APPENDIX 9.3-A

Noise and Vibration Technical Report

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ROBERTS BANK TERMINAL 2
TECHNICAL REPORT
Noise and Vibration Study

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Technical Report/Technical Data Report Disclaimer

The Canadian Environmental Assessment Agency determined the scope of the proposed Roberts Bank Terminal 2 Project (RBT2 or the Project) and the scope of the assessment in the Final Environmental Impact Statement Guidelines (EISG) issued January 7, 2014. The scope of the Project includes the project components and physical activities to be considered in the environmental assessment. The scope of the assessment includes the factors to be considered and the scope of those factors. The Environmental Impact Statement (EIS) has been prepared in accordance with the scope of the Project and the scope of the assessment specified in the EISG. For each component of the natural or human environment considered in the EIS, the geographic scope of the assessment depends on the extent of potential effects.

At the time supporting technical studies were initiated in 2011, with the objective of ensuring adequate information would be available to inform the environmental assessment of the Project, neither the scope of the Project nor the scope of the assessment had been determined.

Therefore, the scope of supporting studies may include physical activities that are not included in the scope of the Project as determined by the Agency. Similarly, the scope of supporting studies may also include spatial areas that are not expected to be affected by the Project.

This out-of-scope information is included in the Technical Report (TR)/Technical Data Report (TDR) for each study, but may not be considered in the assessment of potential effects of the Project unless relevant for understanding the context of those effects or to assessing potential cumulative effects.

EXECUTIVE SUMMARY

The Roberts Bank Terminal 2 Project (RBT2 or Project) is a proposed new three-berth marine terminal at Roberts Bank in Delta, B.C. that could provide 2.4 million twenty-foot equivalent units (TEUs) of additional container capacity annually. The Project is part of Port Metro Vancouver's (PMV's) Container Capacity Improvement Program (CCIP), a long-term strategy to deliver projects to meet anticipated growth in demand for container capacity to 2030.

The purpose of the Noise and Vibration Study was to characterise existing noise and ground-borne vibration levels at sensitive receptors, and to forecast future levels with and without the Project. The study included the following components:

1. Existing noise and ground-borne vibration measurements;
2. Project construction noise and vibration prediction;
3. Noise propagation modelling; and
4. Prediction of future noise levels with and without Project operation.

From July to August 2013, noise, low-frequency noise and ground-borne vibration levels were measured at seven residential sites. Ground-borne vibration levels were measured at sites 1, 2 and 3 where it was found that ambient levels were dominated by road and rail traffic. At sites 1 and 2, heavy truck traffic was responsible for the highest transient vibration levels. At site 3, which is closer to the Roberts Bank Rail Corridor, train traffic created the highest transient vibration levels. At sites 3, 4 and 5, 48-hour continuous noise level measurements were conducted to characterise average daily community noise levels. Two-day average day-night equivalent sound levels (L_{dn}) ranged from 52.7 to 55.7 A-weighted decibels (dBA). Long-term monitoring conducted during the 2011 Deltaport Terminal, Road and Rail Improvement Project (DTRRIP) Environmental Assessment (BKL 2012) indicated that day-to-day L_{dn} variation at these sites is, on average, +/- 2 dBA. The noise environments at these sites were observed to be influenced by a variety of diverse sources including Roberts Bank terminals operations, road and rail traffic, aircraft overflights, BC Ferries operations, and natural sounds. At sites 5, 6 and 7, frequency-spectra were measured in one-third octave bands to investigate the degree to which low-frequency noise was present. The differences between C-weighted and A-weighted levels at these sites ranged from 12.6 to 22.5 decibels (dB) indicating the presence of low-frequency noise.

During Project construction, monthly-average L_{dn} at sites 3, 4 and 5 are predicted to range from 51.7 to 60.0 dBA. These levels represent increases in L_{dn}, relative to future conditions without the Project, of 0.0 to 4.3 dBA. On average, these increases would not exceed 1.3 dBA. These relatively modest increases are primarily a result of the large setback distances of noise-sensitive upland receptors from the terminal and causeway construction zones. Maximum ground-borne vibration levels created by construction activities are not expected to exceed the threshold of perception.

Noise models were created using the software CadnaA to estimate existing (2013), and predict future (2025), annual average noise levels at sites 3, 4 and 5. Existing annual average L_{dn} are estimated to range from 50.9 to 56.7 dBA. In the future, without the Project, annual average L_{dn} are predicted to increase by 0.6 to 1.3 dBA to levels of 51.7 to 58.0 dBA. With Project operation, annual average L_{dn} are predicted to further increase by 0.1 to 1.8 dBA to levels of 53.5 to 58.1 dBA.

RBT2 is expected to increase the number, but not the severity, of impulsive and transient port and rail-related noise events. These increases are expected to be proportional to the increases in port throughput capacity and rail traffic volumes. With Project operation, future low-frequency noise levels are predicted to increase by 1.6 to 2.6 dB relative to future conditions without the project. Project operation is not expected to measurably or perceptibly influence ground-borne vibration levels at any upland receptors.

The noise models were used to estimate and predict annual average daytime equivalent sound levels (L_d) in the marine portion of the study area. Existing L_d are estimated to range from 62.5 dBA to 32.7 dBA at locations within approximately one and ten kilometres (km) of the future location of the RBT2 marine terminal respectively. In the future (2025), without the Project, L_d are predicted to increase by 0.2 to 1.3 dBA to levels of 63.7 to 33.9 dBA. During Project construction, L_d are expected to increase by 0.0 to 12.9 to a range of 63.8 to 33.9 dBA. With Project operation, L_d in 2025 are expected to further increase by 0.3 to 13.0 dBA to levels of 64.0 to 38.4 dBA. The largest increases are predicted at locations ≤1 km to the north, south and west of the new marine terminal while the smallest increases are predicted at locations to the east where noise from the existing terminals and Highway 17 (B.C. Ferries causeway) will dominate daytime noise levels.

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LIST OF ACRONYMS AND ABBREVIATIONS

B&K	Bruel & Kjaer
dB	decibel
dBA	A-weighted decibel
dBC	C-weighted decibel
BCRC	British Columbia Railway Corporation
CCIP	Container Capacity Improvement Program
CZBB	Boundary Bay Airport
DTRRIP	Deltaport Terminal, Road and Rail Improvement Project
EL	emission level
FTA	Federal Transit Administration
GIS	geographical information system
hour	h
Hz	Hertz
L_d	daytime equivalent sound level
L_{dn}	day-night equivalent sound level
L_{eq}	24-hour equivalent sound level
L_{max}	maximum sound level
L_n	nighttime equivalent sound level
L_{90}	ninety percent exceedance level
PMV	Port Metro Vancouver
PPV	peak particle velocity
Project	Roberts Bank Terminal 2 Project
RMS	root mean square
RBRC	Roberts Bank Rail Corridor
RBT2	Roberts Bank Terminal 2 Project
SLM	sound level meter
SWL	sound power level
TDR	technical data report
TEU	twenty-foot equivalent unit container
UF	Usage Factor
U.K.	United Kingdom
U.S.	United States
UTM	Universal Transverse Mercator
V	volt
VdB	ground-borne vibration level
WHO	World Health Organisation
YVR	Vancouver International Airport

GLOSSARY

A-weighted decibel (dBA): Because the human ear and brain system is much more sensitive to sounds at mid-range and higher frequencies, or pitches, than at lower frequencies, sound level meters are equipped with electronic filtering, or weighting, networks that replicate the human ear's frequency sensitivity. The most widely used of such weighting networks is called A-weighting, and sound levels measured with this weighting are expressed in dBA.

airborne noise: The propagation of noise through the air via vibrating air molecules.

C-weighted decibel (dBC): This sound weighting is a frequency weighting employed in some sound level meters which replicates the ear's sensitivity to sound at higher intensities (100 dB or greater) than are typically experienced in day-to-day life. At these sound levels, the human ear's frequency response is much flatter than it is at the much lower sound levels for which the more familiar A-weighting was developed.

component noise level (L_{dn}, L_d or L_n): Community noise environments typically feature contributions from a variety of sources — natural and otherwise. Measured community noise levels include contributions from all sources in a noise environment. To model existing or future noise levels, however, it is often necessary to break the noise environment into its various components. Each significant noise source then contributes its own component noise level. The logarithmic sum of the component noise levels is then equal to the total noise level in a community. Component noise level is a generic term in which "noise level", depending on the context, can refer to various specific noise metrics such as L_{dn}, L_d or L_n.

daytime equivalent sound level (L_d): This sound level is the equivalent sound level (L_{eq}) for the time period from 7:00 to 22:00 hours.

day-night equivalent sound level (L_{dn}): Similar to the 24-hour equivalent sound Level [L_{eq}(24)], the L_{dn} is an energy-averaged descriptor of 24-hour noise exposure expressed in dBA. In computing L_{dn}, all noise levels occurring between 22:00 and 07:00 hours are increased by 10 dBA to reflect the greater sensitivity of residential communities to noise at night.

decibel (dB): The standard unit of measurement for sound pressure level in which the reference value is 20 micropascals. A decibel is a logarithmic ratio, multiplied by a factor of 10, of a physical quantity and a standard reference value.

equivalent sound level (L_{eq}): The steady sound level which, over a given 24-hour time period, results in the same overall sound energy exposure as would the actual fluctuating level. Equivalent sound level is expressed in units of dBA.

favourable sound propagation conditions: Meteorological conditions that permit efficient transmission of sound through the atmosphere and hence the highest levels of sound being experienced at long distances from the source. Such conditions tend to be associated with downwind sound propagation (from sound source towards receiver) or the presence of an air temperature inversion (air warmer above). During such conditions, sound waves are refracted or bent downward towards the ground.

frequency spectra: Graphical or tabular representations of the frequency content (i.e., level versus frequency) of sound, vibration, electrical signals, or other physical phenomena, these spectra may be expressed in various frequency increments, the most familiar in noise assessment being octave bands and one-third octave bands.

g: A unit of measure of acceleration that is equal to acceleration under Earth's gravity. It is equal to 9.81 metres per second squared.

ground-borne vibration: Sources such as heavy trucks, trains, and construction activities produce vibration that travels from the source to the receiver via the ground, often as a mixture of surface waves and compressive (longitudinal) waves.

ground effect: The excess sound attenuation, over and above that caused by geometric spreading and atmospheric absorption, that occurs when sound waves pass closely over a soft ground surface (e.g., grasslands, farm fields, forest) while travelling from the sound source to the receiver. The excess attenuation can be quite large and is due to a phase-related cancellation phenomenon between the sound wave that travels directly from source to receiver and a wave reflected from the ground at some point between the source and receiver. This attenuation only occurs when the ground surface is acoustically soft such as with grass, loose soil, or snow.

impulsive noise: Impulsive or impact noise is characterised by the rapid rise and fall in noise levels in which the duration of the noise event is brief (less than 1 second) compared to the period or interval between the noise events. Examples are noise from hammering, metal forming, or pile driving.

low-frequency noise: Typically considered to be noise at frequencies below 200 Hertz (Hz), low-frequency noise propagates more efficiently through the atmosphere, and penetrates more readily through building façades than higher-frequency noise. The human ear is, however, less sensitive to low-frequency sound than middle and higher-frequency sound.

maximum sound level (L_{max}): The highest sound level that occurs or is measured during a particular defined period. Maximum sound level is measured using the root mean square (RMS) averaging detector of sound level meters.

neutral sound propagation conditions: Meteorological conditions that result in sound propagating through the atmosphere with moderate efficiency, and hence with median or average levels of sound being experienced at far distances from the source. Such conditions tend to occur during calm periods (i.e., with little or no wind) and when there is little or no variation in air-temperature with height above ground. During such conditions, sound waves are not refracted upwards or downwards, and hence tend to travel in straight lines.

nighttime equivalent sound level (L_n): The L_{eq} for the time period from 22:00 to 7:00 hours.

ninety percent exceedance level (L_{90}): The noise level that is exceeded for 90% of a given time period; often considered to be representative of the background noise level.

noise: Identifying the point at which sound becomes noise is subjective, as one person's music may be another person's noise. Some sounds, such as a jackhammer may be considered noise by almost everyone, while other sounds, such the sound of a motorcycle or hot rod car engine, may not. In general, noise may be considered to be unwanted sound.

one-third octave band: A standard division of a frequency spectrum in which the interval between the centre frequencies of two adjacent bands is a ratio of approximately 1.25.

peak particle velocity (PPV): A metric for measuring vibration through a solid surface. When a vibration is measured, the point at which the measurement takes place can be considered to have a particle velocity. This particle vibration will take place in three dimensions (x, y, and z), and will usually end up back where it started. The PPV is the maximum velocity that is recorded during a particular event.

rail shunting: The process of sorting rail cars in railway operations. This process can create impulsive noise levels due to rail cars contacting.

root mean square (RMS): The square root of the mean of the square of a series of discrete values or a continuous varying function. It is particularly helpful in representing functions that vary between positive and negative values (e.g., sine wave). In acoustics, RMS is widely used to represent noise and vibration signals. Signals measured using this technique are referred to as RMS levels.

sensitive receptor: In the context of noise travelling through the air, and vibration travelling through soil or rock, a receptor refers to humans that might experience the sound and vibration energies. A sensitive receptor in this context is a person who is most influenced by such noise or vibration propagations by virtue of where that person lives relative to the sources. Specific behaviour and physiology, such as age and general health, may make a person more vulnerable to noise and vibration.

sound: Consists of minute fluctuations in atmospheric (air) pressure usually created by vibrating objects or moving fluids such as loudspeakers, drums, tires, or car exhausts. Our ears sense, and our brains interpret as sound, these pressure fluctuations occurring over the human audible frequency range of approximately 20 Hz to 20,000 Hz.

sound exposure level (SEL): A logarithmic measure of the sound energy content of a well-defined noise event such as a vehicle pass-by or aircraft overflight. Sound exposure level is also a function of the intensity and the duration of the event. For example, the SEL of an event that features a steady noise at level L (dB) for a duration of T (seconds), would be given by: SEL = L + 10 log (T) dB.

sound level: The intensity of sound expressed on a logarithmic scale similar to the Richter scale of earthquake magnitude. The basic unit of sound levels is dB. The wide range of human hearing sensitivity is then compressed to sound level range from the threshold of hearing at approximately 0 dB to the threshold of pain at approximately 130 dB.

sound-level contour map: In communicating the results of noise monitoring or modelling, it is effective to present the data in the form of sound-level contours of equal value (isopleths). Sound level contours are analogous to the ground elevation contours found on topographical maps; they may be labelled with their appropriate levels in dB or they may be colour-coded.

sound level meter (SLM): An instrument that measures and often logs sound pressure levels. A Type 1 sound level meter is the industry standard for precision field measurements used in environmental noise assessments and is accurate to ± 1 dBA.

sound power level (SWL): This term is defined as the logarithmic measure of the sound power emitted by a given sound source relative to the very small reference sound power of 10^{-12} (1 pW). As examples, the SWL of a hushed human voice is approximately 40 dBA, the SWL of a heavy diesel truck is approximately 90 dB, and the SWL of a Saturn V Rocket is approximately 200 dB.

transient noise: This is noise that is intermittent, coming and going over regular or irregular intervals. Examples of transient noise are noises from cyclical or irregular industrial or agricultural processes, the passing of trucks or trains, or the overflights of aircraft.

twenty-foot equivalent unit (TEU): An internationally recognised measurement for shipping containers. A standard twenty-foot long container equals 1 TEU; a forty-foot long container equals 2 TEUs.

unfavourable sound propagation conditions: When meteorological conditions result in the inefficient transmission of sound through the atmosphere, and hence the lowest levels of sound being experienced at far distances from the source, unfavourable sound propagation conditions are associated with upwind sound propagation (i.e., wind blowing from receiver towards sound source) or the presence of an air-temperature lapse (i.e., air cooler above). During such conditions, sound waves are refracted upwards, away from the ground.

usage factor (UF): A term used in the prediction of Project construction noise that refers to the percentage of time during a construction shift that a particular piece of construction equipment is typically operated and producing noise.

volt (V): the standard unit of potential difference and electromotive force in the International System of Units.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

The Roberts Bank Terminal 2 Project (RBT2 or Project) is a proposed new three-berth marine terminal at Roberts Bank in Delta, British Columbia (B.C.) that could provide 2.4 million **twenty-foot equivalent units** (**TEUs**) of additional container capacity annually. The Project is part of the Port Metro Vancouver (PMV) Container Capacity Improvement Program (CCIP), a long-term strategy to deliver projects to meet anticipated growth in demand for container capacity to 2030.

Port Metro Vancouver has retained Hemmera to undertake environmental studies to inform a future effects assessment for the Project. Wakefield Acoustics Ltd. was retained by Hemmera in February 2013 to conduct a Noise and Vibration study, which involved establishing existing **noise** and **ground-borne vibration** environments in areas close to Roberts Bank (the study area), and predicting changes to these environments in the future both with and without the Project. This study focused on noise propagation through air (**airborne noise**) and vibration propagation through the ground (ground-borne vibration). Noise propagation through the water (i.e., underwater noise) is the subject of a separate RBT2-related study. This technical report describes the methodology and results of the Noise and Vibration study.

1.2 STUDY OVERVIEW

The purpose of the Noise and Vibration study was to characterise existing noise and ground-borne vibration levels at **sensitive receptors** for three temporal cases:

1. existing conditions: the year the noise and vibration measurement were conducted (2013);
2. future scenario 1: future conditions without the Project (2025); and
3. future scenario 2: future conditions with the Project (2025).

Study components, major objectives, and a brief overview of each are provided in **Table 1-1**.

Table 1-1 Noise and Vibration Study Components and Major Objectives

Study Component	Major Objective	Brief Overview
Measurement of Existing Noise and Vibration Levels	Characterise existing noise, low-frequency noise, and ground-borne vibration levels at sensitive upland receptors.	Noise, low-frequency noise, and ground-borne vibration levels were measured at seven residential locations within Delta, B.C., during July and August 2013.
Prediction of Construction Noise and Vibration Levels	Predict noise and ground-borne vibration levels at sensitive upland receptors during the Project construction phase.	Average monthly construction noise levels were predicted for each month of construction from July 2018 to November 2023. The expected numbers of construction equipment in various categories were tallied for each construction phase, and the resulting noise levels were predicted based on the setback distances of sensitive receivers from construction zones. Ground-borne vibration levels were only predicted for the most vibration intensive construction activity since it was considered unlikely that most construction activities would results in perceptible levels vibration levels at sensitive receptors.
Noise Propagation Modelling	Create noise propagation models of the Project and surrounding areas using three-dimensional sound propagation and mapping software.	The sound propagation software CadnaA was used to create three-dimensional models of the study area, including noise sources for Deltaport Terminal, RBT2, and road and rail traffic. Models were created that represented existing conditions, and future conditions with and without the Project.
Prediction of Annual Average Noise Levels and Ground-Borne Vibration Levels	Predict future noise and ground-borne vibration levels for the three temporal cases.	The noise models were used to predict annual average noise levels for existing conditions, future conditions without the Project (scenario 1) and future conditions with the Project (scenario 2). Future ground-borne vibration levels were predicted by extrapolating from the results of existing conditions measurement.

2.0 METHODS

This section presents the study area, temporal scope, and methodology used in the Noise and Vibration Study.

