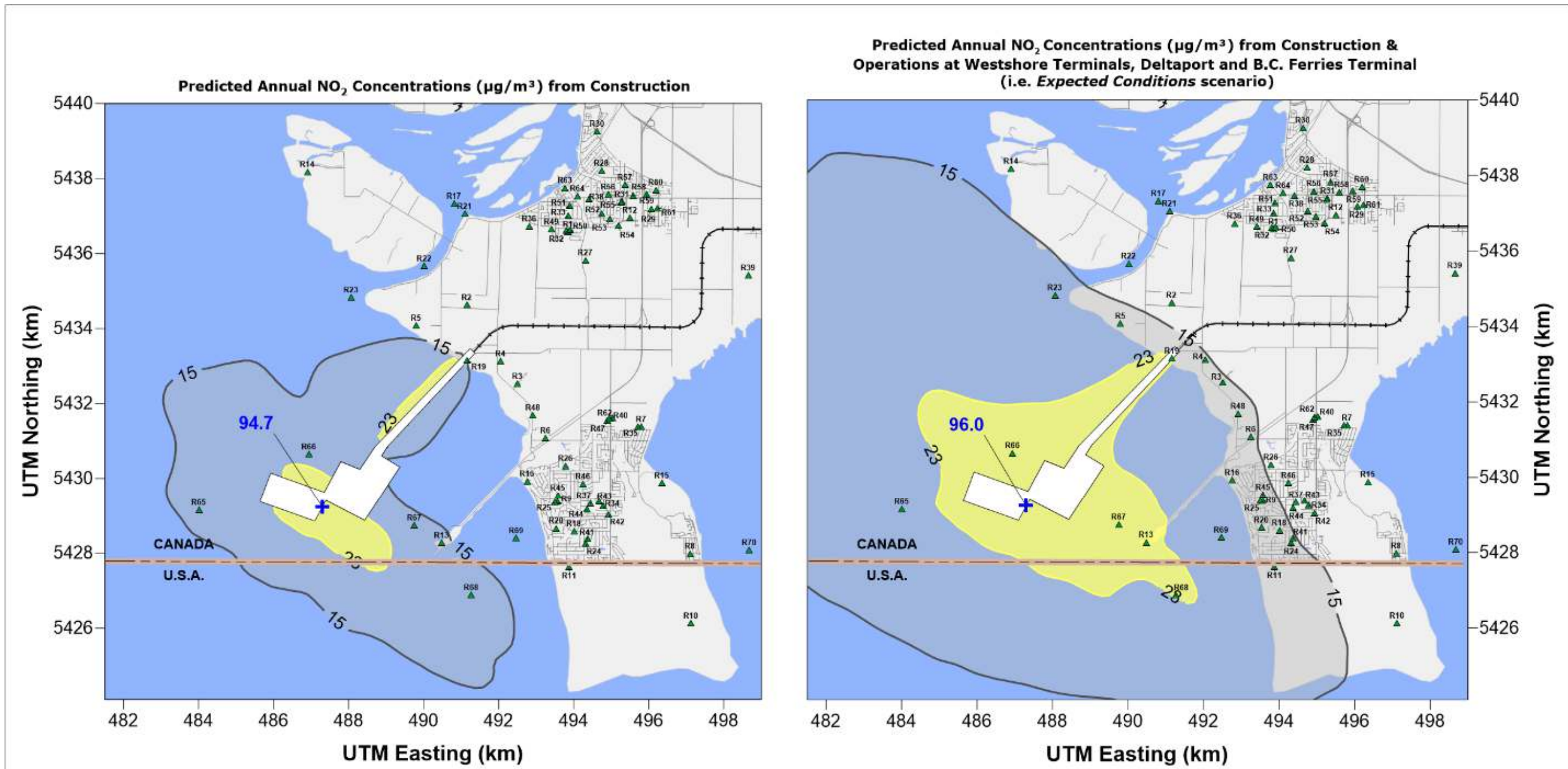
ROBERTS BANK TERMINAL 2

98TH PERCENTILE 1-HOUR NO₂ CONCENTRATIONS ($\mu\text{g}/\text{m}^3$)

DATE:
January 2019

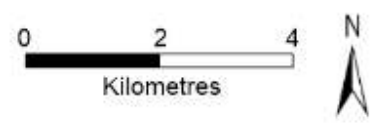
FIG No.
**Revised
IR14-04-A2**

Sources: PMV, GeoGratis "CANVEC"



- Legend**
- PROJECT BLANKING BOUNDARY
 - ROADS
 - RAILWAYS
 - CONCENTRATION CONTOURS (µg/m³)
 - 2025 CAAQS (23 µg/m³)
 - LOCATION OF MAXIMUM CONCENTRATION (µg/m³)
 - DISCRETE AIR QUALITY RECEPTOR LOCATIONS
 - U.S.A - CANADA BORDER

Notes:
 Concentration contour levels include a background concentration of 12.8 µg/m³



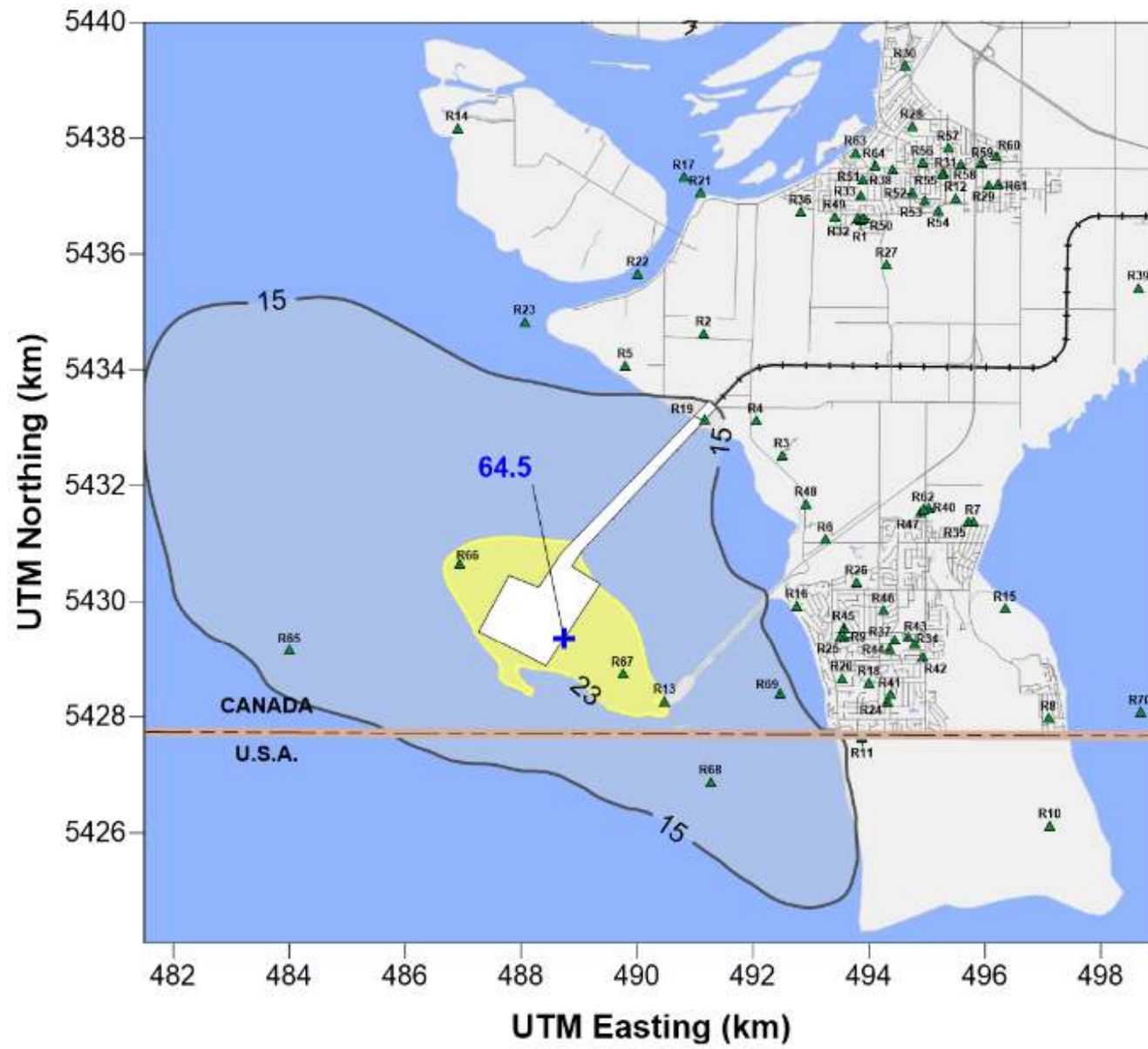
ROBERTS BANK TERMINAL 2

CONSTRUCTION PHASE AVERAGE DAY SCENARIO - ANNUAL AVERAGE NO₂ CONCENTRATIONS (µg/m³)

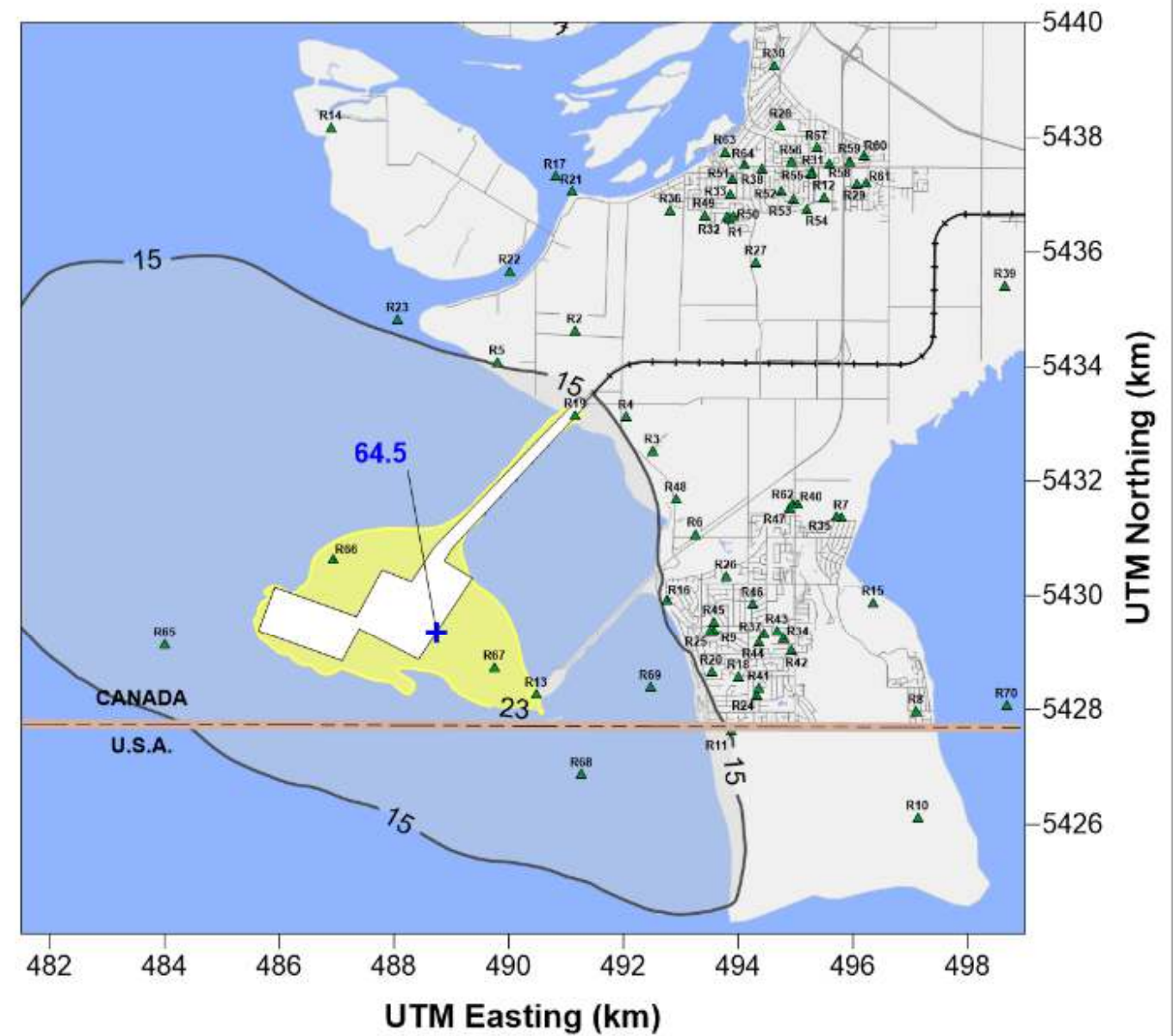
DATE: January 2019	FIG No.: Revision IR14-04-A3
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Sources: PMV, GeoGratis "CANVEC"