2.1 STUDY AREA

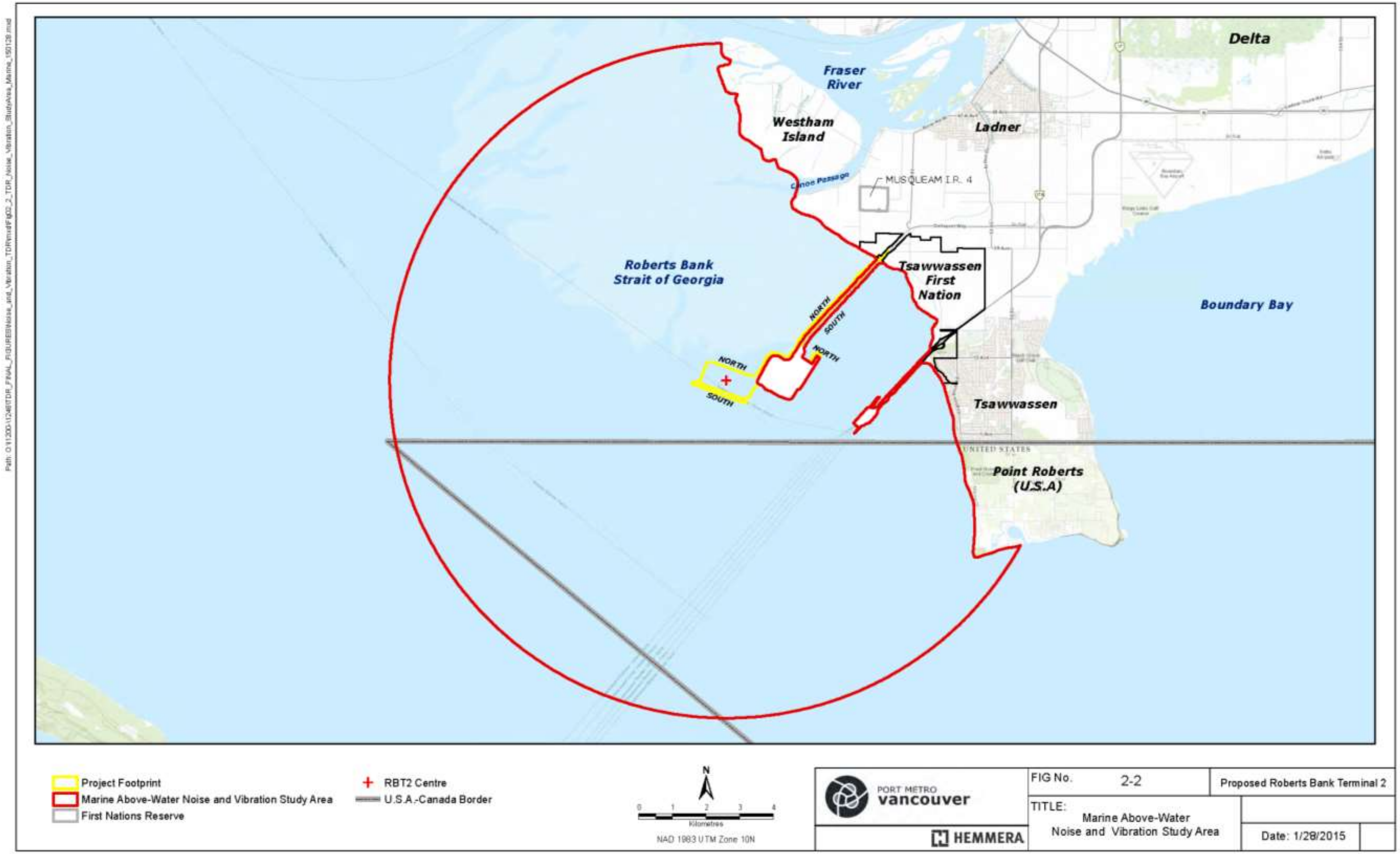
The study area consisted of an upland and marine component. The upland component included sensitive receptors in the Corporation of Delta that are within 5 km of Deltaport or 2 km of the northeast edge of the Roberts Bank causeway. These boundaries were chosen to include all upland areas where Project operation noise levels could potentially exceed the World Health Organisation (WHO) sleep interference threshold of **nighttime equivalent sound level** (**L_n**) 30 **A-weighted decibels** (**dBA**) indoors, which, assuming partially open windows, generally corresponds to an outdoor noise level of approximately L_n 45 dBA (WHO 1999).

The marine study area includes all above-water marine areas within 10 km of the approximate geometric centre of the new RBT2 marine terminal. This 10-km radius was chosen as a conservative setback distance beyond which Project-related noise levels would not be expected to cause any significant speech interference. Since most recreational and commercial activity within marine areas will occur during the daytime, this criterion was considered to be the most relevant in terms of the influence of noise on human health. With a background noise level of 55 dBA, 100% sentence intelligibility can be maintained at a distance of 1 m with raised voices (i.e., increased vocal effort) (WHO 1999). A **daytime equivalent sound level** (**L_d**) of 50 dBA (i.e., 55 dBA with a 5 dBA margin of safety) would then be expected to provide a background noise level that would sufficiently protect speech intelligibility during recreational and commercial marine use.

Project-related sources of noise are those that will be located within the Project area (i.e., the proposed marine terminal and the Roberts Bank causeway). Community or background noise is characterised for existing conditions and future without the Project (scenario 1) cases, and consists of sources of noise located outside of the Project area, but within the upland or marine study areas. The term Roberts Bank Rail Corridor (RBRC) is used in this assessment to refer to only the section of the rail corridor that extends from the eastern end of the Roberts Bank causeway to the eastern boundary of the study area. Similarly, the term Deltaport Way is used to refer to off-causeway portions of Deltaport Way within the study area. References to road and rail traffic on the Roberts Bank causeway are explicitly stated as such (e.g., road and rail traffic on the Roberts Bank causeway).

Figure 2-1 Upland Noise and Vibration Study Area

Figure 2-2 Marine Study Area for Above-water Noise



2.2 TEMPORAL SCOPE

The study characterises existing noise and vibration environments for the year 2013, when noise and vibration measurements were conducted.

2.2.1 Construction Horizon Year

Changes in noise related to Project construction were predicted month by month from 2018 to 2023, the anticipated duration of construction. To calculate total noise levels during Project construction it is necessary to include noise from both construction activities and all other relevant sources of noise. Due to a lack of pertinent data, however, it was not possible to accurately predict non-Project related noise levels for the period of 2018 to 2023. Rather, construction noise levels are considered relative to noise levels in year of 2025 (i.e., future scenario 1). Since annual average noise levels, without the Project, are not predicted to change perceptibly (i.e., <1 dBA) between 2018 and 2025, noise levels in 2025 are considered a sufficiently accurate proxy for noise levels in 2018. This approach is conservative as it will tend towards predicting higher total noise levels than if construction noise had been considered relative to noise levels for the period of 2018 to 2023.

Since most Project construction activities were not expected to result in perceptible levels of ground-borne vibration, changes to vibration levels were predicted only for periods of dynamic soil compaction – the most vibration-intensive construction. Dynamic compaction of marine terminal fill is anticipated to occur over a 1½ year period between November 2020 and March 2022 (**Appendix 4-F**).

2.2.2 Operation Horizon Year

Changes in noise and ground-borne vibration related to Project operation are predicted and characterised for the horizon year of 2025. In this year, RBT2 is expected to be operating at its sustainable design capacity of 2.4 million TEUs annually and, consequently, Project noise emissions are expected to reach their highest levels.

2.3 STUDY METHODS

This section presents the specific methods that were used to carry out the various components of the Noise and Vibration Study, including measurements of existing conditions and prediction and modelling of future conditions with and without the Project.

2.3.1 Existing Noise and Vibration Measurements

In measuring the existing noise and ground-borne vibration environment, particular attention was paid to characterising noise and ground-borne vibration levels created by the exiting Deltaport Terminal and road and rail traffic on the causeway. Since the RBT2 marine terminal will be similar to the existing Deltaport

Terminal, and will contribute road and rail traffic to the causeway, it was possible to use the existing conditions measurements to aid in the prediction of Project operation noise levels.

2.3.1.1 Site Descriptions and Locations

The results of a noise and vibration survey (Economic Planning Group 2013) were used to assist in the selection of the parameters to be studied during the existing noise and ground-borne vibration measurements. The survey revealed that certain members of the public in Delta were concerned about **transient** and **impulsive noises** originating from material handling at the Roberts Bank terminals, and from rail activity on the Roberts Bank causeway and on those sections of the RBRC that are within the study area. Similarly, concerns were expressed about **low-frequency noise** from sources at the Roberts Bank terminals and locomotives on both the Roberts Bank causeway and those sections of the RBRC that are within the study area. Concerns about ground-borne vibration were generally restricted to residences located close to the RBRC and/or arterial roads within the study area

The study team measured either noise, low-frequency noise, or ground-borne vibration levels, or a combination of these, at seven measurement sites to characterise existing noise and ground-borne vibration levels at sensitive receptor locations within the upland study area. Each measurement site is considered to represent a broader area for which Project-related levels of noise and ground-borne vibration are expected to be similar or lower in level. Sites 3, 4 and 5, are locations, within the larger areas they represent, that in the future are expected to receive the highest levels of Project noise. A summary of information about the seven sites is provided in **Table 2-1**. No noise measurements were conducted within the marine portion of the study area but rather, characterisations of noise levels in the marine study area was based on computational modelling.

The measurements were conducted in July and August 2013 on weekdays. The measurements were conducted on weekdays, rather than weekends, since weekday noise levels are experienced for a greater proportion of the year (i.e., 5/7th of the time). During the noise measurements period there were, on average, two ships berthed at Deltaport Terminal, one of these being a ship that residents have in the recent past frequently reported to cause higher-than-usual noise levels.

As shown in **Table 2-1**, not all parameters (ground-borne vibration, noise, and low-frequency noise) were measured at each site. Certain sites were chosen for specific measurement types based upon the likelihood of Project-related noise, low-frequency noise, or vibration impacts occurring at the site and based on information gathered in the noise and vibration survey (Economic Planning Group 2013). For example, ground-borne vibration levels were measured at sites 1 and 2 because these are located adjacent to the RBRC within the study area and because the survey indicated that residents at these sites experience annoyance due to ground-borne vibration. The location of each site is shown in **Figure 2-3**. More detailed site descriptions, maps, and photographs are provided in **Appendix A**.

Table 2-1 Noise and Vibration Measurement Site Descriptions

Site No.	Address or Location	Approximate Distance from Sources of Noise	Measurement Dates (2013)	Receptors Represented by Site	Measurement Type	Measurement Duration
1	3449 Arthur Dr.	Deltaport Way – 675 m RBRC – 700 m Roberts Bank terminals – 6.8 km Future Location of RBT2 Marine Terminal – 8.8 km	August 7	Rural residences in Delta adjacent to arterial roads with heavy trucks and RBRC	Ground-borne Vibration	Multiple short-term (1 to 30 minutes)
2	3395 41B St.	Deltaport Way – 600 m RBRC – 630 m Roberts Bank terminals – 5.2 km Future Location of RBT2 Marine Terminal – 7.0 km	August 7 and 8	Rural residences in Delta adjacent to arterial roads with heavy trucks and RBRC	Ground-borne Vibration	Multiple short-term (1 to 30 minutes)
3	3044 41B St.	RBRC – 240 m Deltaport Way 270 m Roberts Bank terminals – 4.7 km Future Location of RBT2 Marine Terminal – 6.7 km	July 22 to 24, August 7 to 8	Rural residences in Delta adjacent to Deltaport Way and RBRC	Noise and Ground-borne Vibration	24 and 48 hours
4	Tsawwassen First Nation Longhouse	Tsawwassen Dr. N. – 60 m Deltaport Way/RBRC – 1.8 km Highway 17 – 1.3 km Roberts Bank terminals – 3.8 km Future Location of RBT2 Marine Terminal – 6.0 km	July 22 to 24	Tsawwassen First Nation community - residences near the ocean	Noise	48 hours
5	1043 Pacific Dr.	Highway 17 – 430 m B.C. Ferries Terminal – 2.1 km Roberts Bank terminals – 3.5 km Future Location of RBT2 Marine Terminal – 5.6 km	July 22 to 24	Residences in the Tsawwassen neighbourhood near the ocean	Noise and Low-frequency Noise	48 hours
6	965 Underhill Dr.	B.C. Ferries Terminal – 2.9 km Roberts Bank terminals – 4.5 km Future Location of RBT2 Marine Terminal – 6.6 km	July 22 to 24	Residences in Tsawwassen inland from the ocean	Low-frequency Noise	24 hours
7	77 English Bluff Rd.	Highway 17 – 2.3 km B.C. Ferries Terminal – 2.5 km Roberts Bank terminals – 4.7 km Future Location of RBT2 Marine Terminal – 6.5 km	July 22 to 24	Residences in the Tsawwassen neighbourhood near the ocean	Low-frequency Noise	24 hours

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Figure 2-3 Noise Measurement Site Locations

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2.3.1.2 Instrumentation for Noise and Vibration Metrics

The noise level measurements were conducted using either Larson-Davis Model 820 or Bruel and Kjaer (B&K) Type 2250 **sound level meters** (**SLM**), with one instrument employed per site. The low-frequency noise measurements were conducted using B&K Type 2250 SLMs with two instruments employed per site. These digital instruments comply with the American National Standard Specifications for Type 1 SLMs (American National Standards Institute, 2006), and are capable of sampling the ambient **sound level** many times per second and storing the resulting sound-level data for subsequent analysis and display. The SLMs were set to collect a complete statistical description of the noise environment every 15 minutes. All SLMs were set to a “Fast” response time with a dBA filter. The noise metrics that were logged include the following (see **Glossary** for definitions):

- **Equivalent sound level (L_{eq});**
- **Maximum sound level (L_{max}); and**
- **90-percent exceedance level (L_{90}).**

The L_d, L_n, and **day-night equivalent sound level** (L_{dn}) were not logged, but rather calculated from the 15-minute L_{eq}. The meters also logged noise levels at finer time resolutions to capture the levels of **transient** and **impulsive noise** events. The Larson-Davis SLMs logged equivalent and maximum noise levels at two-second intervals, while the B&K SLMs logged L_{eq}, L_{max}, and **frequency spectra** data in **one-third octave bands**, at one-second intervals (the one-third octave band data were collected during the low-frequency noise measurements). In addition, the B&K SLMs recorded audio tracks to identify noise sources.

The SLMs were field-calibrated at the start of each monitoring period and their calibration was verified at the end. Calibration checks were also performed during measurement periods exceeding 24 hours. Type 1 SLMs are accurate to within ±1 dBA. A comprehensive list of specific instrumentation used at each site is provided in **Appendix A**.

The ground-borne vibration measurements were conducted with a B&K Type 2250 running BZ-7230 Fast Fourier Transform Analysis Software and a Dytran Model 3191A1 accelerometer. The accelerometer has a frequency response of 0.08 to 1,000 Hertz (Hz) and a sensitivity of 10 **volts** per **g** (V/g). The B&K Type 2250 was set to measure ground-borne vibration levels in terms of average and maximum **root mean square (RMS)** particle velocities with one-second averaging times. Vibration levels are expressed in units of dB relative to a reference velocity of one nanometer per second ($1x\ 10^{-9}$ meters per second), or VdB.

2.3.1.3 Noise Measurement Methodology

The study team measured noise levels at sites 3, 4 and 5 by logging noise levels over one continuous period, as noted in **Table 2-1**. The measurements were conducted outdoors adjacent to residential façades that face toward the Project and would therefore, be most exposed to Project noise. Noise levels were previously measured in 2011 at sites 3 and 4, and at a site similar to Site 5, as part of the Deltaport Terminal, Road and Rail Improvement Project (DTRRIP) Environmental Assessment (BKL 2012). The 2011 measurements were conducted over a two-week period to investigate the day-to-day variability of noise levels. Since this variability had already been assessed, the primary purpose of the 2013 noise measurements was to investigate if community noise levels had changed since 2011. Meteorological conditions during the 2013 monitoring periods such as air temperature, relative humidity, and wind speed and direction were obtained from the Sand Heads weather station.

2.3.1.4 Low-frequency Noise Measurement Methodology

As indicated in **Table 2-1**, low-frequency noise measurements were conducted at sites 5, 6, and 7 while low-frequency noise levels at site 4 were estimated through comparison with levels measured at other sites. The measurements were conducted using methodology consistent with the United Kingdom Department for Environment, Food, and Rural Affairs (University of Salford, 2005). The low-frequency noise study was not extended to locations north of Tsawwassen First Nation Lands (represented by sites 1, 2, and 3), based on the results of the noise and vibration survey (Economic Planning Group 2013) and professional judgement.

The measurements were made with the B&K Type 2250 SLM, which logged frequency data in one-third octave bands and at a one-second time resolution. An audio file was also recorded to permit identification of noise sources. Two SLMs were used at each site with one located outdoors and one indoors. Additional details regarding the placement of the SLMs is provided in **Appendix A**.

While the measurements were conducted over periods of either 24 or 48 hours, only the data from midnight to 5:00 a.m. were analysed. Nighttime data were considered to be representative of low-frequency noise related to Roberts Bank terminals because port-related noise is more prominent, and therefore, more identifiable, during these hours.

As an alternative to the one-third octave band frequency spectra described above, the presence of low-frequency content in the acoustic environment may also be revealed by comparing the overall A-weighted and **C-weighted** sound levels measured in the community. Community noise levels are normally expressed in terms of dBA, since the “A” frequency weighting best simulates the response of the human ear to sound at the moderate intensities generally encountered. At moderate sound intensities, the ear and brain system is much more sensitive to sound at middle and higher frequencies (or pitches) than at lower frequencies, so the A-weighting network is designed to discriminate strongly against low-frequency sound. In contrast, the C-weighting network is intended for use when dealing with sound at higher intensities at which the ear's frequency response is much flatter, that is it discriminates much less strongly against low-frequency sounds. C-weighted noise levels are then more strongly influenced by the presence of low-frequency noise and will thus, be numerically higher than A-weighted levels when such noise is present. The difference between A- and C-weighted noise levels may then be used to identify the presence of low-frequency noise and assess its prominence.

2.3.1.5 Attended Noise Monitoring

During both the noise and low-frequency noise measurements, the study team spent one to three hours at each site to gain familiarity with the acoustic environment and document the level, source, and time of occurrence of various identifiable noise events. During these attended monitoring sessions, particular attention was paid to noise events originating at the Deltaport Terminal and on the Roberts Bank causeway relative to levels from other sources in the community.

2.3.1.6 Ground-borne Vibration Measurement Methodology

The study team measured ground-borne vibration levels at sites 1, 2, and 3 using methodology consistent with the U.S. Federal Transit Administration Transit Noise and Vibration Impact Assessment procedures (FTA 2006). Both ambient (i.e., background) and event-specific vibration levels were measured. Ambient vibration levels are the quasi-steady levels of vibration that exist within the ground due to natural and anthropogenic sources. Ambient vibration levels were measured over periods of approximately 10 to 20 minutes. Event-specific vibrations are transient and are typically caused by sources such as heavy trucks or trains. Sampling periods of event-specific vibration measurements depended on the pass-by time of the source. For example, train pass-by events typically lasted for two to four minutes while heavy truck pass-by events lasted for only a few seconds. Additional details regarding the placement of the accelerometers are provided in **Appendix A**.

2.3.2 Project Construction Noise and Vibration Prediction

2.3.2.1 Construction Schedule and Activities

The construction activities considered in the prediction of noise and ground-borne vibration levels were based on a preliminary list of construction equipment provided in **Appendix 4-F**. The activities considered included construction of the following Project components:

- Marine terminal;
- Three-berth Wharf;
- Pavements;
- Utilities;

- Buildings;
- Causeway widening
- Utilities on the causeway;
- Expanded tug basin;
- Roads and roadway structures; and
- Rail tracks on the causeway and at the marine terminal.

The overall duration of construction activities is anticipated to extend from July 2018 to November 2023. Construction activities related to the widening of the existing causeway will take place between the natural shoreline and the eastern edge of the planned new terminal, a linear extent of approximately 5 km. Activities related to the construction of the RBT2 marine terminal will take place within a zone approximately 1.6 km long and 0.7 km wide located from approximately 5 km to 7 km from the shoreline of Tsawwassen First Nation Lands.

The hours of work of the main construction tasks are identified as follows (**Appendix 4-E**):

- Those activities that will involve handling the largest volumes of materials, namely dredging and Fraser River sand reclamation from the Intermediate Transfer Pit (ITP), will take place 24 hours per day, seven days per week;
- Other marine equipment (e.g., clams, densification) will be active during two 10-hour shifts per day, six days per week;
- Dynamic compaction (involving the dropping of heavy weights to compact sand fill) will be limited to one shift per day, six days per week; and
- Land-based operations, other than dynamic compaction, will involve two shifts per day, six days per week.
- Road and rail construction activities are expected to involve one 10-hour day shift, six days per week.

2.3.2.2 General Approach

In predicting the construction noise levels that may be experienced by sensitive receptors in the upland study area, the procedure used in the FTA procedures (FTA 2006) has generally been followed. The FTA's procedure suggests that if the duration of construction activities is expected to exceed several months, a detailed quantitative construction noise assessment is warranted. In such cases, such as for the Project, the FTA's procedure account for the following factors related to construction equipment and their planned use:

- Types and numbers of heavy construction equipment active during each phase of construction;
- The location of each phase of construction (adjacent marine environment, causeway or terminal);
- Duration of each construction phase (months, years);

- Rated sound emissions of each type of equipment while operating at or near full load; and
- **Usage factor** (**UF**) of each type of equipment (i.e., proportion of time that the equipment is typically in use at or near full load over the specified time period).

The basic acoustic metric used in the FTA's construction noise procedure is the $L_{eq,}$ and the basic expression for the computation of construction noise at a given distance from a given piece of construction equipment with a rated noise emission level (EL) is:

$$L_{eq}(equip) = EL + 10 \log (UF) – 20 \log (D/15) – 10 G \log (D/50) \text{ dBA}$$

where:

- L_{eq}(equip) is the L_{eq} at the receiver resulting from the operation of a single piece of equipment over a specified time period;
- EL is the rated noise emission level of the equipment at 15 m;
- UF is the equipment usage factor (0.0 to 1.0);
- D is the distance from the piece of equipment to the receiver (in metres); and
- G is a constant that accounts for topography and **ground effect**.

In assessing noise from RBT2 construction activities, the EL and UF terms in the equation above are provided in the FTA procedures. The EL values for the dredging vessels and tug boats were obtained from other sources: noise levels for the dredging vessels were obtained from measurements conducted of the dredge Columbia during the construction phase of the Deltaport 3rd Berth Project (BKL 2007); noise levels for tugboats were obtained from measurements conducted during the Oakland Harbor Navigation Improvement Project (U.S. Army Corps 1988). The software CadnaA (see **Section 2.3.3**) was used to calculate attenuation during sound propagation due to distance and other effects. The software then effectively replaced the third and fourth terms of the FTA's equation. The use of the CadnaA model is expected to have improved the accuracy of the calculation procedure, since it employs more sophisticated algorithms.

2.3.2.3 Adjustments for Hours of Work and Usage Factor

Since the basic L_{eq} used by the U.S. FTA and adopted for this study is a time-averaged sound energy metric, the proportion of the time (i.e., hours per day) that a particular noise-generating construction and equipment operation activity will actually be underway must be accounted for. An initial adjustment must then be applied to reflect the number of hours per day that the construction and equipment activity could potentially occur (i.e., the shift duration). A further adjustment is then applied to account for the typical usage factor of the equipment involved (i.e., the proportion of the shift that the source will be active). For example, when the reference noise emission from a given construction and equipment activity is 80 dBA at 15 m, if that activity occurs for two shifts totalling 16 hours per day, and if the usage factor of the construction and equipment activity is 50%, then its duration-adjusted noise emission, when referenced to a full 24-hour day, would be measured as follows:

Duration-Adjusted EL = 80 + 10 log (16/24) + 10 log (0.50) dBA
= 80 – 1.8 – 3.0 dBA
= 75.2 dBA

Duration adjustments were applied to all reference construction and equipment activity noise ELs before they were entered into the CadnaA model.

2.3.2.4 Accounting for Nighttime Construction Work through use of Day-night Equivalent Sound Levels

Some of the major activities involved in Project construction (e.g., dredging, sand reclamation) will proceed throughout the day and night. It is then appropriate that the same noise metric used to quantify the potential effects of RBT2 operational noise in residential areas, the L_{dn}, is used to assess construction noise. In calculating the L_{dn}, the greater sensitivity of residents to noise exposure at night is accounted for by applying a 10 dBA correction or penalty to all noise levels created between 22:00 and 07:00 hours. Consider a situation in which the construction and equipment activity in question produces 80 dBA at 15 m and persists for 24-hours per day, and produces a duty factor of 1.0 (i.e., a constant noise source). In calculating the L_{dn} for such a noise source, one considers that the source produces L_d of 80 dBA between 07:00 and 22:00 hours (for 15 of 24 hours) and a nighttime equivalent level of L_n + 10, or 90 dBA, between 22:00 and 07:00 (for 9 of 24 hours). The daytime and the adjusted nighttime noise levels are then combined on a time-weighted basis and averaged over the 24-hour day to yield the corresponding L_{dn}. In the above example of a steady, 24-hour-per-day noise source, the L_{dn} is 86.4 dBA, or 6.4 dBA greater than the reference EL of 80 dBA. For a 20-hour-per-day activity (i.e., two 10-hour shifts per day) extending from 07:00 hours to 03:00 hours, and so including 5 hours of nighttime work, the correction would be 4.3 dBA and the L_{dn} would be 84.3 dBA.

2.3.2.5 Simultaneous Construction Activities

Construction of RBT2 will typically feature several concurrent activities. Activities that overlap in time were identified from the start and finish dates provided for each major task in **Appendix 4-F**. Then, for each of the approximately 53 months of the Project construction schedule, the duration-adjusted noise ELs (expressed as L_{dn}) of all equipment scheduled to be active during a given month were combined to yield the overall noise emissions from the entire construction site, with causeway and terminal construction activities treated separately.

In the calculations of the distance attenuation corrections using the CadnaA software, the overall noise emissions calculated in **Section 2.3.2.3** for construction and equipment activities at the RBT2 marine terminal site were assumed to originate from an evenly distributed area source covering the entire surface of the proposed new terminal. Each square metre of the terminal surface was then assumed to radiate the same amount of sound energy. Given the large setback distances from marine terminal to the nearest residences in Delta and Tsawwassen, no improvement in modelling accuracy would be achieved by attempting to position specific construction noise sources more precisely within the proposed terminal footprint.

Total noise emissions due to construction activities on the causeway were assumed to be concentrated at one of three points relative to the causeway's elongated shape, which is approximately oriented perpendicular to the foreshore (hence the variation along the length of the causeway in proximity to residences). Point sources were located at each of the eastern end, the western end, and the middle of the causeway. 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 point source location closest to the residential receivers in question.

2.3.2.6 Calculation of Construction Noise Attenuation during Propagation from Source to Receiver

The CadnaA software that was used to calculate construction noise propagation accounts for the following propagation parameters:

- Frequency content of noise in question;
- Setback distance of noise receivers from construction zones;
- Receiver location and height above ground;
- Meteorological conditions; and
- Presence of any natural or man-made objects that might provide noise shielding.

The attenuation of sound in passing through the atmosphere is frequency dependent, with low-frequency sound being attenuated less rapidly than high-frequency sound. Due to the large setback distances involved, only lower-frequency sound would tend to be audible at residential locations in Delta. The sound emitted by each specific piece of heavy equipment will tend to have a somewhat unique frequency (i.e., sound spectrum). Most equipment that will be operating on the causeway, however, is expected to be diesel-powered. The sound spectrum of a typical piece of heavy diesel-powered equipment, a CAT D7 bulldozer, was adopted therefore, for all propagation calculations. The distance attenuation predicted by the CadnaA model for bulldozer noise was then applied to noise originating from all types of construction equipment.

Meteorological conditions used to model construction noise were the same as those used for modelling operational noise. The long-term average windrose obtained at the Sand Heads weather station (**Figure 3-2**) was used to model the effects of wind direction on propagation of construction noise. While some construction activities may not persist for an entire year, annual average sound propagation conditions have been assumed.

The effective heights of construction noise sources above the built-up ground surfaces of RBT2, and the adjacent water surface will typically vary from approximately 1 m to 5 m. Noise source height can have minor effects on the attenuation rate of sound with distance, but more importantly, it can also influence the degree of noise shielding provided by any large objects or terrain features located near the noise source. It has been conservatively assumed that all construction noise sources at RBT2 will be located 4 m above ground, and that equipment and materials located in and around construction zones will provide no noise-shielding effects for themselves or for other construction equipment.

2.3.2.7 Calculation of Total Community Noise Levels during Construction

To calculate total community noise level during construction, the predicted construction L_{dn} were added to the future without Project (2013) L_{dn} to yield combined L_{dn}. Since the decibel scale is logarithmic, decibels are not added in the standard arithmetic fashion. For example, if a sound source at a level of 60 dBA is added to another 60 dBA source, the result is 63 dBA; not 120 dBA. The mathematical formula for decibel addition is as follows:

$$x \text{ dBA} + y \text{ dBA} = [10\log(10\wedge^{(x/10)}+10\wedge^{(y/10)}] \text{ dBA}$$

The combined L_{dn} provide estimates of community noise levels during construction and permit estimation of noise level increases.

2.3.2.8 Construction Vibration Prediction

In addition to noise, ground-borne vibration will also be generated by equipment used for the RBT2 terminal construction and associated causeway widening. The vibration assessment procedures provided in the FTA procedures (FTA 2006) were used to demonstrate that, given the large setback distances from the active construction zones to the nearest sensitive receptors in the upland study area, vibrations originating from construction activities at RBT2 and along the causeway are not expected to be perceptible at these residences. The most intense ground-borne vibrations are expected to be created by pile driving and dynamic sand compaction activities, which involve repeated raising and dropping of very heavy weights from a mobile crane. It is expected that six such dynamic compaction systems may be operating concurrently. It is expected that this activity will create the most intense, but intermittent vibration or shock waves in the sand fill from which the terminal will be constructed and that this vibration or shock could propagate to the natural shoreline and hence to nearby Tsawwassen First Nation homes. The FTA document does not include vibration levels for dynamic compaction; however, it does provide vibration levels for impact pile drivers, sonic (vibratory) pile drivers, clam bucket drops, and vibratory rollers at a reference distance of 7.62 m. The highest levels of construction vibration provided in the FTA document are the upper-range levels created by impact pile drivers, which are at **peak particle velocities** (PPVs) of 0.03857 m/s at 7.62 m, which corresponds to 152 dB VdB. The following expression

(FTA 2006) may be used to predict the ground-borne vibration levels that will typically result at a given distance D (m) from the source of vibration:

$$PPV_{equip} = PPV_{ref} \times (7.62/D)^{1.5} \text{ nm/sec}$$

The minimum setback distance from the eastern edge of the RBT2 marine terminal site to the nearest residences, or likely future residences, on Tsawwassen First Nation Lands is 5 km, while the minimum setback distance from the eastern end of the causeway construction zone to these residential locations is approximately 1 km.

2.3.3 Noise Modelling and Mapping

Annual average noise levels for three temporal cases (existing conditions, future scenarios 1 and 2) were modelled and mapped throughout the study area using the three-dimensional sound propagation modelling software CadnaA. The future scenario 2 (with Project) noise model was also used to assist in the prediction of noise levels within the study area during different phases of Project construction. The following sections present the methodology used to create these models, and to predict and map noise levels.

2.3.3.1 Software

The noise modelling and mapping was executed with the sound propagation modelling and mapping software CadnaA, which is designed to calculate and map noise levels according to various international and national standards. CadnaA fulfills the requirements of European Directive 2002/49/EC, which commits the European Commission member states to map the noise exposure of all agglomerations with populations of 100,000 inhabitants or more for all major roads, railways, and airports. There is no analogous North American requirement. CadnaA performs noise propagation calculations within a physical environment that the user creates by inputting terrain features, anthropogenic obstacles, meteorology, noise sources, and noise receivers. Once a physical model is built and sound sources are created, noise levels can be calculated at any point within the model using the algorithms of specific noise calculation standards. A noise-level map can also be created by calculating noise levels throughout a grid of specified dimensions and then plotting contour lines that correspond to the various noise levels.

2.3.3.2 Noise Calculation Standards

Within the model, noise levels were calculated according to the International Organization for Standardization (ISO) 9613-2:1996; Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation (ISO 1996); and to the French national standard “NMPB-Routes-1996” (Sétra 1997). ISO 9613-2:1996 is a widely used international sound propagation standard, and both ISO 9613 and NMPB-Routes-1996 are approved by European Directive 2002/49/EC for the creation of noise models and maps. Port and rail traffic noise were calculated according to ISO (1996) while road traffic noise was calculated according to Sétra (1997).

2.3.3.3 *Development of Physical Model*

The physical model refers to the model environment in which the noise propagation calculations take place. The models of the three temporal cases all have similar terrain, noise source types, meteorological conditions, and noise calculation points. The models primarily differ in the number, strength, and to some degree, location of the different noise sources. In developing the models, recommendations from the following three documents were considered:

1. Good Practice Guide on Port Area Noise Mapping and Management (NoMEPorts 2008a);
2. Good Practice Guide on Port Area Noise Mapping and Management – Technical Annex (NoMEPorts 2008b); and
3. Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure, European Commission Working Group Assessment of Exposure to Noise (WG-AEN 2006).

The geometry of the models was created using the inputs presented in **Table 2-2**.

Table 2-2 Noise Model Inputs

Model Input	Description	Sources
Terrain	The terrain of the study area was modelled using three-dimensional ground elevation contours at 0.5 m resolution.	• The Corporation of Delta 2008
Roberts Bank terminals map	Map showing the physical extents of Deltaport Terminal, Westshore Terminals, and the Roberts Bank causeway. Shows the location of berths, container storage, railyards, roads, gantry cranes, and other details.	• KC 1995 • KC 2010
Roberts Bank Terminal 2 map	Map of the physical extents of the terminal and widened Roberts Bank causeway. Shows the same details as the Roberts Bank terminals map.	• **Appendix 4-B - Preliminary engineering drawings (AECOM/KCB)** • **Appendix 4-C - Preliminary engineering drawings (Delcan/DMD)**
Road alignments	Road alignments were modelled based on orthophotos and engineering drawings. Road vertical alignments were modelled based on the ground elevation contours. For overpasses, the vertical alignment were obtained from engineering drawings.	• B.C. MOTI 2010 • **Appendix 4-C - Preliminary engineering drawings (Delcan/DMD)**
Rail alignments	Rail track alignments were determined from geographic information system (GIS) mapping. Rail track vertical alignments were modelled based on ground elevation contours.	• WP/Delcan 2012 • **Appendix 4-C - Preliminary engineering drawings (Delcan/DMD)**

The models contain three distinct noise source types: Port operations (Deltaport Terminal and RBT2 marine terminals); rail traffic; and road traffic. Other sources of community noise (e.g., BC Ferries operations, aircraft overflights, farming activities, and natural sounds) were not modelled because either their influence on overall daily noise levels were negligible or because their noise emissions were difficult to quantify. The omission of these sources, however, is not considered to have meaningfully affected the accuracy of the model since differences between the modelled and measured L_{dn} were less than 1 dBA (**Section 3.3.1**).

Port noise emissions are created by many individual noise sources which vary in both level and position over time. The primary sources of this quasi-steady noise include ship diesel generators, ship-to-shore gantry crane electric motors, rubber-tired gantry crane diesel engines, rail-mounted gantry cranes, electric motors, and locomotive diesel engines. In addition to these relatively steady sources of noise, there are also transient and impulsive noises caused by activities such as material handling impacts, ship cargo hatch handling impacts, rail car shunts, and gantry crane alarms.

Rather than model each of these individual and generally mobile port noise sources, overall port noise emissions were represented by area sources. An area source is a horizontal polygon over which the acoustical source strength is evenly distributed and which can therefore account for the variability of noise source locations over time. At the setback distance of the upland noise receptors (3 km to 5 km), the specific location of a noise source within a marine terminal is not as important as it would be if the receptors were closer. For example, if a noise source were to move 100 m, the difference in noise levels (considering spherical spreading only) at a receptor 3 km away would only be 0.1 dBA. In contrast, if the receptor were set back just 200 m, the noise-level difference would be 3 dBA. Separate area sources were created for the Deltaport Terminal and RBT2 marine terminal but not for the Westshore Terminals. The Westshore Terminals facility was not included in the model as a unique noise source because the relative contributions of the two terminals to overall port noise emissions are not specifically known, and because Deltaport Terminal noise is likely dominant since it has more berths and noise sources. The modelled Deltaport Terminal area source does, however, inherently include any noise contributions from the Westshore Terminals as a result of the field measurement data that was used to calibrate the area source (see **Sections 2.3.3.5** and **3.1.1.2**). Therefore, for the remainder of this report, discussions of modelled noise levels refer to just the Deltaport Terminal, whereas discussions of measured noise levels refer to the Roberts Bank terminals (Westshore Terminals and Deltaport Terminal).

Plan and three-dimensional views of the Deltaport Terminal area source that is used in the noise models are presented in **Figures F-1** and **F-2** in **Appendix F**. Three-dimensional views of the RBT2 Terminal area source that is in the future with Project model are presented in **Figures F-3** and **F-4** in **Appendix F**.

Road traffic noise was modelled using the CadnaA object “road”. Under NMPB-Route-96 (Sétra 1997), the **sound power level** (**SWL**) and frequency spectrum generated by a road is primarily determined by the traffic volume and speed, the percentage of the volume comprised by heavy vehicles, and the type of road surface. The roads and highways included in the model, and the sources of the traffic volumes, are as follows:

- Deltaport Way (causeway) (**Appendix 4-D**)
- Deltaport Way (from the eastern end of the causeway to eastern boundary of the study area) (**Appendix 4-D** and Bunt and Associates 2011[1])
- 41 B Street (CTS 2007)
- Tsawwassen Drive North (Bunt and Associates 2011)
- Highway 17 (B.C. Ferries causeway) (MOTI 2014)
- Highway 17 (from the eastern end of the causeway to the eastern boundary of the study area) (MOTI 2014)

Traffic volumes and heavy truck percentages for these routes were based on the **Annual Average Daily Traffic Volumes** (AADT) and 24-hour average heavy truck percentages**.** It was necessary to split the AADT and heavy truck percentages into separate values for the daytime and nighttime hours to allow for calculation of the L_d, $L_{n,}$ and $L_{dn.}$ In cases where sufficiently detailed data were not available, recommendations from the Good Practice Guide for Strategic Noise Mapping (WG-AEN 2006), which addresses situations where insufficient data are available for modelling, were applied as follows:

- For the case of 41B St. and Tsawwassen Drive North where the general day and night traffic volume split was unknown, a split of 90% daytime and 10% nighttime was assumed;
- For the case of 41B St., where the day and night heavy vehicle traffic volume split was unknown, the same values for day and night were assumed; and
- For Tsawwassen Drive North, where the heavy truck volume was unknown, it was assumed that heavy trucks account for 5% of the total volume during the day and 1% during the night.

All vehicles were assumed to be travelling at posted speed limits, and road surfaces were modelled as regular asphalt. Plan and three-dimensional views of the roads within the model environment are presented in **Figures F-5** to **F-9** in **Appendix F**.

Rail infrastructure within the study area consists of both railyards and mainlines. While there is a built-in rail object in CadnaA that calculates rail noise based on an international standard, it is not well suited for modelling noise emissions from railyards or “stop-and-go” rail activity. Rather than using this built-in object, rail noise was modelled using the “line source” object, which allows the user to input custom SWL

[1] The traffic volumes and heavy truck percentages in these two reports were used to calculate total volumes and truck percentages on the off-causeway portion of Deltaport Way that is within the study area.

and frequency spectra. In this case, the data collected during the field measurements was used to calibrate the SWL of the rail line source (see **Section 2.3.3.5**) and the resulting noise emissions were evenly distributed along its length. With the exception of the Roberts Bank causeway, one line source was used to represent each individual rail track and the total sound power was evenly distributed across all rail tracks. On the causeway, where setback distances from noise receptors are greater, three line sources were used to represent all rail tracks. Plan and three-dimensional views of rail tracks for the existing conditions and future models are presented in **Figures F-10** to **F-24** in **Appendix F**.