2025 EXPECTED CONDITIONS



2025 FUTURE CONDITIONS WITH PROJECT

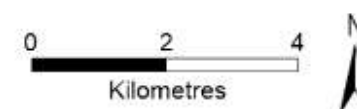


Legend

- PROJECT BLANKING BOUNDARY
- ROADS
- RAILWAYS
- CONCENTRATION CONTOURS ($\mu\text{g}/\text{m}^3$)
- 2025 CAAQS ($23 \mu\text{g}/\text{m}^3$)
- LOCATION OF MAXIMUM CONCENTRATION ($\mu\text{g}/\text{m}^3$)
- DISCRETE AIR QUALITY RECEPTOR LOCATIONS
- U.S.A. - CANADA BORDER

Notes:

Concentration contour levels include a background concentration of $12.8 \mu\text{g}/\text{m}^3$



ROBERTS BANK TERMINAL 2

ANNUAL AVERAGE NO₂ CONCENTRATIONS ($\mu\text{g}/\text{m}^3$)

DATE:
January 2019

FIG No. **Revised
IR14-04-A4**

Sources: PMV, GeoGratis "CANVEC"

APPENDIX IR4-04-B

TABULATED PREDICTED NO₂ CONCENTRATIONS INCLUSIVE OF BACKGROUND CONCENTRATIONS

Table IR4-04-B1 Predicted 98th Percentile 1-Hour NO₂ Concentrations for RBT2 Construction Alone (for Average Day)

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R1	Ladner	57.3
R2	Farmer 1	73.5
R3	Tsawwassen First Nation	74.5
R4	Farmer 2	81.1
R5	Farmer 3	90.2
R6	Tsawwassen Beach Campsite	71.4
R7	Beach Grove	58.5
R8	Boundary Bay	61.2
R9	Tsawwassen	71.4
R10	Point Roberts 1	63.6
R11	Point Roberts 2	86.0
R12	Delta Hospital	55.9
R13	B.C. Ferries Terminal	146.9
R14	Reifel Bird Sanctuary	61.3
R15	Boundary Bay GVRD Park	58.9
R16	English Bluffs Beach	81.7
R17	South Arm Marsh	59.3
R18	Air Quality Station T39	75.9
R19	East End of Roberts Bank Causeway	143.2
R20	English Bluff Elementary	82.3
R21	Boat launch at Wellington Point	61.2
R22	Canoe Passage	68.3
R23	Tidal area where hunting takes place	79.7
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	70.7
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	72.8
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	68.4
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	58.8
R28	Hawthorne Elementary / Ladner Animal Crackers	53.6
R29	Holly Elementary / Holly's Childcare Centre	55.9
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	52.9
R31	Delta Continuing Education	54.5
R32	Ladner Elementary	56.9
R33	Delta Secondary	56.2
R34	South Park Elementary	65.0
R35	Beach Grove Elementary	59.0

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R36	Port Guichon Elementary	59.3
R37	South Delta Secondary	64.8
R38	Delta Christian School	54.5
R39	Boundary Bay Montessori House	55.6
R40	Southpointe Academy	62.6
R41	Rainbow Bridges Enrichment Centre Day Care	71.4
R42	Wind and Tide Preschool	63.6
R43	Hicks Family Playcare	63.3
R44	Sunny Town Learn and Play Childcare Centre	66.4
R45	Shooting Stars Early Learning Centre	71.3
R46	Wee Bairns	66.8
R47	Kids in Paradise	63.5
R48	Smuyuq'wa' Lelum Ece Centre	77.4
R49	Lynne's Daycare	58.2
R50	Happy Castle Child Care	57.4
R51	Reach Development Preschool South Delta	55.3
R52	Wind and Tide Preschool	55.2
R53	Evan's Day Care	55.3
R54	Treasure-Chest Family Daycare	56.7
R55	Westcoast Wee Watch	54.6
R56	Creation Station Day Care	54.3
R57	Little Bunnies	53.9
R58	Mother Hen's Daycare	54.7
R59	The Yellow Door Daycare	54.9
R60	Tina's Tiny Tots Daycare	54.8
R61	Bright Eyes Academy Inc. at Holly	55.8
R62	Renaissance Kids	63.2
R63	Delta Medical Center	54.7
R64	Denning Health Group	54.6
R65	Recreational Fishing Area	151.8
R66	Boating Area	163.6
R67	Operations Closure	152.4
R68	Recreational Boating (U.S.A.)	150.4
R69	Marine Recreation Site	97.0
R70	Recreational Boating Route	56.7

Table IR4-04-B2 Predicted 98th Percentile 1-Hour NO₂ Concentrations for RBT2 Construction (for Average Day), and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R1	Ladner	76.4
R2	Farmer 1	108.1
R3	Tsawwassen First Nation	126.9
R4	Farmer 2	133.1
R5	Farmer 3	140.4
R6	Tsawwassen Beach Campsite	131.9
R7	Beach Grove	89.8
R8	Boundary Bay	96.9
R9	Tsawwassen	132.4
R10	Point Roberts 1	104.6
R11	Point Roberts 2	143.7
R12	Delta Hospital	75.1
R13	B.C. Ferries Terminal	171.3
R14	Reifel Bird Sanctuary	89.2
R15	Boundary Bay GVRD Park	90.5
R16	English Bluffs Beach	143.4
R17	South Arm Marsh	82.7
R18	Air Quality Station T39	143.0
R19	East End of Roberts Bank Causeway	154.4
R20	English Bluff Elementary	145.2
R21	Boat launch at Wellington Point	85.6
R22	Canoe Passage	99.5
R23	Tidal area where hunting takes place	131.0
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	120.9
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	134.3
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	120.4
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	78.7
R28	Hawthorne Elementary / Ladner Animal Crackers	70.6
R29	Holly Elementary / Holly's Childcare Centre	75.4
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	66.9
R31	Delta Continuing Education	70.6
R32	Ladner Elementary	75.9
R33	Delta Secondary	73.6

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R34	South Park Elementary	106.5
R35	Beach Grove Elementary	90.0
R36	Port Guichon Elementary	81.2
R37	South Delta Secondary	105.7
R38	Delta Christian School	72.0
R39	Boundary Bay Montessori House	75.6
R40	Southpointe Academy	97.4
R41	Rainbow Bridges Enrichment Centre Day Care	122.2
R42	Wind and Tide Preschool	100.1
R43	Hicks Family Playcare	103.0
R44	Sunny Town Learn and Play Childcare Centre	112.3
R45	Shooting Stars Early Learning Centre	132.2
R46	Wee Bairns	105.4
R47	Kids in Paradise	100.3
R48	Smuyuq'wa' Lelum Ece Centre	143.5
R49	Lynne's Daycare	76.4
R50	Happy Castle Child Care	76.2
R51	Reach Development Preschool South Delta	72.5
R52	Wind and Tide Preschool	74.1
R53	Evan's Day Care	75.1
R54	Treasure-Chest Family Daycare	77.7
R55	Westcoast Wee Watch	70.8
R56	Creation Station Day Care	70.6
R57	Little Bunnies	68.5
R58	Mother Hen's Daycare	70.2
R59	The Yellow Door Daycare	72.9
R60	Tina's Tiny Tots Daycare	74.1
R61	Bright Eyes Academy Inc. at Holly	75.0
R62	Renaissance Kids	98.9
R63	Delta Medical Center	70.3
R64	Denning Health Group	71.9
R65	Recreational Fishing Area	158.4
R66	Boating Area	173.7
R67	Operations Closure	164.2
R68	Recreational Boating (U.S.A.)	156.3
R69	Marine Recreation Site	145.6
R70	Recreational Boating Route	56.7

Table IR4-04-B3 Predicted 98th Percentile 1-Hour NO₂ Concentrations for Future Conditions with RBT2 Operation Alone

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R1	Ladner	65.5
R2	Farmer 1	88.9
R3	Tsawwassen First Nation	71.4
R4	Farmer 2	76.0
R5	Farmer 3	71.0
R6	Tsawwassen Beach Campsite	73.4
R7	Beach Grove	64.9
R8	Boundary Bay	61.9
R9	Tsawwassen	49.4
R10	Point Roberts 1	59.7
R11	Point Roberts 2	47.2
R12	Delta Hospital	67.7
R13	B.C. Ferries Terminal	44.7
R14	Reifel Bird Sanctuary	64.0
R15	Boundary Bay GVRD Park	58.1
R16	English Bluffs Beach	50.2
R17	South Arm Marsh	73.0
R18	Air Quality Station T39	45.3
R19	East End of Roberts Bank Causeway	144.2
R20	English Bluff Elementary	45.7
R21	Boat launch at Wellington Point	76.6
R22	Canoe Passage	88.7
R23	Tidal area where hunting takes place	67.2
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	57.6
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	48.8
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	60.6
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	78.7
R28	Hawthorne Elementary / Ladner Animal Crackers	62.4
R29	Holly Elementary / Holly's Childcare Centre	63.6
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	54.9
R31	Delta Continuing Education	63.8
R32	Ladner Elementary	67.2
R33	Delta Secondary	65.4
R34	South Park Elementary	52.0