The three primary noise calculation point locations (receivers) were consistent with sites 3, 4, and 5. The receiver heights were 1.7 m above ground, which is consistent with the height of the microphones used in the measurements and the approximate average height of a North American adult. Site 4 is an exception as the microphone used for the field measurements at this site was located on the roof of the Tsawwassen First Nation Longhouse at an approximate height above ground of 6.5 m. During model calibration the site 4 receiver was set at this height. When forecasting existing and future annual average noise levels, however, the receiver was moved down to the standard height of 1.7 m to be consistent with the height of the other two receivers. Plan and three-dimensional views of the receivers within the model environment are presented in **Figures F-25** to **F-28** in **Appendix F**.

2.3.3.4 Modelling Meteorology

Meteorological conditions affect the propagation of sound through the atmosphere. Temperature and wind gradients cause sound waves to refract either upwards or downwards. The temperature and humidity of the air affects the degree to which the atmosphere absorbs sound energy during propagation. Temperature lapses or upwind sound propagation (i.e., wind blowing from receptor to source) cause sound waves to refract upwards while temperature inversions or downwind sound propagation (i.e., wind blowing from source to receptor) cause sound waves to refract downwards. Upward refraction will tend to increase the attenuation of sound as it propagates, while downward refraction will tend to decrease it. Upward refraction of sound waves results in **unfavourable sound propagation conditions** since they tend to reduce noise levels at distant receptors. Conversely, downward refraction conditions result in **favourable sound propagation conditions** since they tend to increase noise levels at receptors. When temperature inversions or lapses are absent, or when there are cross-winds or very low wind speeds, these are considered to be **neutral sound propagation conditions** since these conditions do not refract sound waves either upwards or downwards.

Under ISO 9613 (ISO 1996), all sound propagation is considered to occur under downwind conditions (i.e., downward refraction) in order to calculate a conservative long-term level. The standard also allows a meteorological correction to be applied, however, if the user wishes to calculate a long-term average level based on more realistic meteorological conditions. The implantation of ISO 9613 within CadnaA allows users to select between three different approaches for calculating this meteorological correction factor.

The first two, namely the approaches recommended by the Bavarian Environmental Agency and the Environmental Agency of North-Rhine-Westphalia (LUA NRW 1999), account only for the effects of wind direction (LfU-Bayern 1999). The third approach is recommended by the Oil Companies' European Association for Environment, Health and Safety (CONCAWE 1981) utilises the Pasquill Stability Categories for atmospheric stability in combination with vector wind speed ranges to define six meteorological categories. The CONCAWE method was not used in the model because it is based on empirical sound propagation data collected exclusively over land, and because the Pasquil Stability Categories were similarly developed in relation to ground surfaces rather than water surfaces. Much of the sound propagation within the study area takes place over water, where atmospheric stability conditions do not correspond to those over land.

The LfU Bayern method was chosen because it accounts for wind direction only, and allows the user to explicitly define the corrections that are applied under crosswind, downwind, and upwind propagation conditions. For this study, a crosswind correction value of -1.5 dBA, and an upwind correction value of -10.0 dBA were used. No downwind correction was applied because ISO 9613-2 calculations assume downwind propagation.

These values are consistent with the findings of the Technical Data Report (TDR) Effects of Meteorological Conditions on Sound Propagation from Roberts Bank Terminals (WAL 2014). The actual corrections applied at noise receptor locations consist of an average value calculated from these three correction values. These average values are calculated based on the direction vector between the noise source and receiver, and on prevalence of different wind directions as defined by a 30-degree increment windrose that is input to the model. The windroses used in the model were developed from wind direction data collected at the Sand Heads weather station.

The highway noise calculation standard (Sétra 1997) presents a similar approach to accounting for meteorological effects during sound propagation. The Sétra method allows the user to enter the percentage of time in which conditions favourable to propagation exist. At other times, homogenous (i.e., neutral) propagation conditions are assumed to exist. This standard is conservative since it does not permit upward sound wave diffraction conditions. The model-calculated noise level is thus, the percentage-weighted average of the noise levels calculated under favourable and homogeneous propagation. The same windroses were used in both the ISO (1996) and Sétra standards, the only difference being that the Sétra windrose has 20-degree, rather than 30-degree, increments.

2.3.3.5 Existing Conditions (2013) Model

The noise-level data collected at sites 3 and 5 was used to calibrate the rail activity line sources and the Deltaport Terminal area source respectively.

The Deltaport Terminal area source covers the physical extents of the Deltaport Terminal and its berths, and was given a height of 4 m above the ground. The average nighttime L_{90} and frequency spectra measured at site 5 were used to calibrate the SWL of this source. As described in **Section 3.1.1.2**, nighttime noise levels and frequency spectra measured at site 5 were considered to be representative of noise emissions from the Roberts Bank terminals and causeway. In the context of the noise model, however, it was assumed that all of this noise emanated from the Deltaport Terminals area source. This area source would then also include any noise contributions from the Westshore Terminals and rail activity on the causeway. The area source frequency spectrum was set to be equivalent to the average measured values and the area source SWL was adjusted until the modelled L_n agreed with the measured L_{90}.

Site 3, which is located approximately 250 m to the south of the section of the RBRC that is within the study area was used to calibrate the rail line sources. The representative frequency spectrum of the rail source was determined by reviewing the measurement data. Since the Deltaport Terminal source had already been calibrated, and the road sources were modelled from the provided traffic data, it was possible to use the model to calculate SWL for the rail sources. With all three source types active, the SWL of the rail sources were adjusted until the modelled and measured levels at site 3 agreed.

Two different sets of windroses, based on data collected at the Sand Heads weather station, were used in the existing conditions model. When calibrating the Deltaport Terminal area source and the rail activity sources, daytime and nighttime windroses were used in the model that corresponded to wind directions during the July 22 to 24, 2013 noise measurement periods. After the noise sources were calibrated, the daytime and nighttime windroses were switched to reflect long-term averages (see **Figure 3-1** in **Section 3.1.1.6**). In this way, the model was calibrated and then used to estimate existing annual average levels at the three noise receiver sites, and to create corresponding noise-level contour maps within the study area.

The model was used to estimate annual average noise levels because the two-day average levels measured in July 2013 are not necessarily representative of annual average levels. Daily average community noise levels almost always show some day-to-day variations due to differences in the types and numbers of noise sources that contribute to the noise environment, differences in the noise emissions from one or more sound source, and the influence of varying meteorological conditions (e.g., relative humidity, temperature, wind speed and direction) on sound propagation. While it was not possible to account for all factors that could result in differences between the measured and annual average levels, the influence of meteorology was estimated using the noise model.

2.3.3.6 Future Noise Model Scenario 1: Year 2025 without RBT2

The future scenario 1 noise model was developed to predict and map 2025 annual average noise levels without RBT2. This model was created by modifying the existing conditions model by updating road traffic volumes, off-causeway rail alignments, and rail source levels to represent 2025 conditions without RBT2; and by updating the SWL of the Deltaport Terminal area source to reflect projected 2025 throughput capacity at Deltaport Terminal.

To scale up the noise emissions of the Deltaport Terminal area source and rail line sources, it has been assumed that the overall SWL will increase in proportion to the increases in throughput capacity and train volumes respectively. Fundamental acoustical principles dictate that noise levels, in terms of decibels, increase according to the following relationship:

$$\text{Noise level increase (dB)} = 10\text{Log}_{10}\,(\text{increased sound power/original sound power})$$

As an example, if the throughput capacity or train volumes were to double, the increase would be:

$$10\text{Log}_{10}\,(2) = 3\text{ dB}$$

Appendix 4-D - Roberts Bank Traffic Data Matrix and Traffic Assessment Review provided the throughput capacities and train volumes that were used for these calculation. The throughput capacity at Deltaport Terminal is predicted to increase from 1.8 million TEUs in 2012 to 2.4 million TEUs in 2017. In the horizon year of 2025 the capacity is still anticipated to be 2.4 million TEUs. The 0.6 million TEU increase then corresponds to a 1.2 dBA rise in noise emissions [10Log(2.4/1.8) = 1.2 dB]. Because the existing conditions model Deltaport Terminal area source included noise from the Westshore Terminals (**Section 2.3.3.5**), the future area source also includes scaled up noise emissions from these terminals. This simplified approach to accounting for future Westshore Terminals is acceptable because these terminals are expected to experience a similar percentage increase in throughput. The 2012 average total two-way rail volume (i.e. one inbound and one outbound movement) for Roberts Bank terminals is 17 trains per day. In 2025, this volume is predicted to have increased to 21 trains per day. This volume increase corresponds to an SWL increase of 0.9 dBA. In addition to increased rail volume, the number of tracks at Gulf Yard will be expanded from three to between four and twelve as part of DTRRIP. To reflect these changes, additional line sources were added to represent each new track (**Figure F-21**). The total 2025 SWL was then evenly distributed among the line sources.

While these throughput capacity and rail traffic volume data were provided for the year 2012, it is expected that any changes between 2012 and 2013 would be negligible. The throughput capacity and rail volumes are presented in **Appendix 4-D**.

2.3.3.7 Future Noise Model Scenario 2: Year 2025 with RBT2

The future scenario 2 model was developed to predict and map 2025 annual average noise levels with Project operation. To create the model, the Future Scenario 1 model was modified as follows:

- Ground contours were modified to represent the widened Roberts Bank causeway and new marine terminal;
- A second area source was added to represent noise emissions from the RBT2 marine terminal; and
- Rail configurations on the causeway were updated to reflect 2025 conditions with Project operation.
- The SWL of rail sources on the causeway were updated to represent 2025 volumes with Project operation.

The RBT2 area source covers the physical extents of the proposed terminal and berths, and was given a height of 4 m above ground. The spatial extents and height of the terminal and widened causeway were obtained from information in **Appendices 4-B** and **4-C**. The RBT2 area source was assumed to have the same SWL and frequency spectrum as the 2025 Deltaport Terminal area source. The rationale for assuming this equivalency is that both terminals will have the same 2025 throughput capacities, same number of berths, and similar types and numbers of equipment. This assumption is conservative for a number of reasons. Firstly, since the 2025 Deltaport area source includes noise from the Westhore Terminals, the 2025 RBT2 area source will also include this additional component of noise. Secondly, it is assumed that, due to split service, Deltaport Terminal, with the same TEU capacity as RBT2, will receive 52 more ship calls per year (i.e. 312 ship calls) in 2025 (**Appendix 4-D**). Finally, certain equipment that is diesel-powered at the Deltaport Terminal will be electrically powered at RBT2, and will therefore, have lower noise emissions. In addition, all berths will be equipped with shore-to-ship electrical power and vessels equipped with these systems will be able to run on electrical power rather than diesel generators (AECOM 2013).

With RBT2 in operation, two-way average daily rail volumes in 2025 are expected to increase, relative to future conditions without the Project, from 21 to 29 (**Appendix 4-D**). In terms of acoustical energy, this volume increase would be expected to correspond to a noise level increase of 1.4 dBA.

2.3.4 Prediction of Future Noise Levels

As discussed in the preceding sections (**Sections 2.3.3.6** and **2.3.3.7),** future annual average noise levels, with and without Project operation, were predicted using the noise models. The following sections present the methodology used to predict future transient and impulsive noise levels, and low-frequency noise levels with and without the Project.

2.3.4.1 Transient and Impulsive Noise Levels

In the future, without the Project, increased throughput capacity at the Roberts Bank terminals, and increased rail volumes on the Roberts Bank causeway and those portions of the RBRC that are within the study area, are expected to increase the rate of occurrence, but not the intensity, of transient and impulsive noise events within the study area. The addition of RBT2 will further increase rail volumes and, hence, the rate of occurrence of transient and impulsive events. Transient and impulsive noise events originating at RBT2 are expected to have lower levels than those originating at the Roberts Bank terminals due to the greater setback distance of RBT2 from noise-sensitive receptors in the upland study area. Any such differences, however, would be expected to be similar in magnitude to the standard deviations presented in **Tables 3-5 and 3-6**. Therefore, it has then been conservatively assumed that the intensities of impulsive and **transient noise** events originating at RTB2 will have the same range and mean value as those found, through measurement, to originate from the existing Roberts Bank terminals.

The rates of occurrence of these noise events have been assumed to increase in proportion to both increases in rail volumes and increased throughput capacity. The percentage increases have been estimated based on the following formula:

Percentage Increase = 100[(new volume – existing volume)/existing volume]

2.3.4.2 Low-frequency Noise Levels

In the future, without the Project, low-frequency noise levels are expected to increase as a result of increased throughput capacity at the Roberts Bank terminals and increased rail activity. For the purposes of predicting future levels, existing low-frequency noise levels at sites 4, 5, 6 and 7 (those where low-frequency noise levels were measured) were assumed to predominantly derive from the following sources:

- Deltaport Terminal equipment;
- Ships berthed at Deltaport Terminal; and
- Locomotives and trucks on the Roberts Bank causeway.

Based on this assumption, future increases in low-frequency noise levels at the four sites are expected to be numerically equal to the predicted increases in A-weighted noise levels due to the following:

- RBT2 marine terminal operation;
- Expanded throughput capacity at Deltaport Terminal; and
- Increased locomotive and truck traffic on the Roberts Bank causeway.

To predict these increases it was necessary to estimate noise levels from Deltaport Terminal, RBT2, and the Roberts Bank causeway in isolation from other sources of noise. The noise model was used to calculate **component L_{dn}**, which provide estimates of noise levels due to only these specific noise sources. The increases in the component L_{dn}, from 2013 to 2025, were then applied to the existing low-frequency noise levels to obtain the future levels of low-frequency noise with and without the Project. The low-frequency noise levels estimated at site 4 are considered representative of levels on Tsawwassen First Nation Lands while those measured at sites 5, 6, and 7 are considered representative of the range of levels experienced within the Tsawwassen neighbourhood. Based on professional judgement the results of the noise and vibration survey (Economic Planning Group 2013), the low-frequency noise component of the study was not extended to locations north of Tsawwassen First Nation Lands.

2.3.5 Estimation and Prediction of Above-water Noise Levels in Marine Areas

The following sections describe how above water noise levels were estimated and predicted within the marine portion of the study area.

2.3.5.1 Existing and Future Noise Levels

The noise models were used to estimate and predict daytime, above-water annual average noise levels in the marine portion of the study area. Annual average L_d, were estimated for the existing conditions year (2013), and predicted for the future horizon year (2025) with and without the Project. The limitations of the noise model are discussed briefly. The noise model did not include sources to represent marine vessels in transit. The modelled Deltaport and RBT2 sources do, however, include the contributions of noise from ships at berth. In comparison to noise from berthed ships, which is present for relatively long periods of time (vessels are typically berthed for approx. 30 to 50 hours), the influence of noise from ships in-transit is expected to be negligible in terms of its effect on L_d in the marine study area. The model also did not include noise from other sources such as the B.C. Ferries terminal. As discussed in **Section 2.3.3.3**, these other sources were not included because either their influence on overall daily noise levels were negligible or because their noise emissions were difficult to quantify. Also, while noise from the Westshore Terminals was included in the modelled Deltaport Terminal area source, this source only covers the physical extents of the Deltaport Terminal. Therefore, at locations close to the Westshore Terminals, and the B.C. Ferries Terminal, noise levels would be expected to be higher than predicted by the model. Since no measurements were conducted at above-water locations within the marine area, it was not possible to verify the accuracy of the estimated existing noise levels; however, this limitation does not affect the key results of this analysis, which provides comparisons of future noise levels with and without the Project.

Noise levels were calculated throughout the marine component of the study area over a 100-m by 100-m grid. Noise levels were calculated at a height of 4 m above the water to approximate the average elevation of users of marine vessels. The grid noise levels were then used to create **sound-level contour maps**. Noise levels were also calculated at 1-km interval setback distances in all four cardinal directions from the approximate centre point of the new RBT2 marine terminal out to a distance of 10 km. The coordinates of this estimated centre point, referenced according to the Universal Transverse Mercator (UTM) Coordinate System North America Datum 83 – Zone 10, are as follows:

- Longitude 486466.44; and
- Latitude 5429548.52.

2.3.5.2 Construction Noise

Noise levels within marine areas during the construction phase of the Project were calculated using similar methodology to that used for upland areas (**Section 2.3.2)**. The differences are as follows:

- All construction noise was conservatively assumed to originate from the RBT2 terminal rather than the causeway; and
- L_d rather than L_{dn} were calculated.

Noise levels were calculated at the same 1-km setback distances from the approximate centre point of the new RBT2 marine terminal as was the case for the existing and future noise levels.

3.0 RESULTS

This section presents the main findings of the noise and vibration study.

3.1 NOISE AND VIBRATION MEASUREMENT RESULTS

3.1.1 Average Daily Levels

The results of the noise measurements at sites 3 to 5, expressed as two-day average levels, are summarised in **Table 3-1**.

Table 3-1 Summary of Noise Measurement Results

Site No.	2-Day Average Noise Level (dBA)				Day-to-Day Variation (dBA)			
	L_{dn}	$L_{eq}(24)$	L_d	L_n	L_{dn}	$L_{eq}(24)$	L_d	L_n
3	55.7	49.2	49.2	49.2	2.4	2.0	1.7	2.3
4	52.7	46.9	47.1	46.1	0.2	0.9	1.7	0.7
5	53.4	48.5	49.4	46.4	0.6	0.4	0.3	0.7

Notes: L_{dn} – day-night equivalent sound level; $L_{eq}(24)$ – twenty-four hour equivalent sound level; L_d – daytime equivalent sound level; L_n – night equivalent sound level;.
All measurements collected over a 48-hour period from 22 to 24 July, 2014.

The average L_{dn} at the three sites ranged from 52.7 to 55.7 dBA, and the day-to-day variations in all four noise metrics were 2.4 dBA or less. Noise history charts for the three sites are provided in **Appendix B**. These charts show the variation in 15-minute L_{eq}, L_{max} and L_{90} at the three sites over the 48-hour monitoring periods.

3.1.2 Noise Environment Composition

Table 3-2 presents the various sources of noise that were observed to compose the noise environments at sites 3, 4 and 5.

Table 3-2 Noise Environment Composition

Site No.	Dominant Sources of Community Noise
3	• Roberts Bank terminals; • Roberts Bank causeway road and rail traffic; • Deltaport Way traffic; • RBRC traffic; • Construction activities on Tsawwassen First Nation land; • Farming activities; • Daycare at residence; • Aircraft; • Local activities; and • Natural sounds (e.g., wildlife, wind).
4	• Roberts Bank terminals; • Roberts Bank causeway; • Deltaport Way traffic; • RBRC traffic; • Tsawwassen Dr. N traffic; • Highway 17 traffic; • BC Ferries; • Aircraft; • Local activities; and • Natural sounds (e.g., wildlife, wind).
5	• Roberts Bank Terminal; • Roberts Bank causeway road and rail traffic; • Highway 17 traffic; • BC Ferries; • Marine vessels; • Aircraft; • Local activities; and • Natural sounds (e.g., wildlife, wind).

To aid in the calibration of the existing conditions model, average L_{dn} at sites 4 and 5, due only to operations at the existing Roberts Bank terminals, were estimated from the nighttime L_{90} data collected during the measurements. The nighttime noise level data was used because during these hours, when other sources of community noise are absent or less prominent, the Roberts Bank terminals are the steadiest source of noise. This estimate is conservative (i.e., tending to over-predict Roberts Bank terminals noise emissions) because the nighttime L_{90} inevitably contains acoustic energy from other sources. This same method could not be used at site 3 (41 B St. #2) due to the greater setback distance of this site from the terminals, and due to the presence of nighttime rail noise from the section of the RBRC that is within the study area. At site 3, noise levels from the existing terminals were instead estimated using the existing conditions noise model.

Since the terminals operate twenty-four hours a day, it was assumed that nighttime levels were representative of twenty-four hour average levels. Although there are no heavy trucks travelling to and from the terminals during night, the noise level measurements do not show any evidence that the terminals generate less noise during the night. Referring to the noise history charts for site 4 in **Appendix B**, it can be seen that, for both twenty-four hour measurement periods, the L_{90} were generally higher in level during the night than during the day. Since the L_{90} at this site is strongly influenced by noise from the terminals, these results suggests that the terminals were actually producing higher noise levels at night during the July 2013 measurements.

After estimating component L_{dn} due to the terminals, it was also possible to estimate component L_{dn} due to all other source of community noise. This was done by subtracting the terminals component L_{dn} from the total measured L_{dn} presented in **Table 3-1** (for an explanation of decibel arithmetic, please refer to **Section 2.3.2.7)**.

Table 3-3 presents component L_{dn} for the Roberts Bank terminals, and component L_{dn} for all other sources of community noise. Also presented are the total L_{dn} of **Table 3-1**.

Table 3-3 Noise Levels of Roberts Bank Terminals and Other Sources of Community Noise

Site No.	Component L_{dn} (dBA)		Total L_{dn}	Percentage Contribution to Total L_{dn}	
	Roberts Bank terminals	All other Sources of Community Noise		Roberts Bank terminals	All other Sources of Community Noise
3 (41B St. #2)	44.9	55.3	55.7	8%	92%
4 (Longhouse)	48.9	50.4	52.7	42%	58%
5 (Pacific Dr.)	48.8	51.6	53.4	34%	66%

Noise from the Roberts Bank terminals is conservatively estimated to account for approximately 34 to 42% of the total noise (on an energy basis) experienced at sites 4 and 5. At Site 3 (41 B St. #2), noise from the terminals accounts for only about 8% of the total noise. This is due to larger setback distance of site 3 from the terminals and causeway relative to the other sites, and the dominance of noise from rail activity on the section of the RBRC that is within the study area.

3.1.3 Transient and Impulsive Noise Levels

The many on-going operations at the Roberts Bank terminals and the road and rail traffic on the Roberts Bank causeway produce a quasi-steady noise signature that is occasionally punctuated by impulsive noise events. Impulsive noises are characterised by their rapid onset and decay, and by durations that are very brief (less than one second) compared to the typical period between events. At sites 4 and 5, impulsive noises events from material handling at the terminals and train shunting on the causeway are audible (especially at night). At site 3, impulsive noises from **rail shunting** on the section of the RBRC that is within the study area are more prominent than impulsive noises occurring at the Roberts Bank terminals and on the causeway. The ranges of noise levels created by impulsive noise events were investigated at the three sites during the existing conditions measurements.

At site 4, L_{max} were determined by comparing field notes gathered during a one-hour period on the evening of July 22, 2013 with measured noise-level histories. At site 5, L_{max} were determined by reviewing audio files recorded for the nights of July 23 and 24, 2013 to identify impulsive events in the noise-level histories. At site 3, both techniques were employed. **Table 3-4** presents the numbers of impulsive noise events from the Roberts Bank terminals and causeways, observed at sites 4 and 5, and the numbers of impulsive noise events from shunting on the section of the RBRC that is within the study area, observed at site 3. Also shown are the ranges and averages of the L_{max} noise events.

Table 3-4 Impulsive Noise Levels

Site No.	Time Period	No. of Observed Events	No. of Observed Events/hr	Maximum Sound Level (L_{max}) (dBA)		
				Range	Avg.	St Dev
3	August 8, 2013,12:00 a.m. to 4:00 a.m. July 23, 2013, 3:00 p.m. to 4:00 p.m.	7	1.4	49.5 to 56.5	53.1	2.8
4	July 22, 2013, 9:00 p.m. to 10:00 p.m.	6	6.0	45.8 to 52.2	48.6	2.5
5	July 23, 2013, 12:00 a.m. to 4:00 a.m.; July 24, 2013, 12:00 a.m. to 4:00 a.m.	48	6.0	42.9 to 53.8	49.0	2.0

At site 3 there were also transient noise events on the RBRC that produced non-continuous noises with less rapid onsets and decays than impulsive noises. These events were created during train pass-bys by either locomotive diesel engines or wheel-rail interactions. **Table 3-5** presents L_{max} and **sound exposure levels** (SEL) observed at site 3 from these events. The L_{max} and SEL were determined by reviewing the recorded audio files to identify rail events in the noise-level histories. The events, which included locomotive pass-bys and wheel-rail interactions, occurred during the time periods of 1:00 p.m. August 7, 2013 to 3:00 p.m. August 8, 2013. In certain cases, a wheel-rail noise was present, but there was no identifiable locomotive noise. These circumstances were likely due to train movements in which the locomotives were distant from the microphone position.

Table 3-5 Maximum Sound Levels and Sound Event Levels at Site 3 from Locomotive Pass-bys

Time Period	Number of Observed Events		Number of Observed Events/hr		Locomotive Maximum Sound Level (L_{max}) (dBA)			Wheel-Rail Noise Sound Exposure Level (SEL) (dBA)		
	Loco-motive Pass-by	Train Movement	Loco-motive Pass-by	Wheel-Rail Noise	Range	Avg.	St Dev	Range	Avg.	St Dev
August 7, 1:00 p.m. to August 8, 3:00 p.m., 2013	18	26	0.7	1.0	46.2 to 62.2	55.3	4.1	63.4 to 82.0	73.3	5.0

3.1.4 Day-to-Day Variation in Noise Levels

In 2011, noise levels were measured at sites 3 and 4 for a two-week period as part of the DTRRIP EA (BKL 2012). While site 5 was not included in the 2011 measurements, a residence further south that also fronted the ocean (476 Tsawwassen Beach Road) was included. This longer-term monitoring provides an indication of the day-to-day variation in overall community noise levels. **Table 3-6** presents the ranges and averages of the 2011 L_{dn} and compares them to the average 2013 L_{dn}.

Table 3-6 2011 Noise Measurement Results – Deltaport Terminal, Rail and Road Improvement Project Study

Site No.		2011 Site Address	2011 L_{dn} (dBA)		2013 Average L_{dn} (dBA)
DTRRIP (2011)	2013		Average	St. Dev.	
1	5[1]	476 Tsawwassen Beach Rd.	53	2	53.4
2	4	2148 Tsawwassen Dr. North	50	1	52.7
3	3	3044 41B St.	59	2	55.7

Note: Derived from Deltaport Terminal, Road and Rail Improvement Project Environmental Noise and Vibration Assessment, Final Draft Report (BKL 2012); site 5 in the 2013 study was located at 1043 Pacific Drive.

The average L_{dn} at sites 1 to 3 ranged from 50 and 59 dBA with standard deviations of 1 to 2 dBA (**Table 3-6**). These L_{dn} differ from the 2013 L_{dn} by -2.7 dBA to +3.3 dBA. At sites 2 and 3, the variations are more than one standard deviation away from the 2013 values. These results suggest that average noise levels at sites 1 and 2 may have changed since the 2011 measurements.

If the 2011 standard deviations are applied to the 2013 L_{dn}, typical day-to-day variations would be expected to result in the following noise-level ranges:

- Site 3, 3044 41B Street L_{dn} 53.7 to 57.7 dBA;
- Site 4, 2148 Tsawwassen Drive North L_{dn} 51.7 to 53.7 dBA; and
- Site 5, 476 Tsawwassen Beach Road L_{dn} 51.4 to 55.4 dBA.

Additional historical noise data are available for sites 3 and 4, and for sites that are representative of site 5. **Table 3-7** presents the historical noise data collected by various parties and presented in the DTRRIP environmental assessment (BKL 2012). For comparative purposes, the results of the 2011 and 2013 noise-level measurements are also included.

Table 3-7 Historical Noise Measurement Results

2013 Site No.	Year	Measurement Duration (Days)	Day-night Equivalent Sound Level (L_{dn}) (dBA)
3	1995	7	55
	2004	2	62
	2011	14	59
	2013	2	55.7
4	1993	1	49
	2000	1	54
	2001	1	54
	2011	14	50
	2013	2	52.7
5	2004	2	51
	2011	15	53
	2013	1	53.4

Note: The 2004 and 2011 Site 5 measurements were conducted at 678 and 476 Tsawwassen Beach Road respectively.

Average daily community noise levels, (L_{dn}) at sites 4 and 3 have varied by 5 and 7 dBA respectively between 1993 and 2013, and between 1995 and 2013 respectively (**Table 3-6**). At site 5 the variation has been smaller (2.4 dBA) over a shorter time frame (2004 to 2013). The noise environments at these sites are dynamic and attributable to diverse sources (**Table 3-2**). The causes of changes in annual average community noise levels over time within the study area are considered to include the following:

- Growth in Roberts Bank terminals throughput volumes;
- Growth in road traffic volumes;
- Changes to the arterial road and highway network;
- Growth in rail traffic volumes;
- Changes to the track configuration of the RBRC;
- Operational and fleet changes at BC Ferries Terminal; and
- Residential, commercial, and industrial developments.

3.1.5 Low-frequency Noise Measurement Results

Results of the low-frequency noise measurements are presented in **Appendix C**, which includes tables and charts that list average noise levels in the 12.5- to 10,000-Hz one-third-octave bands for both outdoor and indoor monitoring locations. **Table 3-8** presents the average A- and C-weighted noise levels and their differences, which are used to indicate the presence of low-frequency noise. The noise levels presented are five-hour averages of the one-second L_{eq} logged from midnight until 5:00 a.m.

Table 3-8 Comparison of A and C-weighted Existing Noise Levels

Site	A-weighted Noise Level (dBA)		C-weighted Noise Level (dBC)		Difference (dBC minus dBA)	
	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
5	43.4	35.8	61.3	51.8	17.9	16.0
6	32.5	25.9	49.9	38.5	17.4	12.6
7	42.4	26.9	61.7	49.4	19.3	22.5

Average nighttime A-weighted noise levels at the three sites ranged from 32.5 to 43.4 dBA outdoors and from 25.9 to 35.8 dBA indoors (**Table 3-8**). C-weighted noise levels can be seen to range from 49.9 to 61.7 dBC outdoors and from 38.5 to 51.8 dBC indoors. Outdoor noise levels were the lowest at site 6 since, unlike the other two sites, it is located inland of the bluffs that overlook the ocean and Roberts Bank terminals and causeway. Indoor noise levels were highest at site 5 since, unlike at the other two sites, the window was open in the room in which the microphone was located. The differences between A- and C-weighted noise levels, both indoors and outdoors, can be seen to fall within the range of 12.6 to 22.5, which indicates the presence of low-frequency noise in the community.

3.1.6 Meteorological Conditions

Table 3-9 summarises the meteorological conditions recorded at the Sand Heads weather station during the July 2013 measurement period. For a discussion of the effect of meteorology on sound propagation, please see **Section 2.3.3.4**.

Table 3-9 Meteorological Conditions during Noise Measurements

Date and Time (2013)	Relative Humidity (%)		Air Temperature (C°)		Wind Speed (km/hr.)	
	Range	Avg.	Range	Avg.	Range	Avg.
July 22, Day (7:00 a.m. to 10:00 p.m.)	70 to 84	76	17 to 21	19	4 to 17	9
July 22 to 23, Night (10:00 p.m. to 7:00 a.m.)	82 to 89	87	16 to 19	17	4 to 13	9
July 23, Day (7:00 a.m. to 10:00 p.m.)	52 to 87	74	16 to 23	20	4 to 9	6
July 23 to 24, Night (10:00 p.m. to 7:00 a.m.)	79 to 86	82	15 to 19	17	13 to 17	15
Jul 24, Day (7:00 a.m. to 10:00 p.m.)	77 to 82	80	16 to 17	16	7 to 13	10

Since average wind speeds were never less than 6 km/hr., it is unlikely that either strong temperature inversion or lapse conditions existed during the measurement period for any appreciable amount of time (**Table 3-9**). Wind direction would then be the primary determinant of whether propagation conditions were favourable, unfavourable, or neutral. **Figure 3-1** presents a windrose that was developed from weather data recorded at the Sand Heads weather station for the July 22 to 24, 2013 noise measurement period. The dominant wind direction during this period was between east southeast and southeast. For sites 5 to 7, which are located to the east and southeast of the Roberts Bank terminals and causeway, propagation conditions for Roberts Bank terminals' noise were predominantly unfavourable. For sites 3 and 4, which are located to the northeast of Roberts Bank Terminal and causeway, propagation conditions would have been predominantly neutral.

For comparison, **Figure 3-2** provides a long-term windrose from the Sand Heads weather station based on data collected from 1967 to 2011. Comparing **Figures 3-1** and **3-2**, it can be seen that there is some correlation between the July 22 to 24 and long-term windroses. The primary difference is the absence of any winds directly from the east or northwest in the July 22 to 24 windrose.

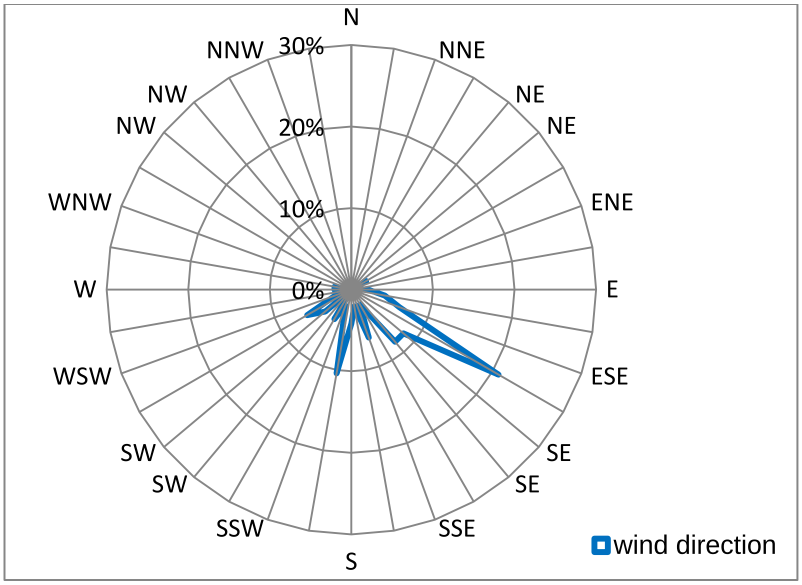

Figure 3-1 Windrose for July 22 to 24, 2013 as Recorded at Sand Heads Weather Station

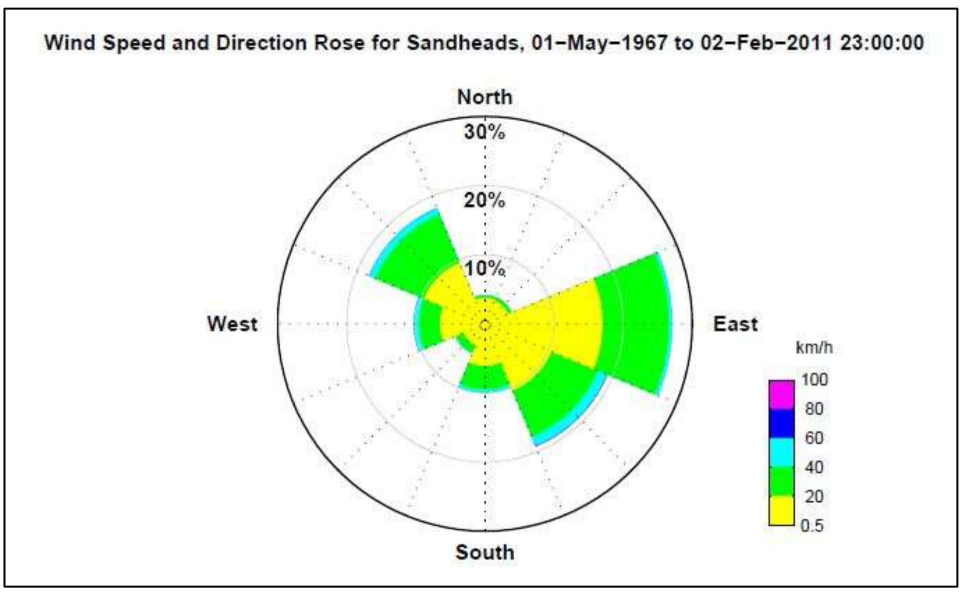

Figure 3-2 Long-term Windrose from Sand Heads Weather Station Historical Data

3.1.7 Ground-borne Vibration Measurement Results

Results of the ground-borne vibration measurements (**Table 3-10**) include observed ambient vibration levels as well as average and maximum vibration levels created by events such as train or heavy truck pass-bys. For reference, the approximate threshold for human perception of ground-borne vibration is 93 VdB (FTA 2006).

Table 3-10 Ground-borne Vibration Measurement Results

Site No.	Measurement Date(s)	Approximate Setback from Rail Tracks (m)	Ground-borne Vibration Level (VdB)				Ground-Borne Vibration Sources
			Ambient (Road Traffic)	Heavy Truck	Train		
			Average	Max.	Average	Max.	
1	August 7, 2013	700 m	88	116	-	-	Arthur St. Traffic, Deltaport Way Traffic, Trains
2	August 7 and 8, 2013	630 m	88	113	84	95	41 B St. Traffic, Deltaport Way Traffic, Trains
3	August 8 2013	250 m	79	90	95	104	Deltaport Way Traffic, Trains

At sites 1 and 2, the dominant sources of vibration were heavy trucks on the nearest roads (Arthur Street for site 1 and 41 B Street for site 2) and trains on the section of the RBRC that is within the study area. At site 2, train pass-bys created average and maximum vibration levels of 84 and 95 VdB respectively (**Table 3-10**). At site 1, it was not possible to measure train vibration levels due to constant interference from traffic on Arthur Street. Since sites 1 and 2 have similar setbacks from the rail tracks, however, train vibration levels at site 2 are expected to be representative of those at site 1. Heavy truck pass-bys created higher vibration levels with maximum levels of 113 and 116 VdB at sites 1 and 2 respectively. At both sites 1 and 2, trains and heavy trucks were found to create ground-borne vibration levels above the threshold of perception.

At Site 3 (41 B St. #2), the dominant sources of vibration were trains on the section of the RBRC that is within the study area and heavy trucks on Deltaport Way. Train pass-bys created average and maximum vibration levels of 95 and 104 VdB respectively (**Table 3-10**). Average train vibration levels were established largely by passing railcars while maximum levels were created by the passage of locomotives. In comparison, heavy truck pass-bys on Deltaport Way created a lower maximum level of 90 VdB. At site 3, therefore, trains on the section of the RBRC that is within the study area were found to create ground-borne vibration levels above the threshold of perception. However, ground-borne vibration levels from heavy trucks on Deltaport Way were not above this threshold.

At all three sites the term "ambient ground-borne vibration" refers to the average ground-borne vibration level in the absence of the dominant transient sources: heavy trucks and trains. Ambient levels at the three sites were likely controlled by light vehicle traffic on the nearest roads. These ambient vibration levels would have included any ground-borne vibration generated at the Roberts Bank terminals or on the Roberts Bank causeway. However, it was not possible to determine if such vibration was present. Ambient vibration levels were found to be below the threshold of perception.

Charts showing the vibration spectra measured at these sites are presented in **Appendix D**.

3.2 Predicted Construction Noise and Vibration Levels

The following sections discuss the predicted noise and vibration levels during Project construction.

3.2.1 Construction Noise Levels

Table E-1 of **Appendix E** presents predicted monthly average construction L_d from July 2018 to November 2023 at sites 3 to 5. **Table E-2** presents combined L_d where predicted construction L_d and modelled annual average future without Project L_d (**Table 3-14**) have been added together (See **Section 2.3.2.7**). **Table E-3** shows the increases represented by the combined L_d when compared with the future without Project L_d. Equivalent data to that presented in **Tables E-1** through **E-3** are presented for L_n in **Tables E-4** through **E-6**, and for L_{dn} in **Tables E-7** through **E-9**. These data are specifically referenced in the Human Health Risk Assessment (Section 27: Human Health Effects Assessment) of the EIS, and in supporting appendices and are summarised in **Table 3-11**.