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R35	Beach Grove Elementary	65.5
R36	Port Guichon Elementary	76.6
R37	South Delta Secondary	53.9
R38	Delta Christian School	57.3
R39	Boundary Bay Montessori House	58.1
R40	Southpointe Academy	65.2
R41	Rainbow Bridges Enrichment Centre Day Care	63.5
R42	Wind and Tide Preschool	62.6
R43	Hicks Family Playcare	55.9
R44	Sunny Town Learn and Play Childcare Centre	53.2
R45	Shooting Stars Early Learning Centre	55.5
R46	Wee Bairns	60.6
R47	Kids in Paradise	65.2
R48	Smuyuq'wa' Lelum Ece Centre	51.8
R49	Lynne's Daycare	75.0
R50	Happy Castle Child Care	68.6
R51	Reach Development Preschool South Delta	66.6
R52	Wind and Tide Preschool	66.8
R53	Evan's Day Care	68.6
R54	Treasure-Chest Family Daycare	67.9
R55	Westcoast Wee Watch	64.0
R56	Creation Station Day Care	66.3
R57	Little Bunnies	62.2
R58	Mother Hen's Daycare	62.8
R59	The Yellow Door Daycare	63.5
R60	Tina's Tiny Tots Daycare	60.8
R61	Bright Eyes Academy Inc. at Holly	61.8
R62	Renaissance Kids	64.7
R63	Delta Medical Center	61.3
R64	Denning Health Group	63.3
R65	Recreational Fishing Area	50.0
R66	Boating Area	47.0
R67	Operations Closure	46.1
R68	Recreational Boating (U.S.A.)	44.7
R69	Marine Recreation Site	45.8
R70	Recreational Boating Route	56.5

Table IR4-04-B4 Predicted 98th percentile 1-Hour NO₂ Concentrations for Future Conditions with RBT2 Operation and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R1	Ladner	97.8
R2	Farmer 1	149.0
R3	Tsawwassen First Nation	146.9
R4	Farmer 2	156.5
R5	Farmer 3	149.4
R6	Tsawwassen Beach Campsite	143.2
R7	Beach Grove	102.8
R8	Boundary Bay	120.3
R9	Tsawwassen	143.4
R10	Point Roberts 1	122.5
R11	Point Roberts 2	145.9
R12	Delta Hospital	97.3
R13	B.C. Ferries Terminal	171.3
R14	Reifel Bird Sanctuary	111.1
R15	Boundary Bay GVRD Park	101.9
R16	English Bluffs Beach	145.1
R17	South Arm Marsh	111.9
R18	Air Quality Station T39	143.5
R19	East End of Roberts Bank Causeway	259.0
R20	English Bluff Elementary	145.7
R21	Boat launch at Wellington Point	114.1
R22	Canoe Passage	139.1
R23	Tidal area where hunting takes place	143.9
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	143.2
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	144.0
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	121.7
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	113.7
R28	Hawthorne Elementary / Ladner Animal Crackers	86.3
R29	Holly Elementary / Holly's Childcare Centre	94.5
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	79.3
R31	Delta Continuing Education	93.2
R32	Ladner Elementary	99.9
R33	Delta Secondary	95.1

Discrete Receptor No.	Location Description	98 th Percentile 1-hour NO ₂
	CAAQS 2025 (ug/m ³)	79
	<i>Background Concentration (included in concentrations below)</i>	44.7
R34	South Park Elementary	113.3
R35	Beach Grove Elementary	103.6
R36	Port Guichon Elementary	110.8
R37	South Delta Secondary	123.0
R38	Delta Christian School	87.6
R39	Boundary Bay Montessori House	91.0
R40	Southpointe Academy	109.6
R41	Rainbow Bridges Enrichment Centre Day Care	141.7
R42	Wind and Tide Preschool	120.6
R43	Hicks Family Playcare	118.8
R44	Sunny Town Learn and Play Childcare Centre	126.7
R45	Shooting Stars Early Learning Centre	139.1
R46	Wee Bairns	116.4
R47	Kids in Paradise	111.5
R48	Smuyuq'wa' Lelum Ece Centre	147.0
R49	Lynne's Daycare	107.8
R50	Happy Castle Child Care	100.3
R51	Reach Development Preschool South Delta	94.0
R52	Wind and Tide Preschool	94.9
R53	Evan's Day Care	98.5
R54	Treasure-Chest Family Daycare	99.2
R55	Westcoast Wee Watch	93.5
R56	Creation Station Day Care	91.2
R57	Little Bunnies	88.4
R58	Mother Hen's Daycare	90.9
R59	The Yellow Door Daycare	91.3
R60	Tina's Tiny Tots Daycare	90.5
R61	Bright Eyes Academy Inc. at Holly	94.1
R62	Renaissance Kids	110.5
R63	Delta Medical Center	89.2
R64	Denning Health Group	90.6
R65	Recreational Fishing Area	151.8
R66	Boating Area	167.0
R67	Operations Closure	164.2
R68	Recreational Boating (U.S.A.)	150.2
R69	Marine Recreation Site	146.5
R70	Recreational Boating Route	108.0

Table IR4-04-B5 Predicted Annual Average NO₂ Concentrations for RBT2 Construction (for Average Day) Alone

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R1	Ladner	13.0
R2	Farmer 1	13.3
R3	Tsawwassen First Nation	13.5
R4	Farmer 2	13.5
R5	Farmer 3	14.1
R6	Tsawwassen Beach Campsite	13.5
R7	Beach Grove	13.1
R8	Boundary Bay	13.1
R9	Tsawwassen	13.4
R10	Point Roberts 1	13.1
R11	Point Roberts 2	13.7
R12	Delta Hospital	13.0
R13	B.C. Ferries Terminal	15.8
R14	Reifel Bird Sanctuary	13.2
R15	Boundary Bay GVRD Park	13.1
R16	English Bluffs Beach	13.7
R17	South Arm Marsh	13.0
R18	Air Quality Station T39	13.4
R19	East End of Roberts Bank Causeway	14.9
R20	English Bluff Elementary	13.6
R21	Boat launch at Wellington Point	13.0
R22	Canoe Passage	13.2
R23	Tidal area where hunting takes place	14.0
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	13.4
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	13.5
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	13.3
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	13.0
R28	Hawthorne Elementary / Ladner Animal Crackers	12.9
R29	Holly Elementary / Holly's Childcare Centre	12.9
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	12.9
R31	Delta Continuing Education	12.9
R32	Ladner Elementary	13.0
R33	Delta Secondary	13.0

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R34	South Park Elementary	13.2
R35	Beach Grove Elementary	13.1
R36	Port Guichon Elementary	13.0
R37	South Delta Secondary	13.2
R38	Delta Christian School	13.0
R39	Boundary Bay Montessori House	12.9
R40	Southpointe Academy	13.1
R41	Rainbow Bridges Enrichment Centre Day Care	13.3
R42	Wind and Tide Preschool	13.2
R43	Hicks Family Playcare	13.2
R44	Sunny Town Learn and Play Childcare Centre	13.3
R45	Shooting Stars Early Learning Centre	13.4
R46	Wee Bairns	13.3
R47	Kids in Paradise	13.1
R48	Smuyuq'wa' Lelum Ece Centre	13.6
R49	Lynne's Daycare	13.0
R50	Happy Castle Child Care	13.0
R51	Reach Development Preschool South Delta	13.0
R52	Wind and Tide Preschool	13.0
R53	Evan's Day Care	13.0
R54	Treasure-Chest Family Daycare	13.0
R55	Westcoast Wee Watch	12.9
R56	Creation Station Day Care	12.9
R57	Little Bunnies	12.9
R58	Mother Hen's Daycare	12.9
R59	The Yellow Door Daycare	12.9
R60	Tina's Tiny Tots Daycare	12.9
R61	Bright Eyes Academy Inc. at Holly	12.9
R62	Renaissance Kids	13.1
R63	Delta Medical Center	13.0
R64	Denning Health Group	13.0
R65	Recreational Fishing Area	15.5
R66	Boating Area	18.4
R67	Operations Closure	16.3
R68	Recreational Boating (U.S.A.)	16.1
R69	Marine Recreation Site	14.0
R70	Recreational Boating Route	13.0

Table IR4-04-B6 Predicted Annual Average Concentrations for RBT2 Construction (for Average Day), and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R1	Ladner	13.3
R2	Farmer 1	14.0
R3	Tsawwassen First Nation	14.7
R4	Farmer 2	14.7
R5	Farmer 3	15.5
R6	Tsawwassen Beach Campsite	14.6
R7	Beach Grove	13.6
R8	Boundary Bay	13.6
R9	Tsawwassen	14.8
R10	Point Roberts 1	13.8
R11	Point Roberts 2	15.5
R12	Delta Hospital	13.2
R13	B.C. Ferries Terminal	25.4
R14	Reifel Bird Sanctuary	13.9
R15	Boundary Bay GVRD Park	13.5
R16	English Bluffs Beach	15.4
R17	South Arm Marsh	13.4
R18	Air Quality Station T39	14.7
R19	East End of Roberts Bank Causeway	22.0
R20	English Bluff Elementary	15.3
R21	Boat launch at Wellington Point	13.5
R22	Canoe Passage	13.9
R23	Tidal area where hunting takes place	15.5
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	14.5
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	14.8
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	14.3
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	13.4
R28	Hawthorne Elementary / Ladner Animal Crackers	13.2
R29	Holly Elementary / Holly's Childcare Centre	13.2
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	13.1
R31	Delta Continuing Education	13.2
R32	Ladner Elementary	13.3

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R33	Delta Secondary	13.3
R34	South Park Elementary	13.9
R35	Beach Grove Elementary	13.6
R36	Port Guichon Elementary	13.4
R37	South Delta Secondary	14.1
R38	Delta Christian School	13.2
R39	Boundary Bay Montessori House	13.2
R40	Southpointe Academy	13.7
R41	Rainbow Bridges Enrichment Centre Day Care	14.4
R42	Wind and Tide Preschool	13.9
R43	Hicks Family Playcare	14.0
R44	Sunny Town Learn and Play Childcare Centre	14.2
R45	Shooting Stars Early Learning Centre	14.7
R46	Wee Bairns	14.1
R47	Kids in Paradise	13.8
R48	Smuyuq'wa' Lelum Ece Centre	15.0
R49	Lynne's Daycare	13.4
R50	Happy Castle Child Care	13.3
R51	Reach Development Preschool South Delta	13.3
R52	Wind and Tide Preschool	13.3
R53	Evan's Day Care	13.3
R54	Treasure-Chest Family Daycare	13.3
R55	Westcoast Wee Watch	13.2
R56	Creation Station Day Care	13.2
R57	Little Bunnies	13.2
R58	Mother Hen's Daycare	13.2
R59	The Yellow Door Daycare	13.2
R60	Tina's Tiny Tots Daycare	13.2
R61	Bright Eyes Academy Inc. at Holly	13.2
R62	Renaissance Kids	13.8
R63	Delta Medical Center	13.2
R64	Denning Health Group	13.2
R65	Recreational Fishing Area	18.3
R66	Boating Area	30.4
R67	Operations Closure	29.1
R68	Recreational Boating (U.S.A.)	20.6
R69	Marine Recreation Site	16.4

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R70	Recreational Boating Route	13.4

Table IR4-04-B7 Predicted Annual Average NO₂ Concentrations for Future Conditions with RBT2 Operation Alone