Table 3-11 Predicted Noise Levels and Noise-level Increases during Project Construction

Site	Annual Average Future without Project L_d (dBA)	Construction L_d (dBA)		Combined L_d (dBA)		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	51.9	14.7 to 49.3	39.5	51.9 to 53.8	52.5	0.0 to 1.9	0.6
4	48.4	16.1 to 47.5	39.0	48.4 to 51.0	49.3	0.0 to 2.6	0.9
5	52.3	17.3 to 41.2	36.1	52.3 to 52.6	52.4	0.0 to 0.3	0.1
Site	Annual Average Future without Project L_n (dBA)	Construction L_n (dBA)		Combined L_n (dBA)		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	51.5	14.7 to 49.3	37.8	51.5 to 53.5	51.9	0.0 to 2.0	0.4
4	44.5	16.1 to 47.5	37.4	44.5 to 49.3	48.5	0.0 to 4.8	1.3
5	48.5	17.3 to 40.6	34.8	48.5 to 49.1	48.7	0.0 to 0.6	0.2
Site	Annual Average Future without Project L_{dn} (dBA)	Construction L_{dn} (dBA)		Combined L_{dn} (dBA)		Increase, Combined vs. Existing (dBA)	
		Range	Avg.	Range	Avg.	Range	Avg.
3	58.0	21.1 to 55.7	45.0	58.0 to 60.0	58.5	0.0 to 2.0	0.5
4	51.7	22.5 to 53.9	44.4	51.7 to 56.0	53.0	0.0 to 4.3	1.3
5	55.7	23.7 to 49.9	42.0	55.7 to 56.7	56.0	0.0 to 1.0	0.3

Construction noise is predicted to increase L_d, L_n, and L_{dn} by 0.0 dBA to 4.8 dBA over the five-and-a-half-year construction phase. The highest noise levels are expected to occur in January 2019 during dredging and reclamation associated with construction of the new marine terminal and causeway widening. On average, construction noise is not expected to increase the three noise metrics by more than 1.3 dBA. These relatively modest increases are primarily a result of the large setback distances of noise-sensitive upland receptors from the RBT2 terminal and causeway construction zones.

3.2.2 Construction Vibration Noise Levels

Maximum construction ground-borne vibration levels, during dynamic compaction, are not expected to exceed 90 VdB. This level is 3 VdB below the 93 VdB threshold of perception (FTA 2006).

3.3 Noise Modelling and Mapping Results

3.3.1 Calibration of Deltaport Terminal and Rail Noise Sources in Existing Conditions Model

The existing noise model was used to calibrate the Deltaport Terminal area source and the rail activity sources as described in **Section 2.3.3.5**. The results of the model calibration are presented in **Table 3-12**.

Table 3-12 Existing Conditions Model Calibration

Site	Modelled Noise Level (dBA)		Measured Existing Noise Level (dBA)	
	Noise Sources			
	Deltaport Terminal	All Modelled Sources	Avg. Nighttime Ninety Percent Exceedance Level (L_{90})	Day-night Equivalent Sound Level (L_{dn})
	Night Equivalent Sound Level (L_n)	Day-night Equivalent Sound Level (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

The SWL of the Deltaport Terminal source was adjusted until the model calculated L_n at site 5 matched the average nighttime L_{90} of 42.4 dBA measured at site 5. At site 3 the modelled Deltaport Terminal L_n is 3.3 dBA lower than the measured L_{90}. This result is attributed to the nighttime L_{90} at this site being strongly influenced by noise from the section of the RBRC that is within the study area **(Section 3.1.2)**. At site 4, where nighttime levels are strongly influenced by noise from the Roberts Bank terminals, the model calculated L_n for the Deltaport Terminal is within 0.8 dBA of the measured average nighttime L_{90} (**Table 3-1**). With all sources of noise active in the model, the model calculated and field measured L_{dn} agree to within 0.8 dBA.

After the model was calibrated, and before prediction of annual average levels, the model windrose was changed to represent long-term average wind conditions, and the height of the site 4 receiver was changed from 6.5 m to 1.7 m above ground (see **Section 2.3.3.5**). **Table 3-13** compares the modelled L_{dn} before and after these changes were made.

Table 3-13 Existing Day-night Equivalent Sound Levels – Model Calibration and Annual Average Estimates

Site	Model Calculated Day-Night Equivalent Sound Level (L_{dn}) (dBA)		Difference between Annual Average and Model Calibration L_{dn} (dBA)
	Model Calibration (July 22-24, 2013)	Estimated Annual Average (2013)	
3	55.6	56.7	1.1
4	52.5	50.9	-1.6
5	54.2	55.1	0.9

The modelled annual average L_{dn} at sites 3 and 5 were from 0.9 to 1.1 dBA higher than the L_{dn} modelled during the calibration procedure (**Table 3-13**). The annual average L_{dn} at these sites are higher because the annual average windrose includes winds from the west and northwest[2] that were not present during the monitoring period. At site 4, the annual average L_{dn} was 1.6 dBA lower than the calibration L_{dn} due to the effect of lowering the receiver height from 6.5 m to 1.7 m above ground.

3.3.2 Existing Conditions Noise Model – Calculated Noise Levels and Maps

Table 3-14 presents the existing annual average noise levels (total noise levels due to all modelled sources) at each site as predicted by the model.

Table 3-14 Existing (2013) Annual Average Noise Levels

Site	Noise Level (dBA)		
	Daytime Equivalent Sound Level (L_d)	Night Equivalent Sound Level (L_n)	Day-night Equivalent Sound Level (L_{dn})
3	50.2	50.3	56.7
4	47.9	43.5	50.9
5	52.0	47.8	55.1

Noise contour maps of existing L_{dn} within the study are presented in **Figures G-1** to **G-4** in **Appendix G**. **Figure G-5** of **Appendix G** provides a three-dimensional view of the noise contours from the vantage point of site 5 on the Tsawwassen bluffs.

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[2] Winds from the west and northwest would tend to increase noise levels from the Roberts Bank terminals at sites 4 and 5 relative to conditions where there is no wind or a cross-wind (see **Section 2.3.3.4**)

Using the noise model, it is possible to toggle different groups of noise sources on or off and calculate component L_{dn}. These component L_{dn} are then only due to noise from certain noise sources. The noise source groups modelled included the following:

1. Deltaport Terminal sources (Deltaport Terminal area source and Roberts Bank causeway road and rail sources);
2. Upland rail sources (rail traffic sources on the RBRC within the study area but outside of the Project area); and
3. Upland road sources (road traffic sources outside of the Project area).

Table 3-15 presents the modelled component L_{dn} for these source groups and their percentage contributions to the total L_{dn} of **Table 3-15**.

Table 3-15 Existing Component Day-night Equivalent Sound Levels (L_{dn})

Site	Component Day-night Equivalent Sound Level (L_{dn}) (dBA)			Percentage of Total L_{dn}		
	Deltaport Terminal Sources	Upland Rail Sources	Upland Road Sources	Deltaport Terminal Sources	Upland Rail Sources	Upland Road Sources
3	45.3	55.5	48.8	7%	77%	16%
4	48.4	39.5	46.4	57%	7%	36%
5	51.8	32.9	52.4	46%	1%	53%

In the existing conditions model, the L_{dn} at site 3 is dominated by upland rail sources (**Table 3-15**). At site 4, the L_{dn} is dominated by Deltaport Terminal noise but also includes a sizeable contribution from road noise (Tsawwassen Drive North). At site 5, there is predicted to be almost equal contributions from Deltaport Terminal and road sources (Highway 17).

3.3.3 Future Scenario 1 Model (without RBT2) – Calculated Noise Levels and Maps

Future scenario 1 represents 2025 conditions without the Project. **Table 3-16** presents the modelled annual average noise levels at each site with all model noise sources active.

Table 3-16 Future Scenario 1 Annual Average Noise Levels

Site	Noise Levels (dBA)		
	Daytime Equivalent Sound Level (L_d)	Night Equivalent Sound Level (L_n)	Day-night Equivalent Sound Level (L_{dn})
3	51.9	51.5	58.0
4	48.4	44.5	51.7
5	52.3	48.5	55.7

Noise contour maps of future scenario 1 L_{dn} within the study area are presented in **Figures G-6** to **G-9** in **Appendix G**. **Figure G-10** provides a three-dimensional view of the noise contours from the vantage point of site 5.

Table 3-17 presents the future scenario 1 component L_{dn} for the different noise source groups and their percentage contributions to total L_{dn}.

Table 3-17 Component Day-night Equivalent Sound Levels

Site	Day-night Equivalent Sound Level (L_{dn}) (dBA)			Percentage of Total L_{dn}		
	Deltaport Terminal-Sources	Upland Rail Sources	Upland Road Sources	Deltaport Terminal Sources	Upland Rail Sources	Upland Road Sources
3	46.5	56.6	51.0	7%	73%	20%
4	49.6	40.3	46.5	62%	7%	31%
5	53.0	33.7	52.4	53%	1%	46%

The percentage contributions for the different sources (**Table 3-17**) are similar to those calculated in the existing conditions (2013) model (**Table 3-15)**. At site 3, a slight decrease is predicted in 2025 for the dominance of noise from upland rail sources, as well as a slight increase in the contribution of upland road noise. At sites 4 and 5, the percentage contributions of Deltaport Terminal sources to the total L_{dn} are predicted to increase.

3.3.4 Future Scenario 2 Model – Calculated Noise Levels and Maps

Future scenario 2 represents 2025 conditions with RBT2 in operation. **Table 3-18** presents the modelled annual average noise levels at each site based on all noise sources.

Table 3-18 Future Scenario 2 Model Results – Annual Average Noise Levels

Site	Noise Level (dBA)		
	Daytime Equivalent Sound Level (L_d)	Night Equivalent Sound Level (L_n)	Day-night Equivalent Sound Level (L_{dn})
3	52.0	51.7	58.1
4	49.5	46.5	53.5
5	52.8	49.6	56.7

Noise contour maps of future scenario 2 L_{dn} within the study area are presented in **Figures G-10** to **G-14** in **Appendix G**. **Figure G-15** of **Appendix G** provides a three-dimensional view of the noise contours from the vantage point of site 5.

Table 3-19 shows the modelled scenario 2 component L_{dn} for the different noise source groups and their percentage contributions to total L_{dn}. In this scenario, there is an additional component L_{dn} which includes the sources that are directly attributable to the Project – namely, the RBT2 terminal area source and RBT2 road and rail traffic sources on the Roberts Bank causeway.

Table 3-19 Future Scenario 2 Model Results – Component Day-night Equivalent Sound Levels

Site	Component Day-night Equivalent Sound Levels (L_{dn}) (dBA)				Percentage of Total L_{dn}			
	Deltaport Terminal Sources	RBT2 Sources	Upland Rail Sources	Upland Road Sources	Deltaport Terminal Sources	RBT2 Sources	Upland Rail Sources	Upland Road Sources
3	46.5	44.1	56.6	51.0	7%	4%	70%	19%
4	49.6	48.8	40.3	46.5	41%	34%	5%	20%
5	53.0	49.6	33.7	52.4	43%	19%	1%	37%

The introduction of the RBT2 sources (marine terminal and road and rail traffic on the causeway) changes the percentage contributions of the different noise source groups (**Table 3-18**) in comparison with those calculated with the existing and future scenario 1 models (**Tables 3-14** and **3-16**). At site 3, the predicted changes are minor because RBT2 sources only contribute by 4% to the total L_{dn}. At sites 4 and 5, however, the predicted contributions of upland road and rail noise decreased relative to the combined contributions of the Deltaport Terminal and RBT2 sources. At all three sites, the model predicts that noise from the Deltaport Terminal is a larger contributor to sound exposures than noise from RBT2. This result is attributable to the greater setback distance of the RBT2 marine terminal than the Deltaport Terminal from the upland receivers.

3.3.5 Comparison of Existing Conditions and Future Scenario Noise Model

Table 3-20 compares the L_{dn} predicted by the existing conditions and two future scenario models. Also presented are the L_{dn} increases represented by the future scenario levels relative to existing conditions.

Table 3-20 Comparison of Existing Conditions and Future Scenario Model Results

Site	Model Calculated Day-night Equivalent (L_{dn}), All Noise Sources (dBA)			Predicted Increase in L_{dn} relative to Existing Conditions (dBA)	
	Existing Conditions (2013)	Future (2025) Scenario 1	Future (2025) Scenario 2	Future (2025) Scenario 1	Future (2025) Scenario 2
3	56.7	58.0	58.1	1.3	1.4
4	50.9	51.7	53.5	0.8	2.6
5	55.1	55.7	56.7	0.6	1.6

In 2025, the total L_{dn} at the three sites are predicted to increase relative to existing conditions by 0.6 to 1.3 dBA without the Project, and by 1.4 to 2.6 dBA with the Project (**Table 3-20**).

3.3.6 Comparison of Future Noise Levels with and without RBT2

Table 3-21 compares future scenario 1 and 2 noise levels at sites 3 to 5. Also presented are the resulting increases in future noise levels due to RBT2 operation.

Table 3-21 Effect of Roberts Bank Terminal 2 on Community Noise Levels

Site	Model Calculated Noise Level, All Noise Sources (dBA)						Increase in Future Noise Levels due to Project (dBA)		
	Future Scenario 1 (without Project)			Future Scenario 2 (with Project)					
	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	52.0	51.7	58.1	0.1	0.2	0.1
4	48.4	44.5	51.7	49.5	46.5	53.5	1.1	2.0	1.8
5	52.3	48.5	55.7	52.8	49.6	56.7	0.5	1.1	1.0

Note: L_d – daytime equivalent sound level; L_n – night equivalent sound level; L_{dn} – day-night equivalent sound level.

RBT2 operation is predicted to increase future (2025) noise levels, L_{dn}, by from 0.1 to 1.8 dBA. These increases depend on the setback distances of the sites from RBT2 and on the prominence of RBT2 noise relative to that from other sources. The predicted increases are lowest at site 3 since it is the farthest of the three sites from RBT2, and the future noise environment is predicted to be dominated by road and rail traffic noise. While sites 4 and 5 have similar setbacks from RBT2, site 4 has a lower predicted future scenario 1 average noise level; therefore, the site is predicted to be more strongly affected by noise from RBT2. The future noise environment at site 5 is predicted to be influenced to a greater degree by upland road traffic noise, the presence of which lessens the impact of RBT2 noise.

3.3.7 Predicted Future Transient and Impulsive Noise Levels

Table 3-22 presents the anticipated increases in throughput capcity and train volumes and the corresponding estimated percentage increase in port and rail-related transient and impulsive noise events for future scenarios 1 and 2. These percentage increases were applied to the measured numbers of transient and impulsive events presented in the measurement results (**Tables 3-3** and **3-4**) to predict the future average number of these events per hour.

Table 3-22 Predicted Percentage Increases in Port and Rail-related Transient and Impulsive Noise Events

Scenario	Volumes		Percentage Increases in Transient and Impulsive Noise Events Relative to Existing Conditions	
	Annual Port Throughput capacity (million TEU)	Average Two Way Trains/Day	Material Handling Events	Rail Related Events
Existing Conditions (2013)	1.8	17	N/A	N/A
Future Scenario 1 (without Project)	2.4	21	33 %	24 %
Future Scenario 2 (with Project)	4.8	29	167 %	71 %*

*Note: this increase only applies to trains on the Roberts Bank causeway within the Project footprint.

Table 3-23 presents the predicted future numbers of transient and impulsive events at sites 3 to 5 with and without the Project. The numbers of future impulsive events at sites 4 and 5 are presented as a range to reflect the percentage increases in both throughput capacity and rail volumes on the Robert Bank causeway. At site 3, where impulsive noises are almost exclusively due to rail shunting on the section of the RBRC that is within the study area, the numbers of events only reflect the anticipated percentage increases in rail volumes (**Table 3-22**). These events are not predicted to increase at site 3 due to the Project because rail volumes on the section of the RBRC that is within the study area are the same for the two future scenarios (with and without the Project). No results are presented for locomotive pass-bys or train movements at sites 4 and 5 as these transient events were not at measurable levels at these sites.

Table 3-23 Predicted Numbers of Future Transient and Impulsive Noise Events

Site	Numbers of Events per Hour								
	Existing Conditions			Future without Project			Future with Project		
	Impulsive	Loco-motive Pass-by	Wheel-Rail Noise	Impulsive	Loco-motive Pass-by	Wheel-Rail Noise	Impulsive	Loco-motive Pass-by	Wheel-Rail Noise
3	1.4	0.7	1.0	1.7	0.9	1.2	1.7	0.9	1.2
4	6.0	-	-	7.4 to 8.0	-	-	10.3 to 16.0	-	-
5	6.0	-	-	7.4 to 8.0	-	-	10.3 to 16.0	-	-

3.3.8 Predicted Future Low-frequency Noise Levels

Increased throughput capacity at Deltaport Terminal, increased rail traffic on the Roberts Bank causeway, and the addition of RBT2 would be expected to increase low-frequency noise levels at sites 4, 5, 6 and 7. Site 3 is not included in this analysis as the noise levels there are dominated by non-Project related upland road and rail traffic.

Incremental increases in low-frequency noise associated with increased container throughput, and increased rail traffic on the causeway, would be expected to be the same in each octave band within the low-frequency spectra presented in **Appendix C** and to be numerically equal to the increases in L_{dn} from the sources listed above. Therefore, the modelled Deltaport Terminal and RBT2 component L_n at sites 4 and 5 (**Table 3-18**) can be used to estimate the increases in low-frequency noise levels.

Table 3-24 presents the existing and future Deltaport Terminal component L_{dn}, as well as the combined future levels due to both the Deltaport Terminal and RBT2 component L_{dn}. These levels are then compared to show the increases in low-frequency noise levels relative to both existing conditions and the future without Project scenario. The low-frequency noise increases at site 4 are considered to represent those to be experienced on Tsawwassen First Nation Lands, while the increases at site 5 are considered to represent those to be experienced within Tsawwassen; including at sites 6 and 7.

Table 3-24 Predicted Increases in Low-frequency Noise Levels

Site	Modelled Source Group Day-night Equivalent Sound Levels (L_{dn}) (dBA)			Predicted Increase in Low-Frequency Noise Levels (dB)		
	Existing Conditions, Deltaport Terminal	Future, Deltaport Terminal	Future, Deltaport Terminal and RBT2	Future w/o Project vs. Existing Conditions	Future w/ Project vs. Existing Conditions	Future w/ Project vs. Future w/o Project
4	48.4	49.6	52.2	1.2	3.8	2.6
5	51.8	53.0	54.6	1.2	2.8	1.6

3.3.9 Predicted Future Vibration Levels

Due to the large setback distances of sensitive receivers and the presence of local vibration sources (i.e., upland road and rail traffic), RBT2 operation is not expected to affect ground-borne vibration levels experienced by noise and vibration sensitive upland receptors. In the future without the Project, ground-borne vibration levels within the study area will change due to increases in upland road traffic volumes and due to increased rail activity on the section of the RBRC that is within the study area, and the addition of rail tracks at the Gulf Yard. After DTRRIP, the closest train track near to site 3 will be setback 210 m versus 240 m prior to the DTRRIP project. This setback change is predicted to increase ground-borne vibration levels during train pass-bys by approximately 1.3 VdB.

3.3.10 Estimated and Predicted Noise Levels in Marine Areas

Tables H-1 to **H-4** in **Appendix H** present estimated and predicted annual average L_d in marine areas for existing conditions, Project construction and the two future scenarios. As described in **Section 2.3.5**, noise levels are presented at 1-km interval setback distances from the approximate centre-point of the future location of the RBT2 marine terminal. **Table H-1** presents estimated existing annual average levels; **Tables H-2** and **H-3** present predicted future annual average levels; and **Table H-4** present predicted construction noise levels. **Figures H-1** to **H-3** present noise contour maps of L_d for the existing conditions and future scenarios.