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R1	Ladner	12.9
R2	Farmer 1	13.1
R3	Tsawwassen First Nation	13.3
R4	Farmer 2	13.4
R5	Farmer 3	13.5
R6	Tsawwassen Beach Campsite	13.2
R7	Beach Grove	12.9
R8	Boundary Bay	12.9
R9	Tsawwassen	13.1
R10	Point Roberts 1	12.9
R11	Point Roberts 2	13.1
R12	Delta Hospital	12.9
R13	B.C. Ferries Terminal	13.3
R14	Reifel Bird Sanctuary	13.0
R15	Boundary Bay GVRD Park	12.9
R16	English Bluffs Beach	13.2
R17	South Arm Marsh	12.9
R18	Air Quality Station T39	13.0
R19	East End of Roberts Bank Causeway	20.0
R20	English Bluff Elementary	13.1
R21	Boat launch at Wellington Point	12.9
R22	Canoe Passage	13.0
R23	Tidal area where hunting takes place	13.3
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	13.0
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	13.1
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	13.1

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	12.9
R28	Hawthorne Elementary / Ladner Animal Crackers	12.9
R29	Holly Elementary / Holly's Childcare Centre	12.9
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	12.9
R31	Delta Continuing Education	12.9
R32	Ladner Elementary	12.9
R33	Delta Secondary	12.9
R34	South Park Elementary	13.0
R35	Beach Grove Elementary	12.9
R36	Port Guichon Elementary	12.9
R37	South Delta Secondary	13.0
R38	Delta Christian School	12.9
R39	Boundary Bay Montessori House	12.9
R40	Southpointe Academy	13.0
R41	Rainbow Bridges Enrichment Centre Day Care	13.0
R42	Wind and Tide Preschool	13.0
R43	Hicks Family Playcare	13.0
R44	Sunny Town Learn and Play Childcare Centre	13.0
R45	Shooting Stars Early Learning Centre	13.1
R46	Wee Bairns	13.0
R47	Kids in Paradise	13.0
R48	Smuyuq'wa' Lelum Ece Centre	13.3
R49	Lynne's Daycare	12.9
R50	Happy Castle Child Care	12.9
R51	Reach Development Preschool South Delta	12.9
R52	Wind and Tide Preschool	12.9
R53	Evan's Day Care	12.9
R54	Treasure-Chest Family Daycare	12.9
R55	Westcoast Wee Watch	12.9
R56	Creation Station Day Care	12.9
R57	Little Bunnies	12.9
R58	Mother Hen's Daycare	12.9
R59	The Yellow Door Daycare	12.9
R60	Tina's Tiny Tots Daycare	12.9
R61	Bright Eyes Academy Inc. at Holly	12.9
R62	Renaissance Kids	13.0
R63	Delta Medical Center	12.9

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R64	Denning Health Group	12.9
R65	Recreational Fishing Area	13.8
R66	Boating Area	12.7
R67	Operations Closure	13.3
R68	Recreational Boating (U.S.A.)	13.3
R69	Marine Recreation Site	13.2
R70	Recreational Boating Route	12.9

Table IR4-04-B8 Predicted Annual Average NO₂ Concentrations for Future Conditions with RBT2 Operation and Operations at Westshore Terminals, Deltaport, and BC Ferries Terminal

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R1	Ladner	13.2
R2	Farmer 1	13.8
R3	Tsawwassen First Nation	14.5
R4	Farmer 2	14.6
R5	Farmer 3	14.9
R6	Tsawwassen Beach Campsite	14.3
R7	Beach Grove	13.4
R8	Boundary Bay	13.5
R9	Tsawwassen	14.4
R10	Point Roberts 1	13.6
R11	Point Roberts 2	15.0
R12	Delta Hospital	13.2
R13	B.C. Ferries Terminal	22.9
R14	Reifel Bird Sanctuary	13.6
R15	Boundary Bay GVRD Park	13.4
R16	English Bluffs Beach	15.0
R17	South Arm Marsh	13.3
R18	Air Quality Station T39	14.3
R19	East End of Roberts Bank Causeway	27.1

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R20	English Bluff Elementary	14.8
R21	Boat launch at Wellington Point	13.3
R22	Canoe Passage	13.7
R23	Tidal area where hunting takes place	14.8
R24	Pebble Hill Traditional Elementary /The Rainbow Connection Children's Centre at Pebble Hill	14.2
R25	Ecole du Bois-Joli / Prematernelle Lutins Du Bois	14.5
R26	Cliff Drive Elementary /Aird's Kidzone Learning Centre/ Tsawwassen Little Friends Preschool	14.0
R27	Sacred Heart / Neverland Childrens Centre / Lil' Saints Preschool At Sacred Heart	13.3
R28	Hawthorne Elementary / Ladner Animal Crackers	13.1
R29	Holly Elementary / Holly's Childcare Centre	13.2
R30	Neilson Grove Elementary / Bright Eyes Academy Inc	13.1
R31	Delta Continuing Education	13.1
R32	Ladner Elementary	13.2
R33	Delta Secondary	13.2
R34	South Park Elementary	13.7
R35	Beach Grove Elementary	13.4
R36	Port Guichon Elementary	13.3
R37	South Delta Secondary	13.8
R38	Delta Christian School	13.2
R39	Boundary Bay Montessori House	13.1
R40	Southpointe Academy	13.6
R41	Rainbow Bridges Enrichment Centre Day Care	14.1
R42	Wind and Tide Preschool	13.7
R43	Hicks Family Playcare	13.7
R44	Sunny Town Learn and Play Childcare Centre	13.9
R45	Shooting Stars Early Learning Centre	14.3
R46	Wee Bairns	13.9
R47	Kids in Paradise	13.6
R48	Smuyuq'wa' Lelum Ece Centre	14.7
R49	Lynne's Daycare	13.3
R50	Happy Castle Child Care	13.2
R51	Reach Development Preschool South Delta	13.2
R52	Wind and Tide Preschool	13.2
R53	Evan's Day Care	13.2
R54	Treasure-Chest Family Daycare	13.2
R55	Westcoast Wee Watch	13.1
R56	Creation Station Day Care	13.1

Discrete Receptor No.	Location Description	Annual Average NO ₂
	CAAQS 2025 (ug/m ³)	23
	<i>Background Concentration (included in concentrations below)</i>	12.8
R57	Little Bunnies	13.1
R58	Mother Hen's Daycare	13.1
R59	The Yellow Door Daycare	13.1
R60	Tina's Tiny Tots Daycare	13.1
R61	Bright Eyes Academy Inc. at Holly	13.1
R62	Renaissance Kids	13.6
R63	Delta Medical Center	13.2
R64	Denning Health Group	13.2
R65	Recreational Fishing Area	16.5
R66	Boating Area	24.7
R67	Operations Closure	26.1
R68	Recreational Boating (U.S.A.)	17.8
R69	Marine Recreation Site	15.6
R70	Recreational Boating Route	13.3

IR14-05 Human Health – Worst-Case Scenario for Noise Human Health Risk Assessment

Information Source(s)

TDR: Effects of Meteorological Conditions on Sound Propagation from Roberts Bank Terminals (CEAR Doc#986)

Proponent Response to IR7-01 (CEAR Doc#1104)

Proponent Response to IR12-05 (CEAR Doc#1333)

Proponent Response to IR12-07 (CEAR Doc#1355)

Project Construction Update (CEAR Doc#1210)

EIS Volume 4: Revised EIS Section 27 (CEAR Doc#412; Table 27-2)

Context

As described in CEAR Doc#986, the following four conditions contribute to enhanced propagation of noise:

- temperature inversion;
- low-level jets;
- downwind propagation;
- noise propagation over water.

Should these four conditions occur simultaneously, they would represent worst-case conditions for the propagation of noise.

In response to information request IR7-01, the Proponent provided an assessment of the worst-case noise levels that could occur as a result of these four conditions using CONCAWE category 6 meteorology. In information request IR12-05 and IR12-07, the Proponent was asked to apply the same approach to a revised human health risk assessment (HHRA). In response, the Proponent provided a rationale for why it did not undertake the analysis. Further, the Proponent did not integrate the output from CONCAWE as presented in the response to IR7-01 into the revised HHRA.

In the response to IR12-05, the Proponent indicated that a sufficient degree of conservatism was already applied through the noise modelling approach, methods, and assumptions. However, the majority of reasons for conservatism described in the response to IR12-05 apply to the prediction of noise emissions at source, and do not apply to the propagation of noise from source to receptor as influenced by specific meteorological conditions. The Proponent also indicated that modelling sound propagation under meteorological conditions that represent worst-case or conservative scenarios in terms of sound propagation would be

appropriate if detailed meteorological data, representing annual average conditions, were not available.

The Proponent further indicated that in the case of the Project, a historical wind-rose was available, which allowed for the calculation of noise levels that reflected annual-average meteorological conditions. However, wind-rose data only accounts for wind direction, and does not account for temperature inversion and low-level jets and therefore is not sufficient to represent detailed meteorological data.

An assessment of noise levels due to the Project using CONCAWE category 6 meteorology and that integrates the results of the Project construction update is required. In addition, these results should be brought forward and used to present a revised HHRA.

Information Request

Provide a revised noise assessment using the CONCAWE category 6 meteorology that integrates the changes to noise emissions as described by the Project construction update.

Provide tables similar to that of Table IR7-01-6, that describe Ld and Ln during construction and operation at sites 3, 4, 5 and low-frequency noise at sites 6 and 7. The table should provide a comparison of the original EIS predictions, the CONCAWE results as described in IR7-01, and the results integrating the CONCAWE output and that of the Project construction update.

Provide a revised HHRA that includes the following:

- Noise levels under existing conditions, expected conditions, future with the Project, and cumulative effects;
- Noise levels during construction and operation;
- Noise levels at sites 4, 5, and 6 in the upland study area and low-frequency noise levels at 4, 5, 6 and 7;
- An assessment of potential effects of noise on human health using the same indicators that were presented in Table 27-2 of Section 27 of the EIS (CEAR Doc#412) and as requested in IR12-07;
- Tables for each indicator that compare existing conditions, expected conditions, future with the Project and cumulative effects with the applicable human health standards requested in IR12-07;
- A discussion of the results;
- A description of relevant mitigation measures for all phases of the Project; and
- A characterization of any residual effects and their significance, as well as a characterization of any cumulative effects and their significance.

VFPA Response

An analysis of predicted noise levels using CONCAWE meteorological category 6 is provided in this response, along with a comparison to levels provided in the EIS and Project Construction Update (PCU; CEAR Document #1210¹). An updated human health risk assessment (HHRA) is not provided, as noise model results that apply CONCAWE meteorology

¹ CEAR Document #1210 From the Vancouver Fraser Port Authority to the Review Panel re: Project Construction Update (See Reference Document #995) (NOTE: Updated June 13, 2018).

only consider a single weather condition (i.e., category 6), and does not represent a 'high-normal' exposure that would occur over the course of a year. For this reason, CONCAWE worst case meteorology is not considered a valid methodology for use in HHRA for health indicators that rely on annual average noise level predictions.

This response is structured in three sections:

- Part 1 – Clarification of several aspects of sound propagation, particularly from previous responses to IR7-01 and IR12-05 (CEAR Document #934²), to ensure clarity regarding the degree of confidence in the propagation methods;
- Part 2 – Operation and construction phase noise prediction using CONCAWE meteorology; and
- Part 3 – Discussion of implications for the HHRA.

Part 1 – Clarification

ISO 9613 Treatment of Meteorology

The ISO 9613 noise propagation standard used for the noise assessment in Appendix 9.3-A of the EIS includes meteorology in the attenuation equations developed for the standard. ISO9613-2 specifically states the conditions valid for this method are the following:

- *"Wind direction within an angle of 45% of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with wind blowing from the source to the receiver, and*
- *Wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3m to 11m above the ground."* (ISO 1996)

In addition, ISO 9613 specifically states:

"These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights."

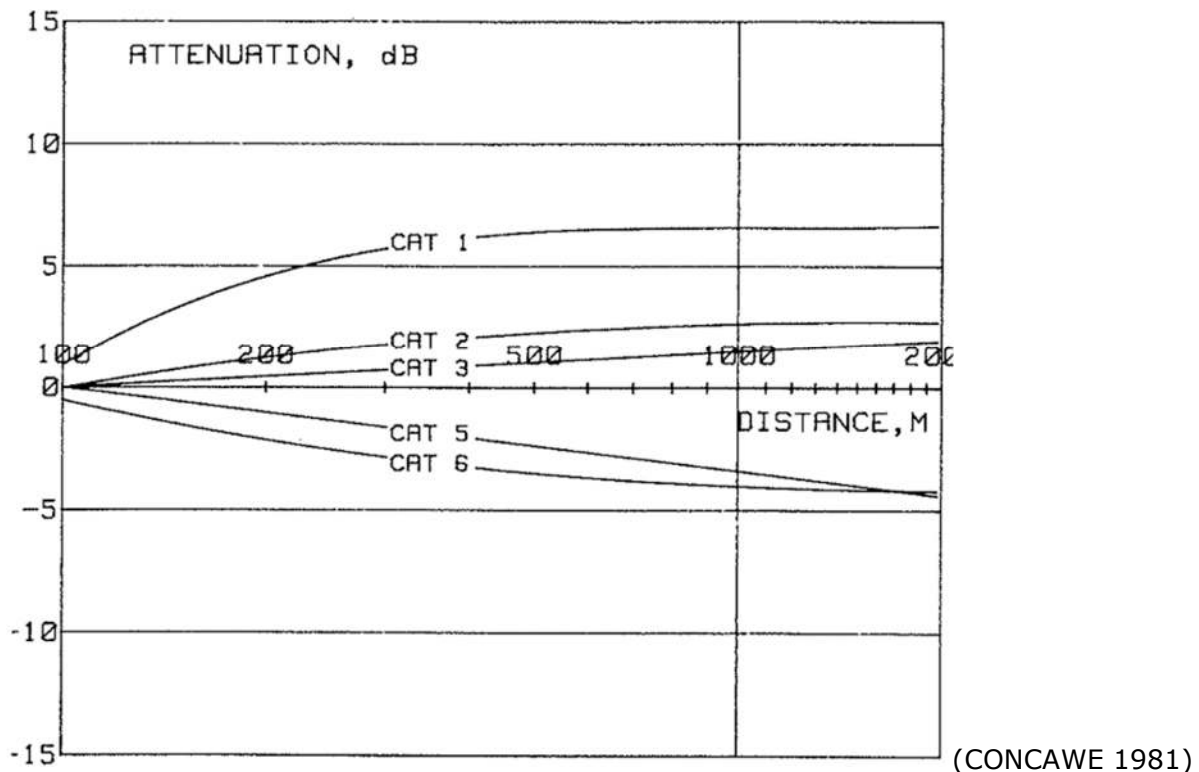
Meteorology effects on propagation are inherent in all propagation factors listed in the ISO 9613 standard (ISO 1996), such as atmospheric absorption and ground attenuation. The implementation of the standard in the CadnaA model results in every source to receptor calculation being considered downwind, under moderate inversion conditions. The application of annual average wind directions in the model only adjusts the overall result for an annual average condition suitable for long-term health risk assessment and does not remove the effects of inversion inherent in the base propagation equations.

² CEAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (NOTE: Updated November 30, 2018).

Therefore, the conservatism described in the responses to IR7-01 and IR12-05 (CEAR Document #934) does apply to the propagation of noise from source to receptor as influenced by specific meteorological conditions. The meteorology and conservatism in the ISO 9613 standard applies to propagation, and to sound sources determined using sound levels measured at distance.

The equivalent condition from the CONCAWE method to match ISO meteorology is category 5, based on the range of valid wind speeds and moderate inversion conditions. At farther distances from sound sources, the CONCAWE meteorological attenuation curves for category 5 and 6 converge, particularly at the lower frequencies. Low frequencies travel farther than mid to high frequencies (influenced most by atmospheric absorption), and dominate sound predictions at distances over 1000 m. When source to receptor distances are considered, category 5 meteorology becomes equivalent to category 6 from a propagation perspective. This is demonstrated in the following figure from the CONCAWE study.

Figure 3: Meteorological Attenuation Curves - 125 Hz
 (Experimental Data not available for Category 1)



At farther distances, both CONCAWE category 5 and category 6 are the worst case for noise due to the dominance of lower frequencies beyond 1 km distance. Noise sensitive receptors in the EIS are all farther than 2 km from the terminal site (i.e., where category 5 and 6 attenuation curves converge).

In the CONCAWE method, meteorology is applied separately for specific stability class (i.e., wind speed) and singular wind directions. Only a single meteorological condition over land can be considered in a calculation, which is not appropriate when evaluating noise levels that

fluctuate daily or even hourly based on prevailing meteorological conditions. In addition to limiting the assessment of annual sound levels to one meteorological condition, the study identified a separate meteorological attenuation to be used for propagation over water (as described in more detail in IR12-05 of CEAR Document #934). These limitations are expected to be a contributing factor in the degree of inconsistency in CONCAWE results identified in the Deltaport Terminal, Road and Rail Improvement Project study of the reliability of CONCAWE predictions (BKL 2012). As the ISO 9613 standard has meteorology considered in all other attenuation parameters, it is better suited to determining long term sound levels.

This analysis, therefore, supports the use of ISO 9613 as the appropriate method for assessing annual average sound levels, required to appropriately assess health risk in the HHRA:

- ISO 9613 meteorology is representative of CONCAWE category 5;
- The convergence of CONCAWE meteorological attenuation for category 5 and 6 at distances past 1,500 m indicates that assessment using category 5 meteorology is appropriate; and
- CONCAWE methods limit results to a single meteorological condition rather than an annual average.

Context of Noise Results Provided in IR7-01

An analysis of CONCAWE-based meteorology and associated noise predictions for Project operation and construction were provided in IR7-01 (CEAR Document #934). The analysis illustrated the differences in sound propagation when the meteorological correction factor was modelled on an annual average basis with the LfU Bayern method used in the EIS (LfU-Bayern 1999) versus a 'worst-case' meteorological condition with CONCAWE meteorology category 6. The IR7-01 analysis was intended to provide an indication of the potential variability in sound level outputs when comparing annualized long term exposure inputs (i.e., ISO 9613) and short term single meteorological condition inputs (i.e., CONCAWE category 6).

The calculations completed for IR7-01 (CEAR Document #934) assumed that during category 6 meteorology, each receptor was downwind of the Project, with sea breezes occurring 100% of the time, including at night. As identified in IR7-01, this requires sea breezes to be present and strong enough to suppress a land breeze. Sea breezes are a daytime occurrence and occur 10% of the time. Thus, assuming sea breezes occur all the time, including at night, is not a realistic assumption for worst-case nighttime sound propagation. Category 6 meteorology may occur at night, in stable atmospheric conditions with cloud cover and calm winds. Combined (with or without sea breezes), category 6 conditions occur approximately 20% of the time, which is not representative of long-term exposures.

A worst-case estimate of sound propagation using the CONCAWE method cannot be made based on simply changing meteorological model inputs. The nature of how sound propagates over distance and how the sound sources were established in the EIS are strongly linked with meteorology in a non-linear relationship. The results in IR7-01 (CEAR Document #934) are not representative of an environmental acoustic condition that may actually occur, because of the following:

- The analysis assumed use of the category 6 meteorological condition for prediction of annual average noise levels, which means that a condition that occurs 20% of the time was assumed to occur 100% of the time; and
- The analysis was conducted using sound source emission levels established using ISO meteorology.

As IR7-01 (CEAR Document #934) was a high-level comparison of different approaches to accounting for meteorological effects in noise modelling, the sound sources for the analysis were taken directly from the EIS. To fully consider use of CONCAWE meteorology for assessment of sound from the Project, the operation phase sound sources need to be re-established also using CONCAWE meteorology. This re-calibration exercise is outlined in Part 2 of this response. Construction sources were based on near-field measurement data where meteorology was not a factor, and source re-calibration was not applicable.

Part 2 – Operation and Construction Phase Noise Prediction Using CONCAWE Meteorology

Operation Phase

Model Calibration Approach

The following approach was used to re-calculate noise levels during the four temporal scenarios, including the future with Project operation, using CONCAWE meteorology as follows:

- The Deltaport Terminal sound source was re-established in the existing conditions model using the CONCAWE equivalent meteorological conditions as they occurred on the measurement dates, including stability classes and wind direction for the relevant time periods;
- The RBT2 marine terminal sound source was similarly re-established based on the revised Deltaport Terminal sound source;
- The implementation of CONCAWE in predictive models, including the CadnaA software, requires assignment of both stability class and wind direction for category 6 conditions. The CadnaA implementation of CONCAWE only calculates a single wind direction at a time, giving a singular case. The CONCAWE meteorological consideration does not allow for the spatial distribution of sound sources in multiple directions from a receptor such as the Project, local roads, and rail. Therefore category 6 meteorology was established in the model by using wind vectors that pointed from the RBT2 marine terminal to each of the three receptors in the model. As such, it was necessary to establish a different wind vector for each of sites 3, 4, and 5 in order to represent category 6 meteorological conditions; and
- Operations related low-frequency noise (LFN) at sites 6 and 7 were based on measurement data alone, and not model outputs. CONCAWE meteorology can only be applied to modelled values.

As noted in Section 2.3.3.5 of EIS Appendix 9.3-A, noise data collected during July 2013 were used to calibrate the Deltaport Terminal area source and rail activity sources in the existing conditions noise model. The resulting sound emission of the existing Deltaport Terminal

source was subsequently used as the basis for calculating sound power level of the future RBT2 marine terminal (see Section 2.3.3.7 of EIS Appendix 9.3-A). To establish the sound power level (L_w) of the existing Deltaport Terminal source, the L_w was adjusted until the model calculated L_n at site 5 matched the measured average nighttime L_{90} ³ of 42.4 dBA at site 5. This calibration is based on the conservative assumption that the nighttime background noise level at site 5 was dominated by noise from the Deltaport Terminal.

When calibrating the model noise sources, daytime and nighttime meteorological data that reflected conditions during the July 2013 measurements were input to the model. **Table IR14-05-1** and **Table IR14-05-2** present the results of the model calibration with meteorology considered according to the EIS approach (i.e., LfU Bayern) and CONCAWE, respectively. **Table IR14-05-3** compares the L_{dn} in **Table IR14-05-1** and **Table IR14-05-2** to the L_{dn} measured in July 2013.

Table IR14-05-1 Model Calibration – EIS Approach (Table 3-12 of EIS Appendix 9.3-A)

Site	Modelled Noise Level (dBA)		July 2013 Measured Noise Level (dBA)	
	Noise Sources Active in Model		Avg. Nighttime L_{90}	L_{dn}
	Deltaport Terminal	All Source		
	L_n	L_{dn}		
3	38.4	55.6	41.7	55.7
4	41.7	52.5	42.5	52.7
5	42.4	54.2	42.4	53.4

Table IR14-05-2 Existing Conditions Model Calibration – CONCAWE

Site	Modelled Noise Level (dBA)		July 2013 Measured Noise Level (dBA)	
	Noise Sources Active in Model		Avg. Nighttime L_{90}	L_{dn}
	Deltaport Terminal	All Source		
	L_n	L_{dn}		
3	35.8	55.6	41.7	55.7
4	40.2	52.1	42.5	52.7
5	42.4	54.1	42.4	53.4

³ The ninety percent exceedance level (L_{90}) is the noise level that is exceeded for 90% of the time during a given time interval. The L_{90} is often considered to be reflective of the background noise level.

Table IR14-05-3 Comparison of Model Calibration Results – EIS Approach versus CONCAWE

Site	L _{dn} (dBA)			L _{dn} Comparison (dBA)	
	Modelled – EIS Calibration	Modelled – CONCAWE Calibration	Measured – July 2013	Modelled – EIS Calibration	Modelled – CONCAWE Calibration
3	55.6	55.6	55.7	-0.1	-0.1
4	52.5	52.1	52.7	-0.2	-0.6
5	54.2	54.1	53.4	0.8	0.7

Table IR14-05-3 shows that there is very little difference between the noise levels predicted by the two calibrated noise models. This equivalency results because the model is made to fit the measurements to establish the sound emission of the Deltaport Terminal and rail sources. The sound power levels (L_w) of the Deltaport Terminal sources have the following magnitudes in the two models:

- EIS Model $L_w = 133.8$ dBA
- CONCAWE Model $L_w = 128.8$ dBA

The CONCAWE approach to accounting for meteorology tends to assume less attenuation of noise levels than the LfU Bayern approach used in the EIS. Consequently, the CONCAWE meteorology resulted in a lower L_w for the Deltaport Terminal noise source to obtain agreement between the modelled and measured noise levels.

Continuous Noise Levels (L_d , L_n , L_{dn})

Using the re-calibrated noise model, CONCAWE category 6 meteorology was applied to the existing, expected, future conditions with Project operation, and future conditions with Project operation and other certain and reasonably foreseeable projects. The sound sources of the future Deltaport Terminal and RTB2 marine terminal were also updated to reflect the CONCAWE-calibrated model sound sources (i.e., reduced by 5 dBA). The results in **Tables IR14-05-4, IR14-05-5, and IR14-05-6** all show that the worst-case conditions that may occur using full CONCAWE analysis is at most 1.4 dBA higher than the EIS analysis.

The fact that a worst case meteorological condition that occurs 20% of the time, when assumed to occur 100% of the time, only results in a maximum 1.4 dBA difference provides strong support that the EIS results are appropriately conservative for evaluating potential health effects associated with annual (long-term) noise exposure. A one-decibel difference between 'worst case' meteorology through CONCAWE and the annual average levels based on the EIS approach is not considered substantial as Type 1 sound level meters used for environmental measurements are only accurate to ± 1 dBA. In addition, noise in the natural environment can vary by more than 10 dBA between 15 minute measurements at any time of day or night (Appendix B of EIS Appendix 9.3-A).

Table IR14-05-4 Noise Levels with Re-calibrated Sources and CONCAWE Meteorology Category 6 – Existing Conditions

Site	Noise Level (dBA) EIS Model			Noise Level (dBA) CONCAWE Model			Noise Level Diff. (dBA) CONCAWE vs. EIS		
	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}
3	50.2	50.3	56.7	50.5	51.7	58.0	0.3	1.4	1.3
4	47.9	43.5	50.9	48.2	44.9	51.9	0.3	1.4	1.0
5	52.0	47.8	55.1	52.4	48.9	56.0	0.4	1.1	0.9

Table IR14-05-5 Noise Levels with Re-calibrated Sources and CONCAWE Meteorology Category 6 - Expected Conditions

Site	Noise Level (dBA) EIS Model			Noise Level (dBA) CONCAWE Model			Noise Level Diff. (dBA) CONCAWE vs. EIS		
	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}
3	51.9	51.5	58.0	52.1	52.8	59.1	0.2	1.3	1.1
4	48.4	44.5	51.7	48.8	45.8	52.8	0.4	1.3	1.1
5	52.3	48.5	55.7	52.8	49.8	56.7	0.5	1.3	1.0

Table IR14-05-6 Noise Levels with Re-calibrated Sources and CONCAWE Meteorology Category 6 – Future Conditions with Project Operation

Site	Noise Level (dBA) EIS Model			Noise Level (dBA) CONCAWE Model			Noise Level Diff. (dBA) CONCAWE vs. EIS		
	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}
3	52.0	51.7	58.1	52.3	53.0	59.3	0.3	1.3	1.2
4	49.5	46.5	53.5	50.0	47.8	54.6	0.5	1.3	1.1
5	52.8	49.6	56.7	53.4	51.0	57.8	0.6	1.4	1.1

Table IR14-05-7 Noise Levels with CONCAWE Meteorology Category 6 – Future Conditions with Project Operation and Incremental Road and Rail Traffic Volume Increases

Site	Noise Level (dBA) EIS Model			Noise Level (dBA) CONCAWE Model			Noise Level Diff. (dBA) CONCAWE vs. EIS		
	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}	L _d	L _n	L _{dn}
3	55.3	53.0	59.8	55.4	54.3	60.9	0.1	1.3	1.1
4	49.6	46.6	53.6	50.1	48.0	54.8	0.5	1.4	1.2
5	52.8	49.6	56.7	53.4	51.0	57.8	0.6	1.4	1.1

Impulsive Noise Levels – L_{max}

For impulsive sound events, results for direct downwind conditions using the default ISO 9613 downwind condition (CMet annual average wind direction removed) were provided in IR12-05 (CEAR Document #934). The ‘maximum’ event sound levels were taken from the July 2013 measurements, put into the calibration model, then adjusted for the difference between measurement wind condition and downwind conditions based on ISO 9613 methods. The same exercise has been completed using the re-calibrated model for CONCAWE category 6 downwind conditions. The results provided in **Table IR14-05-8** demonstrate that the ISO 9613 downwind calculation for impulsive events is the more conservative approach and leads to higher sound level results.

Table IR14-05-8 Predicted Impulsive Project Noise Levels – Actual Meteorology versus ISO 9613 and CONCAWE Downwind Conditions

Assessment Site	L _{max} Range (dBA)			L _{max} Increase	
	Actual Meteorology (July 2013 Measurements)	‘Worst-case’ Meteorology ISO 9613 Downwind	‘Worst-case’ Meteorology CONCAWE Category 6	ISO 9613 Propagation (dBA)	CONCAWE Propagation (dBA)
4	45.8 – 52.2	52.1 – 58.5	49.9 - 56.3	6.3	4.1
5	42.9 – 53.8	48.2 – 59.1	47.2 – 58.1	5.3	4.3

Low-frequency Noise

It was not possible to use the EIS noise model to calculate LFN levels using CONCAWE category 6 meteorology because LFN levels were not modelled. Rather, LFN levels were established for existing conditions through measurement. Future LFN levels were then predicted by proportionally adjusting the existing condition LFN levels to reflect anticipated increases in cargo capacity and locomotive volumes on the Roberts Bank causeway with the operation of RBT2. If the CONCAWE analysis were extended to LFN, it is expected that the relative increases between CONCAWE category 6 meteorology and the EIS annual average approach would be similar to those presented above for the L_d, L_n, and L_{dn}.

Construction Phase

In the EIS, the propagation of construction noise from the causeway and RBT2 marine terminal was calculated according to ISO 9613 with annual average meteorology as per LfU Bayern. These propagation calculations have been revised to consider meteorology under CONCAWE category 6 meteorological conditions.

Table IR14-05-9 presents the construction phase noise levels that result from these revised noise propagation calculations. **Table IR14-05-10** compares the revised construction phase noise levels to those presented in the PCU.

Table IR14-05-9 Noise Levels with CONCAWE Meteorology Category 6 – Project Construction

Site	L _d for Expected Conditions	Construction L _d		Combined Construction L _d		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	52.1	30.0-58.2	48.5	52.1-59.2	54.8	0.0-7.1	2.7
4	48.8	31.8-57.1	48.2	48.9-57.7	52.6	0.1-8.9	3.8
5	52.8	33.5-50.5	44.6	52.9-54.8	53.6	0.1-2.0	0.8
Site	L _n for Expected Conditions	Construction L _n		Combined Construction L _n		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	52.8	0.0-58.2	48.2	52.8-59.3	54.7	0.0-6.5	1.9
4	45.8	0.0-57.1	45.9	45.8-57.4	50.2	0.0-11.6	4.4
5	49.8	0.0-50.2	42.3	49.8-53.0	50.8	0.0-3.2	1.0
Site	L _{dn} for Expected Conditions	Construction L _{dn}		Combined Construction L _{dn}		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	59.1	31.2-64.6	53.2	59.1-65.7	61.1	0.0-6.6	2.0
4	52.8	33.0-63.5	53.0	52.8-63.8	57.1	0.0-11.0	4.3
5	56.7	34.7-56.6	49.4	56.8-59.7	57.8	0.1-3.0	1.1

Table IR14-05-10 CONCAWE Meteorology Category 6 Results minus Project Construction Update Results

Site	L _d for Expected Conditions	Construction L _d		Combined Construction L _d		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	0.2	6.6-7.6	7.3	0.2-4.9	2.2	0.0-4.7	2.0
4	0.4	7.0-8.2	7.8	0.5-6.0	3.1	0.1-5.6	2.7
5	0.5	7.5-7.9	7.8	0.5-2.1	1.1	0.0-1.6	0.6
Site	L _n for Expected Conditions	Construction L _n		Combined Construction L _n		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	1.3	0.0-7.6	7.8	1.3-5.2	2.6	0.0-3.9	1.3
4	1.3	0.0-8.2	7.7	1.3-7.1	4.1	0.0-5.8	2.8
5	1.3	0.0-8.0	7.7	1.3-3.6	2.1	0.0-2.3	0.8

Site	L _{dn} for Expected Conditions	Construction L _{dn}		Combined Construction L _{dn}		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	1.1	6.6-7.6	7.3	1.2-5.2	2.5	0.1-4.1	1.4
4	1.1	7.0-8.2	7.8	1.1-7.0	3.8	0.0-5.9	2.7
5	1.0	7.5-8.0	7.8	1.1-3.2	1.8	0.1-2.2	0.8

Table IR14-05-10 shows that calculating construction noise using CONCAWE meteorological category 6 results in construction phase noise levels that are from 0.0 to 5.9 dBA higher than those presented in the PCU. These relative increases are larger than those calculated for Project operation because construction noise sources were not recalibrated for the CONCAWE modelling. Unlike the noise sources used to represent marine terminals in the operation model, construction equipment noise emissions were not determined from long-distance measurements. Rather, construction equipment noise emissions were based on published values, and there was therefore no need to recalibrate them for this analysis. These higher noise predictions indicate the amount of variability in sound levels that could occur when considering a single meteorological condition (CONCAWE category 6) when compared to the long-term exposure approach appropriately applied for the PCU.

While the construction phase noise levels presented in **Table IR14-05-9** indicate a higher degree of variability in monthly construction noise levels than those presented in the PCU, there is also greater uncertainty associated with them. This increased uncertainty results from applying worst-case noise propagation conditions to an already conservative analysis. The following conservative assumptions were included in the PCU construction noise calculations to account for the inherent variability of construction site noise emissions:

- Construction equipment noise emissions were based on maximum loads (i.e., published L_{max} values);
- All construction equipment listed for a given construction phase was assumed to be always working concurrently; and
- In predicting construction noise levels at the three key residential locations (sites 3, 4, and 5), all causeway construction noise emissions were conservatively considered to originate from the causeway location closest to the residential receivers in question.

Adding another layer of conservatism to this analysis by modelling construction noise propagation under CONCAWE category 6 meteorology, a condition that occurs less than 20% of the time, would increase the uncertainty of the results. For example, in the case of causeway construction, there is low probability of all four of the following conditions occurring simultaneously:

- All construction equipment working concurrently;
- All construction equipment working at the closest location on the causeway to a given receptor;
- All equipment working at full load; and
- Meteorological conditions consistent with worst-case CONCAWE category 6.

It was necessary to apply conservative assumptions to account for the inherent variability and uncertainty associated with construction site noise emissions. Adding the assumption of worst-case meteorological conditions 100% of the time creates a particularly unrealistic scenario that increases the uncertainty of the results, rather than providing appropriate levels of conservatism.

Part 3 – Implications for HHRA

As outlined at the beginning of this response, and further supported by the analysis and rationale in Part 2 of this response, a revised HHRA for long term exposures requires predicted noise levels reflective of a realistic annual average noise environment. Use of noise levels based on CONCAWE worst case meteorology is not considered a valid methodology for most health indicators included in the HHRA. The response to IR12-07 (CEAR Document #934) provides rationale for why it is not appropriate to use noise levels reflective of relatively infrequent meteorological conditions (i.e., CONCAWE category 6) to predict health effects using noise thresholds that were developed for long-term (i.e., annual) noise exposure. The two key reasons are as follows:

- Health Canada (2017) states that it “prefers the use of the dose-response relationship only for long-term noise exposure considerations in [environmental assessments] and holds the view that %HA be calculated only for receptors exposed to long-term noise”; and
- The noise metrics used to calculate %HA (L_{dn}) and evaluate sleep disturbance (L_n) are calculated based on annual average levels and, as such, implicitly account for variations in meteorological conditions that can contribute to short periods of elevated noise, such as those considered by CONCAWE category 6.

The CONCAWE category 6 considers meteorological conditions favourable to downwind propagation. These conditions occur 20% of the time. Assuming CONCAWE category 6 is representative of annual meteorological conditions will overestimate actual noise levels because it assumes favourable downwind propagation for an additional 80% of the time when downwind conditions favourable for noise propagation do not exist. For this primary reason, a revised HHRA for health indicators based on CONCAWE category 6 meteorology has not been provided in this response. The analysis in Part 2 of this response provides additional rationale, as summarised below:

- **Operation Phase** – The data presented above show there is up to a 1.4 dBA difference between the results presented in the EIS and those developed using CONCAWE category 6. The increased noise levels based on CONCAWE are very small considering that the results implicitly assume favourable downwind propagation events for 100% of the time compared with the 20% of the time when such conditions exist. In fact, at most receptor locations these increases would not likely be measurable using a Type 1 sound level meter; and
- **Construction Phase** – Construction phase noise predictions include several conservative assumptions to account for variability and uncertainty with regard to timing and location of specific construction activities. Applying the CONCAWE method

to noise predictions would increase the uncertainty to a level at which HHRA predictions would not be realistic or reliable for management decisions.

As outlined in the response to IR12-07 (CEAR Document #934), the CONCAWE approach for considering a single meteorological condition is applicable when considering transient and impulsive noises. A sensitivity analysis was provided in that response, indicating that the sleep disturbance threshold for transient and impulsive noise (L_{\max} 60 dB, 10-15 times per night), is not exceeded when the non-adjusted (i.e., source power level is not re-calibrated with measured levels) CONCAWE noise levels are applied. The analysis above, **Table IR14-05-8**, shows that the predicted L_{\max} levels using the re-calibrated CONCAWE analysis is less conservative than the levels in the EIS (i.e., a lower sound level is produced).

On the basis of the analysis in this response, the conclusions of the EIS and PCU health assessments remain unchanged.

References

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Oil Companies' European Association for Environment, Health and Safety (CONCAWE). 1981. The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighbouring Communities. Report no. 4/81, prepared by C.J. Manning. Den Haag, May 1981.

IR14-06 Human Health – Low-Frequency Noise

Information Source(s)

Health Canada Submission to the Review Panel (CEAR Doc#1286)

Article by Broner (CEAR Doc#1357)

Proponent Response to IR7-04 (CEAR Doc#1141)

Proponent Response to IR12-05 (CEAR Doc#1333): Table IR12-05-2

EIS Volume 2: Section 9.3.8.4; Section 9.3.9.3; Table 9.3-10; and Table 9.3-25

Context

In their submission to the Review Panel (CEAR Doc#1286), Health Canada indicated that a low-frequency noise (LFN) limit between 60-65 dBC is recommended for residential locations to minimize community complaints and annoyance associated with LFN. Health Canada indicated that this limit was based on an article by Broner, published in 2011 in the Journal of Acoustics Australia (CEAR Doc#1357).

In the response to Review Panel IR7-04 (CEAR Doc#1141), the Proponent indicated that the average measured nighttime C-weighted baseline LFN level, measured at site 4A, was 63.9 dBC, which is 6.0 dBC higher than the estimated level at site 4 presented in Table 9.3-10 of the EIS.

In Table IR12-05-2 of the response to IR12-05 (CEAR Doc#1355), the Proponent presented a summary of Project-related changes to noise during the operation phase. It identified that the LFN level (outdoors) at site 4, with the Project is 61.7 dBC. However, this calculation appears to be based on the estimated LFN level at site 4, and not the measured LFN as presented in the response to IR7-04.

When predicting future changes to LFN levels, the Proponent estimated that there would be:

- a 1.2 dB increase at site 4 under the expected conditions scenario (Section 9.3.8.4 of the EIS); and
- a 2.6 dB increase at site 4 when adding the contributions of Project operation (Table 3-24 of Appendix 9.3-A of the EIS).

Based on the information presented in the above bullet points, and using the measured LFN at site 4, the LFN level with the Project at site 4 would be 67.7 dBC (63.9 + 1.2 + 2.6). This value would be in exceedance of the threshold identified by Broner. In addition, the LFN levels at other sites presented in Table IR12-05-2 are in exceedance of the threshold.

Information is required to determine the potential health effects of LFN noise at sites 4, 5, 6, and 7. In addition, information on technically and economically feasible measures that would be implemented to mitigate a potential effect is also required.

Information Request

Provide the Low Frequency Noise (LFN) levels under existing conditions, expected conditions, and with the Project using the measured LFN levels at site 4.

Provide a discussion of the LFN levels with the Project at sites 4 (based on the above calculation), 5, 6, and 7 (based on Table IR12-05-2) in relation to the findings of the Broner article. Discuss the implications of any exceedances of the 60-65 dBC limit and describe the potential health effects from LFN on individuals residing in the local study area.

Discuss the technically and economically feasible measures that would be implemented to mitigate the effect.

Where relevant, integrate the results from IR14-05 into this response.

VFPA Response

Provide the Low Frequency Noise (LFN) levels under existing conditions, expected conditions, and with the Project using the measured LFN levels at site 4.

Nighttime low-frequency noise (LFN) levels under existing conditions, expected conditions, and with the Project for sites 4a, 5, 6, and 7 are provided in **Table IR14-06-1**. Predicted levels at site 4a are based on levels measured at this site in 2017, as described in IR7-04 (CEAR Document #934¹). All calculations for expected conditions and future conditions with the Project used the EIS ISO 9613 standard method.

Table IR14-06-1 Nighttime Low-frequency Noise Levels

Noise Metric and Units	Assessment Sites	Existing Conditions	Range of Future Levels		Project-related Increase
			Expected Conditions	With Project	
L _n ^a (dBC)	4a ^b	63.9	65.1	67.7	2.6
	5	61.3	62.5	64.1	1.6
	6	49.9	51.1	52.7	1.6
	7	61.7	62.9	64.5	1.6

Notes: a. As noted in Section 9.3.7.1 of the EIS, LFN levels for existing conditions were assessed based on the noise levels measured during the nighttime (midnight to 5 a.m.). Nighttime data were considered to be representative of LFN related to the existing terminals and causeway because port-related noise is more prominent, and therefore identifiable during these hours. This assumption was verified in the response to IR7-05 (CEAR Document #934), which provided a comparison of measured daytime and nighttime LFN levels. This comparison showed that there was less than a 1 dBC difference between daytime and nighttime LFN levels.

¹ CEAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (NOTE: Updated November 30, 2018).

b. Based on measured values reported in IR7-04 (CEAR Document #934), C-weighted nighttime noise levels measured in 2017.

Provide a discussion of the LFN levels with the Project at sites 4 (based on the above calculation), 5, 6, and 7 (based on Table IR12-05-2) in relation to the findings of the Broner article.

The Broner (2011) article provides two recommended LFN criteria aimed at managing LFN related complaints in residential areas. For nighttime or where the LFN source operates continuously (24/7), the proposed criteria for residential locations are a 'desirable' level of 60 dBC and 'maximum' level of 65 dBC.

Further examination of the data presented by Broner (Tables 1 and 2) show that a 60 dBC limit for 24/7 facility operation is applicable to [very] quiet suburban or rural residential areas. As described in IR12-07 (CEAR Document #934) and information on background noise levels according to land use provided in Health Canada (2017), the area potentially impacted by LFN from the Project is characterised as a 'normal suburban residential' community type rather than a [very] quiet suburban or rural residential area. Accordingly, the 60 dBC 'desirable' threshold to limit noise complaints is not applicable.

The 65 dBC threshold is applicable to normal suburban residential areas and is applicable to existing land use in the study area. This threshold is intended to minimise complaints from LFN and is not directly related to measurable health effects. For this reason, 65 dBC should be used as an indicator for potential community complaints, and a prompt for evaluation of further monitoring and investigation into the source(s) of LFN.

The 70 dB rattle criterion adopted for the EIS, as a threshold for health effects related to annoyance, is supported by a 2017 Health Canada guidance document (2017) that states the following:

"To prevent rattles from low-frequency noise and the associated annoyance from this effect, ANSI indicates that the (energy) sum of the sound levels in the 16-, 31.5- and 63-Hz octave bands be less than 70 dBZ. If this 70-dBZ "rattle criterion" is exceeded, Health Canada may suggest the implementation of feasible mitigation measures."

The 65 dBC and 70 dB criteria are complementary. 65 dBC is an appropriate indicator for further evaluation of monitoring and investigation, and 70 dB is an appropriate threshold for potential health effects requiring mitigation, based on source identification.

Comparison of LFN levels for the expected (Future without the Project) and future conditions with Project operation using the 65 dBC and 70 dB criteria is provided in **Table IR14-06-2**. The results indicate that at sites 4a, 5, and 7, there are exceedances of the 65 dBC criterion for expected conditions (without the Project). While the Project will contribute 1.6 to 2.6 dB to the expected LFN levels (see **Table IR14-06-1**). Exceedances of the 65 dBC threshold are attributable to sources other than the Project. Similarly, the 70 dB threshold is exceeded at site 4a for both the expected and future scenarios. LFN levels at site 6 are lower than the 65 dBC threshold for both temporal scenarios.

Table IR14-06-2 Updated Comparison of Predicted Nighttime Low-frequency Noise to 65 dBC and 70 dB Criteria

Site	Measurement Location	Expected Conditions without the Project			Future Conditions with Project Operation		
		Sum of Sound Levels (dB)	Do Predicted Levels Exceed 65 dBC?	Do Predicted Levels Exceed 70 dB?	Sum of Sound Levels	Do Predicted Levels Exceed 65 dBC?	Do Predicted Levels Exceed 70 dB?
4a	Outside	71.0	Yes	Yes	73.6	Yes	Yes
	Inside	Not available			Not available		
5	Outside	66.0	Yes	No	67.6	Yes	No
	Inside	57.0	No	No	58.6	No	No
6	Outside	54.7	No	No	56.3	No	No
	Inside	44.3	No	No	45.9	No	No
7	Outside	68.3	Yes	No	69.9	Yes	No
	Inside	57.7	No	No	59.3	No	No

For daytime hours in 'normal suburban/urban residential' areas, the Broner (2011) article identifies a threshold of 70 dB. As this value is the same as the 70 dB rattle criterion adopted for the EIS, further assessment of daytime LFN levels was not required.

Discuss the implications of any exceedances of the 60-65 dBC limit and describe the potential health effects from LFN on individuals residing in the local study area.

The 60-65 dBC thresholds are based on LFN levels that result in acceptably low levels of complaints. LFN above these levels can lead to increased annoyance, which, in turn, can lead to increased complaints. As discussed above, the 60 dBC threshold is not applicable to the local study area because it is for very quiet suburban and rural residential areas and not for more developed suburban areas potentially impacted by the Project. Therefore, the following discussion focuses on the threshold of 65 dBC.

With respect to LFN levels above 65 dBC identified in **Table IR14-06-2** (i.e., sites 4a, 5, and 7), there may be an increase in complaints for both the expected and future scenarios. In expected conditions, exceedances of the 65 dBC threshold would be attributable to LFN sources other than the Project. The incremental increase in complaints associated with the 1.6 to 2.6 dBC increase in LFN levels associated with the Project is expected to be minor given the relatively small increase in dBC levels compared to expected conditions.

For sites 5 and 7, LFN levels are predicted to increase by 1.6 dBC levels but will still be lower than the 70 dB rattle criterion adopted by Health Canada (2017). Any increases in complaints are expected to be minor and below the level considered acceptable by Health Canada. All complaints will be evaluated for further monitoring and investigation into the source and nature of the noise, as appropriate. In particular, investigation will include determining whether LFN is originating from an RBT2-related source, and whether the LFN is intermittent

or continuous.² The response to IR12-06 (CEAR Document #934) describes the process by which the VFPA will investigate and respond to community complaints related to noise.

For site 4a, there is a 2.6 dBC increase predicted with the Project compared to expected conditions. Levels are also greater than the 70 dB rattle criterion for both expected conditions and future conditions with the Project. This indicates that increased complaints are possible. Due to the presence of a variety of other sources of LFN, it is difficult to predict the contribution the Project will have to possible future increases in complaints.

To address the possibility of an increase in complaints from LFN during Project construction and operation, the RBT2 Follow-up Program (described in more detail below) includes continuous noise monitoring in combination with a process for responding to noise-related complaints, including adaptive mitigation where required.

Discuss the technically and economically feasible measures that would be implemented to mitigate the effect.

Measures to reduce LFN during construction and operation will be included in the Construction and Operation Environmental Management Plans, and the RBT2 Follow-up Program. The RBT2 terminal will have shore power capacity, and vessels running on shore power instead of auxiliary engines while at berth would produce less LFN. Each of these environmental management plans, and the VFPA initiative to encourage use of shore power, is described below.

Environmental Management Plans

The response to IR13-30, Appendix 13-30-A (CEAR Document #934), provides an updated list of proposed mitigation measures and environmental management plans for RBT2. This includes noise management plans for construction and operation, a land and marine traffic management plan, and a follow-up plan element with adaptive management for unanticipated effects due to noise. These plans are currently in development, and the specific measures to be included in them are under evaluation. However, the response to IR7-12 (CEAR Document #934) identified several potential technically and economically feasible measures that could support reductions in LFN, and that could be included in the management plans listed above. The measures listed in IR13-30, and additional measures under consideration listed in IR7-12 that are relevant for reducing LFN, are listed in the sections that follow. Shore power, the use of which reduces LFN from vessels, will be available at the RBT2 terminal. The VFPA program to encourage use of shore power is also described below.

² The Broner (2011) article indicates that when LFN noise is intermittent rather than continuous, complaints may not occur before a threshold of LFN 70 dB is exceeded.

Construction Noise Management Plan

The measures below are listed in the response to IR13-30, Appendix IR13-30-A (CEAR Document #934) as potential measures to be included in the Construction Noise Management Plan:

- Shutdown of equipment and vehicles when not in use;
- Utilisation of equipment that produces less noise where feasible;
- Awareness and training for construction crew;
- Using barriers (e.g., acoustic blankets) where feasible;
- Increasing or ramping-up sound levels slowly;
- Where possible, implementing measures to minimise impulsive noise; and
- Scheduling of higher noise-generating activities during weekdays, and during the daytime.

In addition, several measures listed in the response to IR7-12, Table IR7-12-A1 (CEAR Document #934) are currently under consideration as potential mitigation measures that could also be included in the Construction Noise Management Plan. The specific measures that have the most potential to reduce LFN include the following:

- Give preference to use of quieter technology for construction equipment. Compare noise level data to select least noisy units (Items 2 and 27, Table IR7-12-A1);
- Avoid, where possible, mobile plant clustering near residences and other sensitive receptors (Item 13, Table IR7-12-A1);
- Consider alternatives to diesel and gasoline engines and pneumatic units such as hydraulic or electric controlled units where feasible and reasonable (Item 23, Table IR7-12-A1); and
- Use walls or other temporary noise barriers for truck waiting areas (Item 61, Table IR7-12-A1).

Operation Noise Management Plan

The measures below are listed in the response to IR13-30, Appendix IR13-30-A (CEAR Document #934) as potential measures to be included in the Operation Noise Management Plan:

- Operator awareness and training;
- Regular maintenance of equipment (e.g., lubrication of pulleys and other moving parts, replacement of deteriorated exhaust mufflers, maintaining efficiencies of engines through servicing); and
- Optimise tonality of equipment alarms to limit audibility on shore while meeting safety requirements.

In addition, several measures listed in the response to IR7-12, Table IR7-12-A1 (CEAR Document #934) are currently under consideration as potential mitigation measures that could also be included in the Operation Noise Management Plan. The specific measures that have the most potential to reduce LFN include the following:

- Give preference to use of quieter technology for equipment. Compare noise level data to select least noisy units (Items 2 and 27, Table IR7-12-A1); and
- Consider alternatives to diesel and gasoline engines and pneumatic units such as hydraulic or electric controlled units where feasible and reasonable (Item 23, Table IR7-12-A1).

Land and Marine Traffic Management Plan

As described in Table IR13-30-A1 (CEAR Document #934), the objective of the Land and Marine Traffic Management plan is to “Implement measures to address land-based construction and operation-related traffic, traffic control, and potential traffic hazards.” Specific measures to be included in the plan are under consideration. However, several of the measures listed in Table IR7-12-A1 (CEAR Document #934), having the potential to reduce LFN, could be included in the Land and Marine Traffic Management Plan. These include the following:

- Inform construction-related truck drivers of designated vehicle routes, acceptable delivery hours, and other relevant practices to minimise use of engine breaks and periods of engine idling (Item 7, Table IR7-12-A1);
- Where possible, schedule truck movements to avoid residential streets (Item 12, Table IR7-12-A1); and
- Provide onsite parking areas for staff, and onsite truck waiting areas, away from residences and other sensitive receptors (Item 60, Table IR7-12-A1).

Follow-up Program and Adaptive Management

As described in the responses to IR12-06 and IR13-30 (CEAR Document #934), as part of the Follow-up Program during construction and operation, the VFPA will rely on three mechanisms for feedback from the community to identify noise-related issues. These include the Port Community Liaison Committee in Delta, the 24-hour Community Response Line, and the dedicated RBT2 Project email address (container.improvement@portvancouver.com). Receipt of a complaint, or multiple complaints, about Project-related noise will trigger a process to evaluate and respond accordingly. This evaluation will include consideration of the following:

- Noise levels recorded by the permanent noise monitoring station during the time of the complaint(s);
- RBT2 activities occurring at the time of the complaint(s), in an attempt to identify if the source of noise related to the complaint is from a Project source;
- The need for additional monitoring to clearly identify if the sound is generated by RBT2 construction or operation;
- Compliance with standard noise-reduction measures as outlined in the Construction and Operation Noise Management Plans; and
- Whether the complaint and associated noise levels are related to an RBT2 construction activity likely to be ongoing or continuous for a period of time, or associated with a construction activity that is complete, close to complete, or short in duration.

As warranted based on these considerations, adaptive measures will be implemented as defined in the applicable Construction or Operation Noise Management Plan, and/or Follow-up Plan for noise, to reduce noise associated with the complaint. The amount of reduction achievable for a specific mitigation will vary based on the nature and location of the source relative to the location of the complaint. These factors would be examined as part of the decision process in determining the most effective approach to addressing a complaint.

Possible adaptive noise reducing measures are described in response to IR7-12, Table IR7-12-A1 (CEAR Document #934), where indicated 'measure could be considered as adaptive measure in Follow-up Program'. Possible adaptive measures identified as applicable to LFN include the following:

- Restrict areas where mobile plants can operate so that they are away from residences and other sensitive receptors at particular times (Item 38, Table IR7-12-A1); and
- Use full enclosures to control noise from nighttime work (Item 44, Table IR7-12-A1).

Shore Power

The inclusion of shore power capacity in the RBT2 project design further supports the potential reduction of LFN during Project operation. The RBT2 terminal will be shore power-equipped, and the VFPA is working with industry and government partners to promote shore power technology at the Port of Vancouver, and has improved operational procedures and facilities to support increased connections. As stated in the response to IR6-19 (CEAR Document #934), the VFPA promotes the use of shore power, and recognises cleaner ships through its EcoAction Program (VFPA 2017). Ships obtain a discount on harbour dues of up to 47% for going beyond requirements by implementing voluntary emission reduction measures and other environmental practices, including implementing vessel and engine technologies (such as shore power), using cleaner fuels, and participating in energy efficiency programs. Shore power is available to container ships at Centerm container terminal and at Deltaport. The port authority installed shore power with support from Transport Canada and BC Hydro, and in collaboration with the respective container terminal operators, and will continue to look for opportunities to add additional systems in the future.

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