Existing L_d were estimated to range from 62.5 dBA to 32.7 dBA at locations within approximately one and ten kilometres (km) of the future location of the RBT2 marine terminal respectively. In the future, without the Project, noise levels are predicted to increase relative to existing conditions by 0.2 to 1.3 dBA to L_d of 63.7 to 33.9 dBA. During Project construction, L_d are expected to range from 63.8 to 33.9 dBA. With Project operation, L_d are expected to range from 64.0 to 38.4 dBA. The largest increases are predicted at locations 1 km to the north, south, and west of the new marine terminal, while the smallest increases are predicted at locations to the east where noise from the existing terminals and Highway 17 will tend to "mask" noise from the new terminal.

4.0 DISCUSSION

4.1 KEY FINDINGS

Noise measurements completed in 2013 found that two-day average L_{dn} at sites 3 to 5 ranged from 52.7 to 55.7 dBA. Long-term monitoring conducted during the 2011 DTRRIP EA (BKL 2012) indicated that day-to-day L_{dn} variation at these sites is, on average, +/- 2 dBA. The noise environments at these sites were observed to be influenced by a variety of diverse sources, including the Roberts Bank terminals, road and rail traffic, aircraft overflights, BC Ferries, and natural sounds. The differences between C- and A-Weighted noise levels at sites 4, 5, 6 and 7 ranged from 12.6 to 22.5, indicating the presence of low-frequency noise. Ground-borne vibration measurements at sites 1 to 3 showed that ambient levels were dominated by local road and rail traffic (i.e., not on the Roberts Bank causeway). At sites 1 and 2, heavy truck traffic was responsible for the highest vibration levels. At site 3, which is closer to the RBRC within the study area, train traffic created the highest vibration levels.

Construction and ground-borne vibration noise levels were predicted using methodology recommended by the U.S. FTA (FTA 2006) in conjunction with noise propagation calculation software. During the construction phase, monthly average L_{dn} at sites 3, 4 and 5 are predicted to range from 51.7 to 60.0 dBA. These levels represent increases in community L_{dn} in the range of 0.0 to 4.3 dBA. On average, however, L_{dn} increases are not expected to exceed 1.3 dBA. The prediction of relatively modest increases is attributable to the large setback distances of noise-sensitive upland receptors from the terminal and causeway construction zones. Maximum construction ground-borne vibration levels are not expected to exceed the 93 VdB threshold of perception.

Noise models were created using the CadnaA software to estimate existing (2013) and predict future (2025) annual average noise levels at sites 3 to 5. Existing annual average L_{dn} were predicted to range from 50.9 to 56.7 dBA. Without the Project, future (2025) annual average L_{dn} were predicted to range from 51.7 to 58.0 dBA, representing increases of 0.6 to 1.3 dBA relative to existing conditions. With Project operation, future (2025) annual average L_{dn} were predicted to range from 53.5 to 58.1 dBA, representing increases of 0.1 to 1.8 dBA relative to future conditions without the Project.

RBT2 is expected to increase the number, but not the severity of impulsive and transient port and rail-related noise events. These increases are expected to be proportional to the increases in port throughput capacity and rail traffic volumes. With Project operation, future low-frequency noise levels are predicted to increase by 1.6 to 2.6 dBA relative to future conditions without the Project. Operation of the Project is not expected to affect ground-borne vibration levels at any upland receptors.

In the marine study area, existing levels were estimated to range from 62.5 dBA to 32.7 dBA at locations within approximately one and ten kilometres (km) of the future location of the RBT2 marine terminal respectively. During Project construction, L_d are expected to range from 63.4 to 32.7 dBA. In the future, without Project operation, noise levels are predicted to increase, relative to existing conditions, by 0.2 to 1.3 dBA resulting in L_ds of 63.7 to 33.9. With the Project, levels are expected to further increase by 0.3 to 13.0 dBA to L_d of 64.0 to 38.4 dBA. The largest increases are predicted at locations 1 km to the north, south, and west of the new marine terminal while the smallest increases are predicted at locations to the east where noise from the existing terminals and Highway 17 will tend to “mask” noise from the new terminal.

4.2 STUDY LIMITATIONS

The following section discusses limitations in both the measurement and modelling studies.

4.2.1 Field Work – Nosie and Vibration Measurements

4.2.1.1 Instrument Accuracy

One limitation inherent in all noise-monitoring programs is the accuracy of the measurement instrumentation. The Type 1 SLMs used in this study are the industry standard and are accurate to within +/- 1 dBA, while the vibration transducer has a frequency response of 0.08 to 1,000 Hz and a sensitivity of 10 V/g.

4.2.1.2 Variations in Daily Average Community Noise Levels

Daily average community noise levels nearly always show some day-to-day variations due to the following factors:

- Variations in the types and numbers of noise sources that contribute to the noise environment;
- Variations in the noise emissions from one or more sound sources; and
- Effects of varying meteorological conditions on sound propagation.

Day-to-day variations of community noise levels in the study area were investigated in the 2011 DTRRIP Noise Assessment (BKL 2012), during which two weeks of continuous monitoring found that, on average, L_{dn} varied by +/- 1 to 2 dBA. These measurements, as well as those of 2013, were conducted during summer months as is customary for extended outdoor noise monitoring programs. Such community noise monitoring is typically conducted in fair weather to minimise interference from environmental noises (e.g., wind in the trees, rain on surfaces) and avoid increased vehicle tire noise due to wet streets. This means that in the Pacific Northwest, extended monitoring is rarely conducted in the winter months. Additionally, community noise exposures during the spring and summer months are generally of greater interest since, it is at those times that windows are more frequently kept open and people are generally spending more time outdoors.

It is possible that community noise levels in the study area are somewhat different in winter than summer due to variations in the factors listed above (e.g., noise source strength, presence of different noise sources, meteorology). For example, there is less traffic on Highway 17 during the winter months and prevailing wind directions are different in the winter than in the summer. It is not expected, however, that there would be any systematic, seasonal variations in global noise emissions from the Roberts Bank terminals.

A TDR was produced regarding the effects of meteorological conditions on sound propagation from the Roberts Bank terminals (WAL 2014). The review found that in travelling largely over water from the terminals to the shores of Delta, noise levels may be expected to fluctuate from + 3 to -20 dBA, due to the effects of changing wind speed and direction, and due to wind speed and air temperature gradients near the earth’s surface that are familiar from the analysis of sound propagation over land. Another conclusion is that for the case of sound propagation over the ocean in coastal settings, a 10- to 15-dB amplification of sound levels may be observed under certain, distinctive wind conditions, referred to as low-level jets. It should be noted, however, that such large variations in noise levels from the Roberts Bank terminals have not been measured and it is not known whether low-level-jets actually occur within the study area. Furthermore, both the measurement and monitoring have been directed at establishing annual average, rather than extreme and largely hypothetical, noise levels.

4.2.1.3 Marine Areas

No existing noise measurements were conducted within the marine portion of the study area because: (i) the primary focus of the noise and vibration studies has been long-term human exposure potential; and (ii) humans are not expected to spend extended periods of time (beyond ~8 h on any given occasion) in the marine areas, based on recreational, fishing, or other activities. This is relevant since the noise and vibration emissions from the Roberts Bank terminals, and especially those that could occur as a result of the RBT2 project, will be much lower than those known to be associated with acute health effects such as hearing loss. Direct human health effects from upland noise and vibration exposures, therefore, are only plausible in geographic areas where chronic (long-term) exposures of humans are possible.

4.2.2 Noise Propagation Modelling and Mapping

4.2.2.1 Noise Calculation Standards

Accuracy limitations are inherent in any noise modelling exercise in which mathematical algorithms are used to simulate the complex physical phenomena of outdoor sound propagation. While it is not possible to apply specific uncertainty values to the noise propagation standards employed, namely ISO 9613 (ISO 1996) and NMPB-Routes 96 (Sétra 1997), these standards do present discussions of the assumptions and limitations of their algorithms. For example, in both standards, in the calculation of ground effect, the study-area terrain is represented as an idealised plane. A specific limitation of ISO

9613 that is relevant to the Noise and Vibration Study is illustrated in the following statement found within the document: “Inversion conditions over water surfaces are not covered and may result in higher sound pressure levels than predicted from this part of ISO 9613” (ISO 1996). Despite such limitations, the algorithms contained in both of these standards are considered state-of-the-art and industry standard.

4.2.2.2 Meteorological Data

Modelling limitations related to meteorological effects were investigated during a study of the effects of meteorology on the propagation of sound over water and in particular, in the vicinity of the existing Roberts Bank terminals. This study was documented in a TDR (WAL 2014).

4.2.2.3 Modelled Noise Sources

Another limitation of the noise model was the inability to include certain sources of community noise. The sources included were identified as follows:

- Deltaport Terminal[3];
- Roberts Bank causeway; and
- Upland Road and Rail traffic.

It was not possible to include all sources of community noise, such as human conversations and activities, wildlife, and natural noises such as wind in the trees, since these are intermittent and vary widely in levels. Therefore, the noise modelling focused on sources that were readily quantifiable, and which make important contributions to the noise environment within the study area.

Within the marine study area, the primary limitation was the exclusion of certain noise sources. The noise model did not include sources to represent commercial and recreational vessels, or the B.C. Ferries Terminal. Also, while noise from the Westshore Terminals was included in the modelled Deltaport Terminal noise source, the noise source only covers the physical extents of the Detlaport Terminal. Therefore, at locations close to the existing Roberts Bank terminals, and the B.C. Ferries Terminal, noise levels would be expected to be lower than actually experienced. These limitations, however, do not prevent the model from providing results that allow for comparisons of existing and future noise environments with and without Project noise.

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[3] The Deltaport Terminal source includes noise from the Westshore Terminal (see Section 2.3.3.5)

4.2.2.4 Modelled Terrain and Obstacles

The contours used to define the terrain over which sound propagates within the noise models have a 0.5-m height resolution, and thereby provided only an approximation of the actual ground surface. The magnitude of any noise-shielding effects provided by terrain was not exact. In addition, buildings were not included in the model. Since buildings can provide noise shielding, calculated noise levels are less accurate at locations where rows of buildings are located between the noise source and noise calculation point. However, by developing an existing conditions model within CadnaA and using it to calibrate the future noise level model (**Section 2.3.3.5**), the effects of many of the above-described sources of modelling uncertainty were minimised.

5.0 CLOSURE

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7.0 STATEMENT OF LIMITATIONS

This report was prepared by Wakefield Acoustics Ltd. based on research and fieldwork conducted by Wakefield Acoustics Ltd. for the sole benefit and exclusive use of Port Metro Vancouver. The material in it reflects Wakefield Acoustics Ltd.'s best judgement in light of the information available to it at the time of preparing this report. Any use that a third party makes of this report or any reliance on or decision made based on it is the responsibility of such third parties, Wakefield Acoustics Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Wakefield Acoustics Ltd. has performed the work as described above and made the findings and conclusions set out in this report in a manner consistent with the level of care and skill normally exercised by members of the consulting engineering profession practicing under similar conditions at the time the work was performed.

This report represents a reasonable review of the information available to Wakefield Acoustics Ltd. within the established scope, work schedule, and budgetary constraints of the contract.

In preparing this report, Wakefield Acoustics Ltd. has relied in good faith on information provided by others as noted in this report, and has assumed that the information provided by those individuals is both factual and accurate. Wakefield Acoustics Ltd. accepts no responsibility for any deficiency, misstatement, or inaccuracy in this report resulting from the information provided by those individuals.

APPENDIX A

Measurement Site Descriptions

Site 1; 3449 Arthur Drive, Delta, B.C.

Description:

Site 1 is located to the northeast of Roberts Bank terminals and approximately 700 m north of the RBRC. The vibration accelerometer was mounted on the ground approximately 4 m to the north of the northeastern corner of the house and approximately 20 m west of Arthur Drive. The accelerometer was mounted on a 10-kg block, which acted as an inertia base, and adhered with epoxy to the concrete ground.

Measurement Instrumentation:

Vibration Meter:	Bruel and Kjaer Type 2250
Accelerometer:	Dytran Model 3191A1

Site Maps:

Site Location

Accelerometer Location

Site 2; 3359 41B St, Delta, B.C.

Description:

Site 2 is located to the northeast of Roberts Bank terminals and approximately 630 m north of the RBRC. The vibration accelerometer was mounted on the ground approximately 2 m to the north of the northeastern corner of the house and approximately 24 m west of 41B St. The accelerometer was mounted on a 10-kg block, which acted as an inertia base, and adhered with epoxy to the concrete ground.

Measurement Instrumentation:

Vibration Meter: Bruel and Kjaer Type 2250

Accelerometer: Dytran Model 3191A1

Site Maps:

Site Location

Accelerometer Location

Site 3; 3044 41B St, Delta, B.C.

Description:

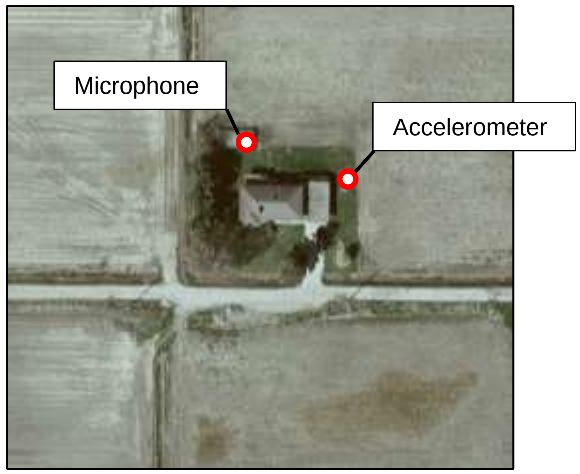
Site 3 is located to the northeast of Roberts Bank terminals and approximately 250 m south of the RBRC. The microphone was mounted on a tripod approximately 1.7 m above the ground and approximately 9 m to the north of the northwestern corner of the residence. The accelerometer was mounted on concrete on the ground approximately 4 m to the east of the northwestern corner of the residence.

Measurement Instrumentation:

Sound Level Meter:	Larson-Davis Type 820
Vibration Meter:	Bruel and Kjaer Type 2250
Accelerometer**:**	Dytran Model 3191A1

Site Maps and Pictures:

Site Location



Accelerometer and Microphone Locations

Microphone; View to the North

Site 4; 2148 Tsawwassen Drive N., Delta, B.C.

Description:

Site 4 is located to the northeast of Roberts Bank terminals. The microphone was mounted on a tripod on the roof of the Tsawwassen First Nation Longhouse at a height of approximately 6.5 m above the ground.

Measurement Instrumentation:

Sound Level Meter: Larson-Davis Type 820

Site Maps and Pictures:

Site Location

Microphone Locations

Microphone; View to the Southwest

Site 5; 1043 Pacific Drive, Delta, B.C.

Description:

Site 5 is located approximately 3.5 km from the eastern edge of Roberts Bank terminals. The microphone was located at the southeastern corner of the residence's backyard and mounted on a tripod at a height of approximately 1.7 m above the ground.

Measurement Instrumentation:

Sound Level Meter: Bruel and Kjaer Type 2250

Site Maps and Pictures:

Site Location

Microphone Locations

Microphone; View to the West

Site 6; 965 Underhill Drive, Delta, B.C.

Description:

Site 6 is located approximately 4.5 km from the eastern edge of Roberts Bank terminals. The outdoor microphone was located in the backyard approximately 9 m to the southwest of the residence and mounted on a tripod at a height of approximately 1.7 m above the ground. The indoor microphone was located within the second-storey master bedroom and also mounted on a tripod approximately 1.7 m above the floor.

Measurement Instrumentation:

Indoor and Outdoor Sound Level Meters:

Bruel and Kjaer Type 2250

Site Maps and Pictures:

Site Location

Outdoor Microphone Location

Microphone; View to the Southeast

Site 7; 77 English Bluff Rd., Delta, B.C.

Description:

Site 7 is located approximately 4.7 km from the eastern edge of Roberts Bank terminals. The outdoor microphone was located in the backyard approximately 23 m to the west of the residence and mounted on a tripod at a height of approximately 1.7 m above the ground. The indoor microphone was located within the first-storey living room, overlooking the deck, and also mounted on a tripod approximately 1.7 m above the floor.

Measurement Instrumentation:

Indoor and Outdoor Sound Level Meters:

Bruel and Kjaer Type 2250

Site Maps and Pictures:

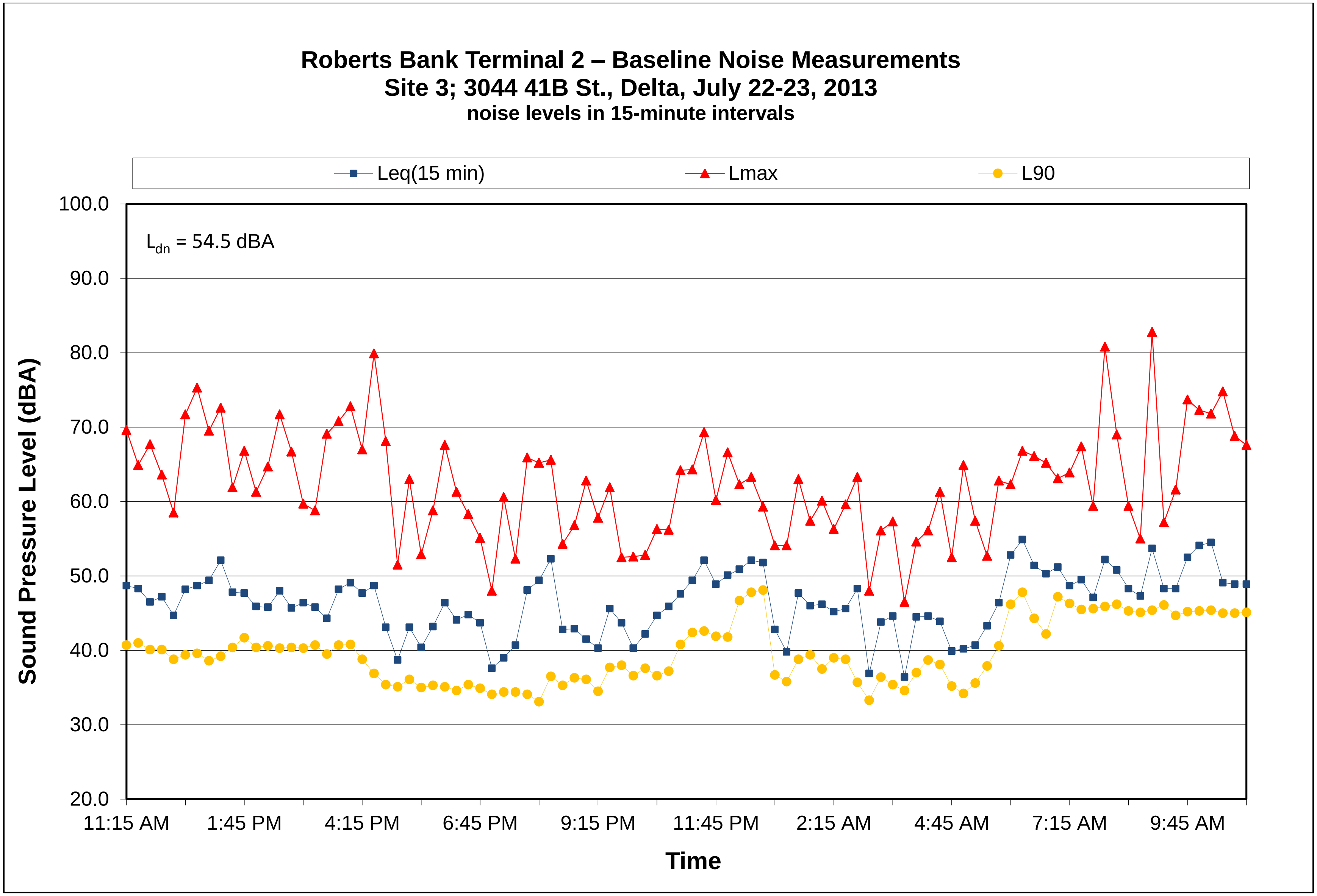
Site Location

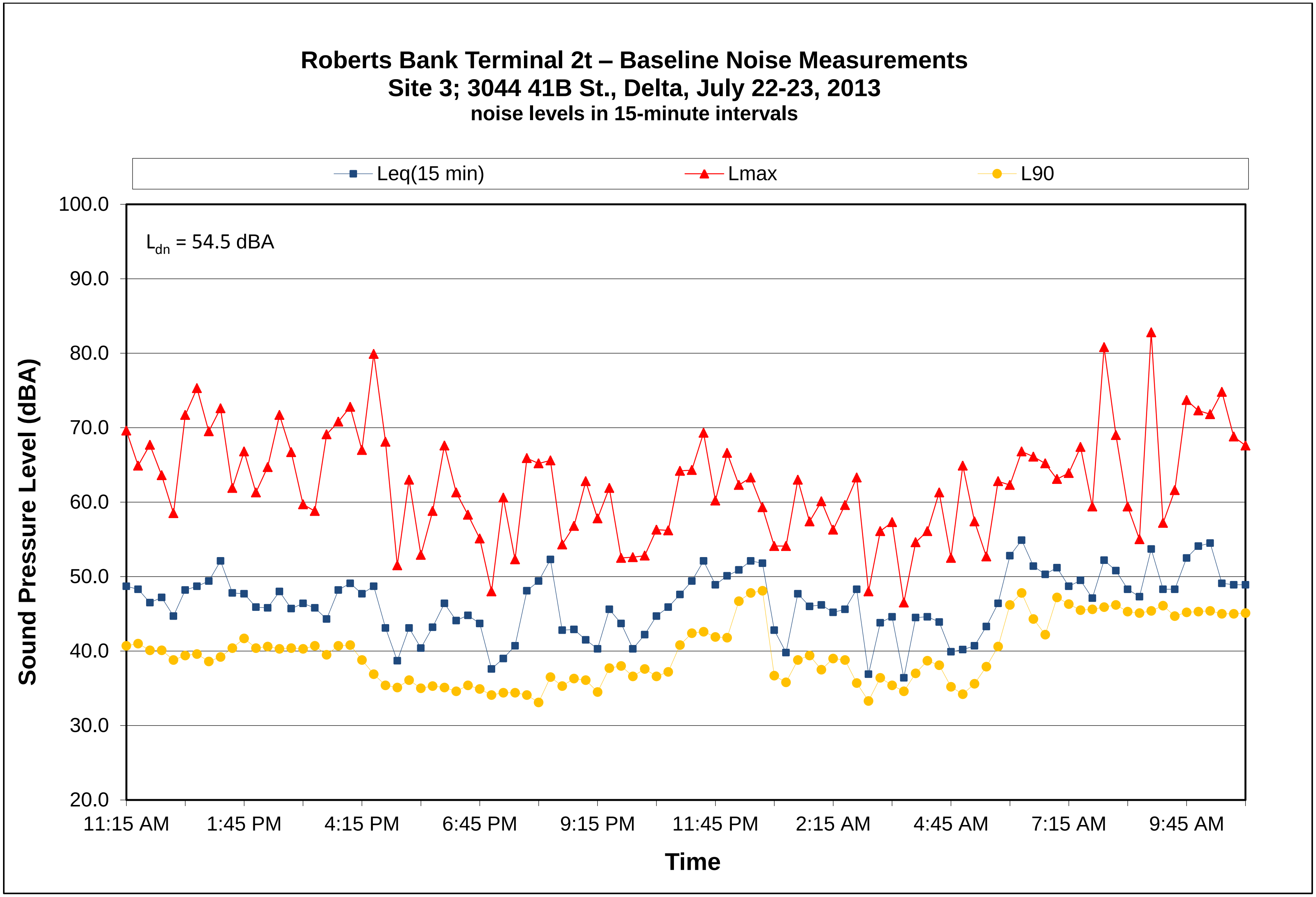
Outdoor Microphone Locations

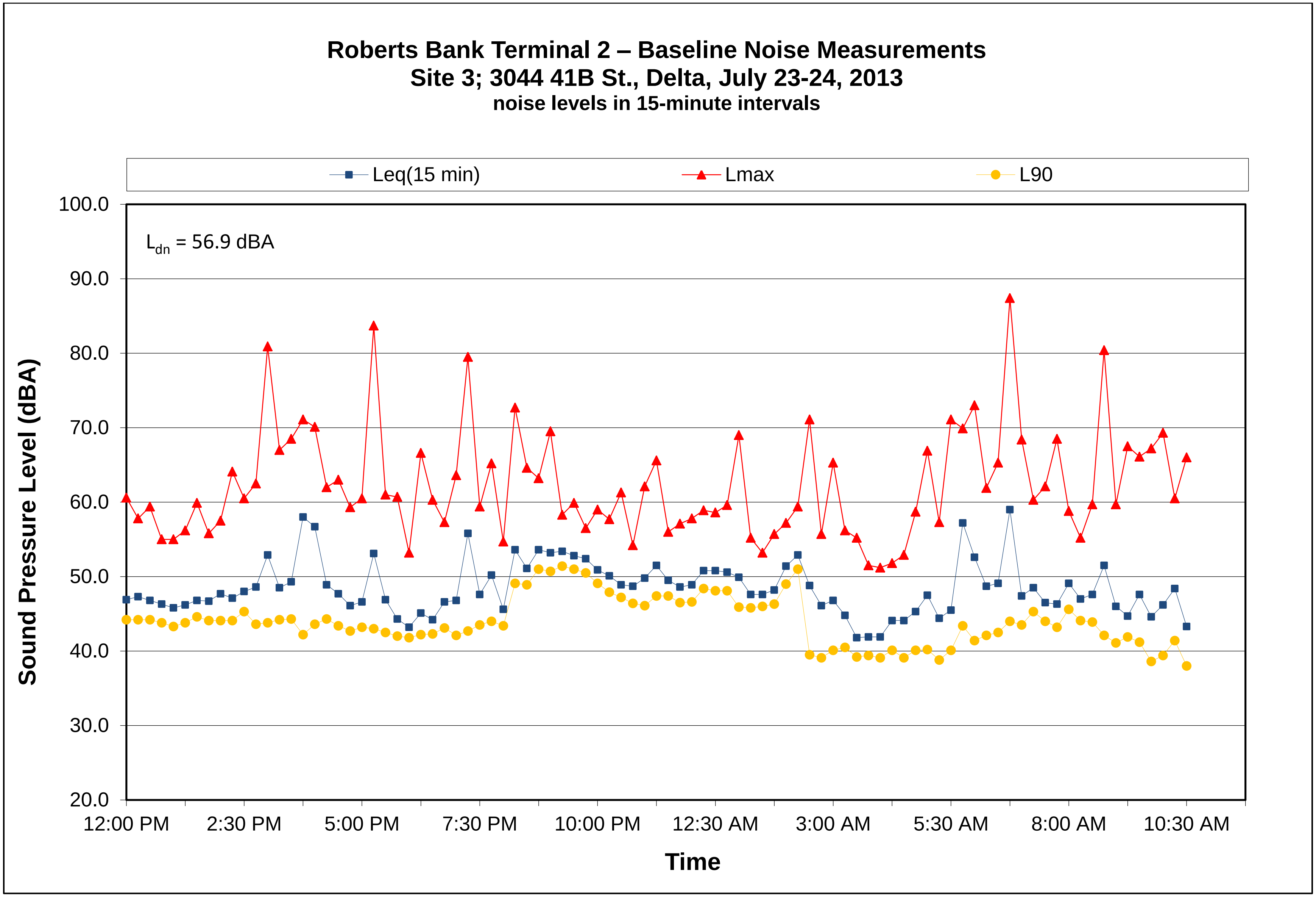
Microphone; View to the Northwest

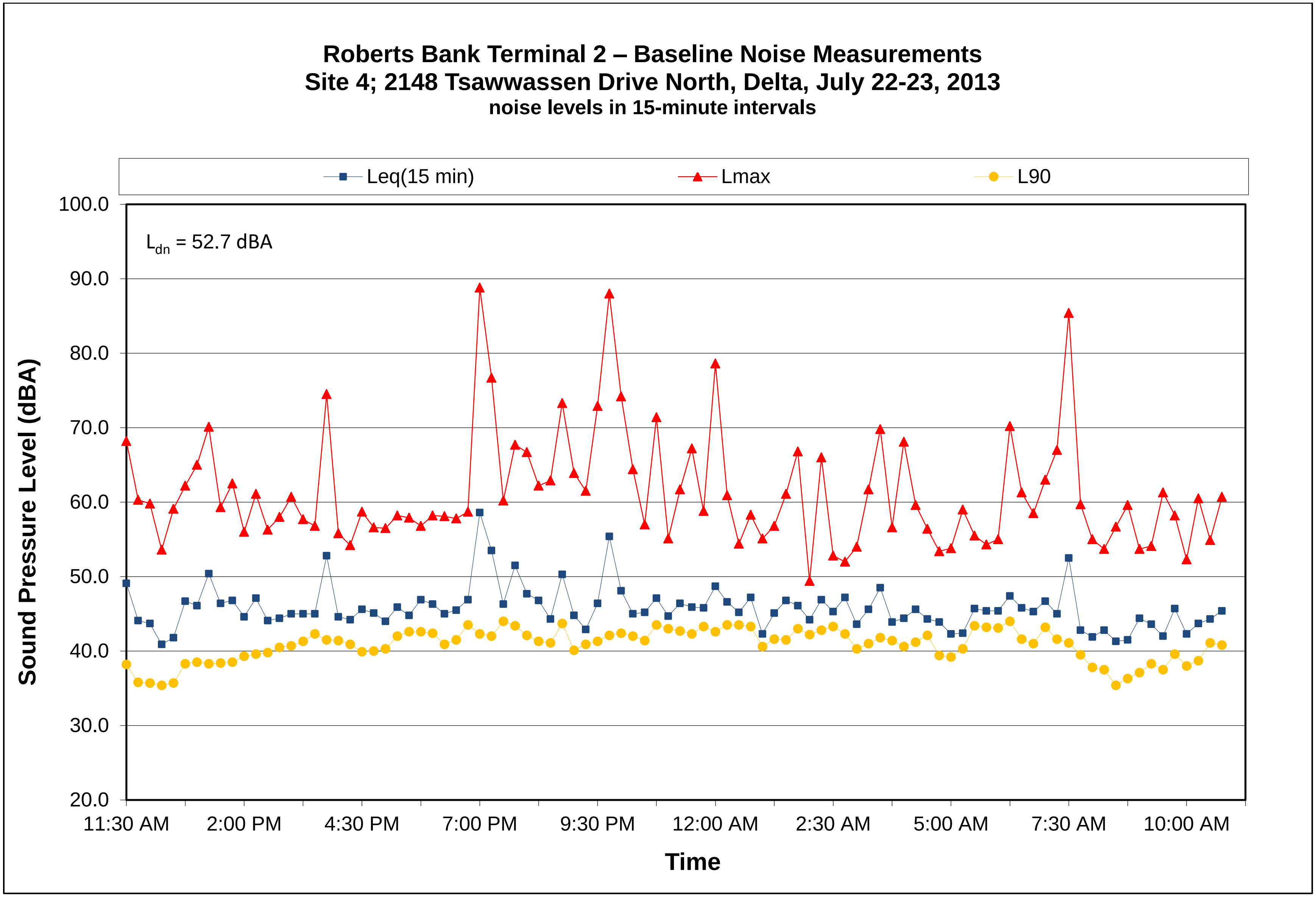
APPENDIX B

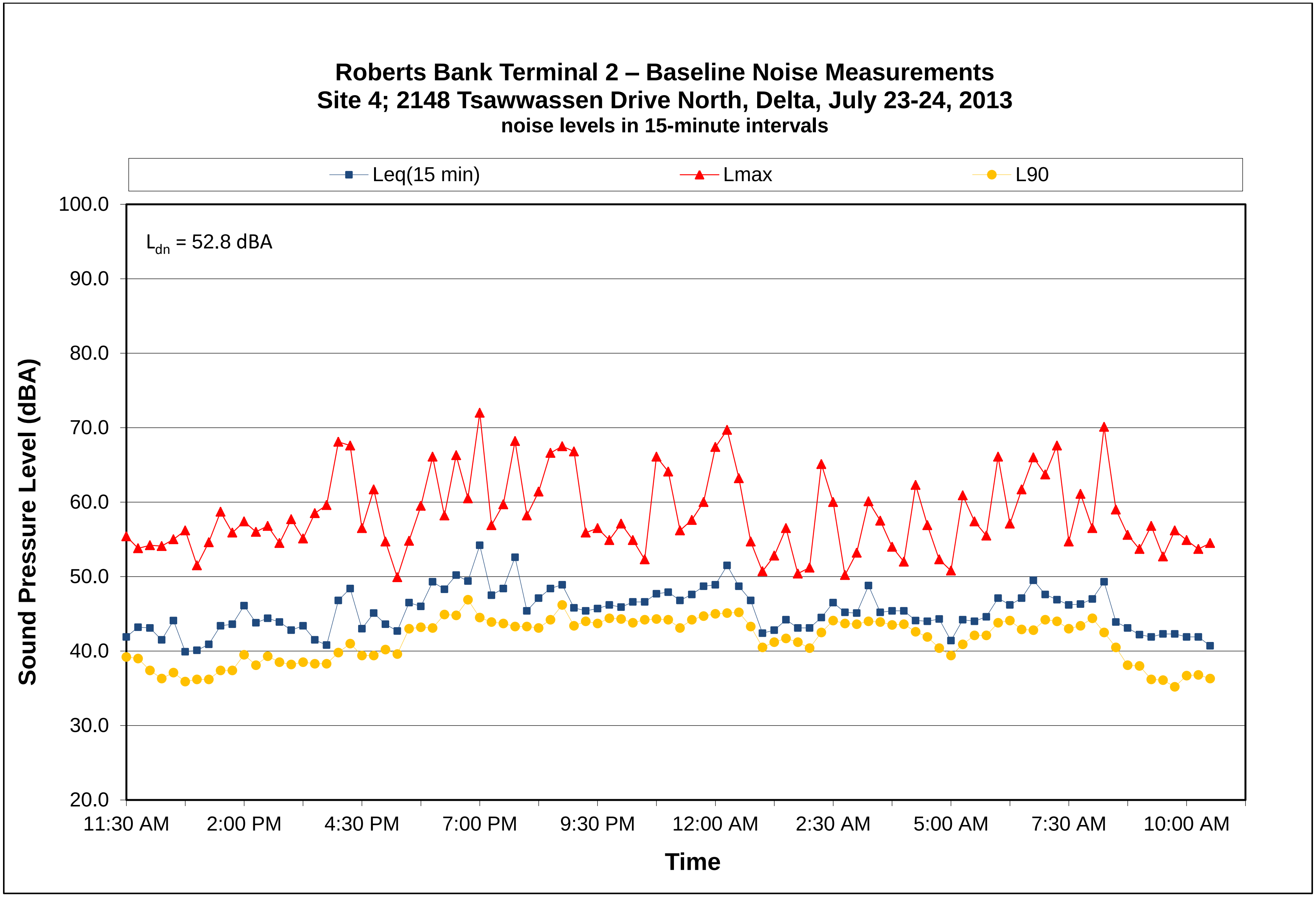
Noise Level History Charts

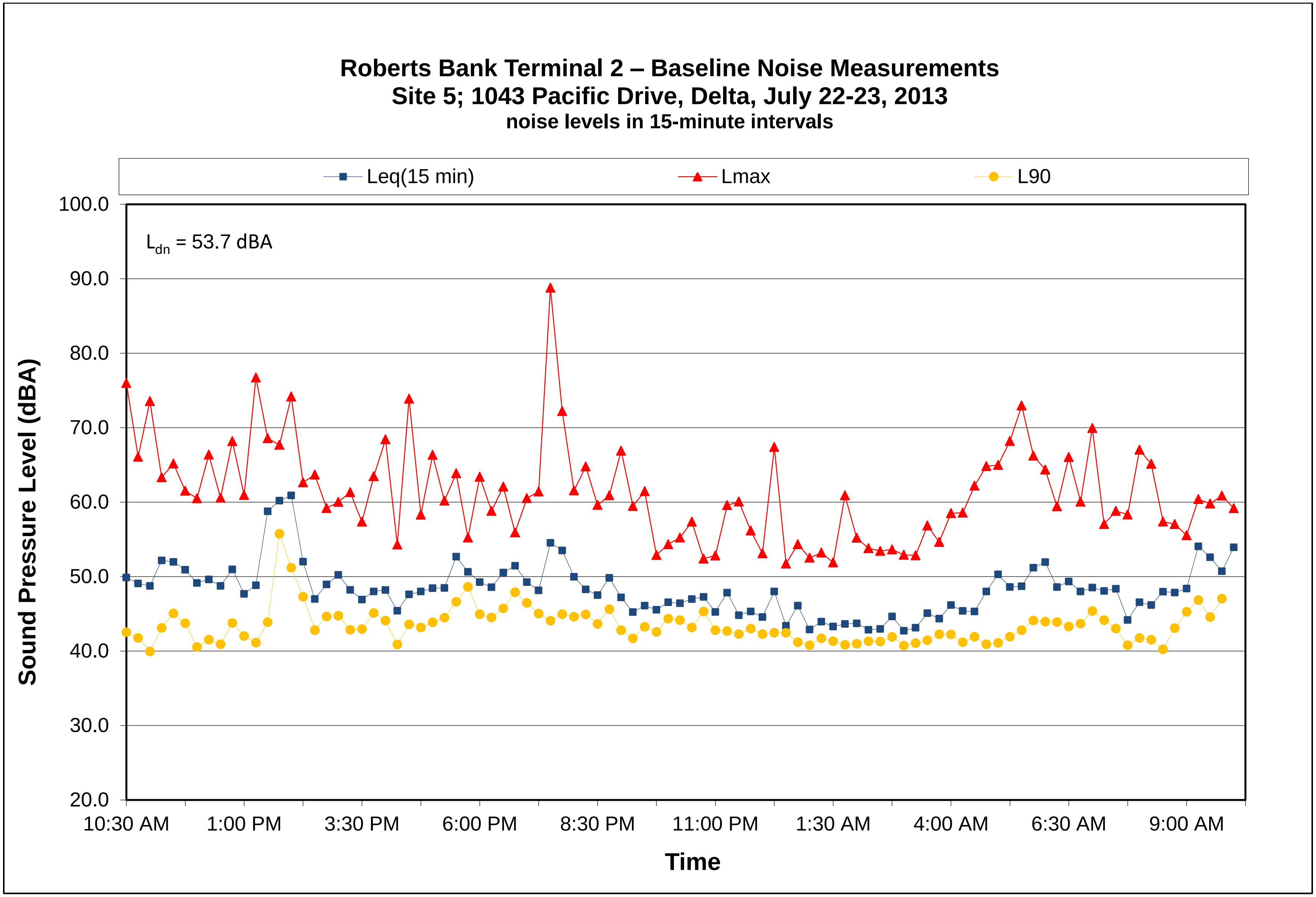

Roberts Bank Terminal 2 – Baseline Noise Measurements
Site 3; 3044 41B St., Delta, July 22-23, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
L_{dn} = 54.5 dBA
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
Sound Pressure Level (dBA)
11:15 AM
1:45 PM
4:15 PM
6:45 PM
9:15 PM
11:45 PM
2:15 AM
4:45 AM
7:15 AM
9:45 AM
Time

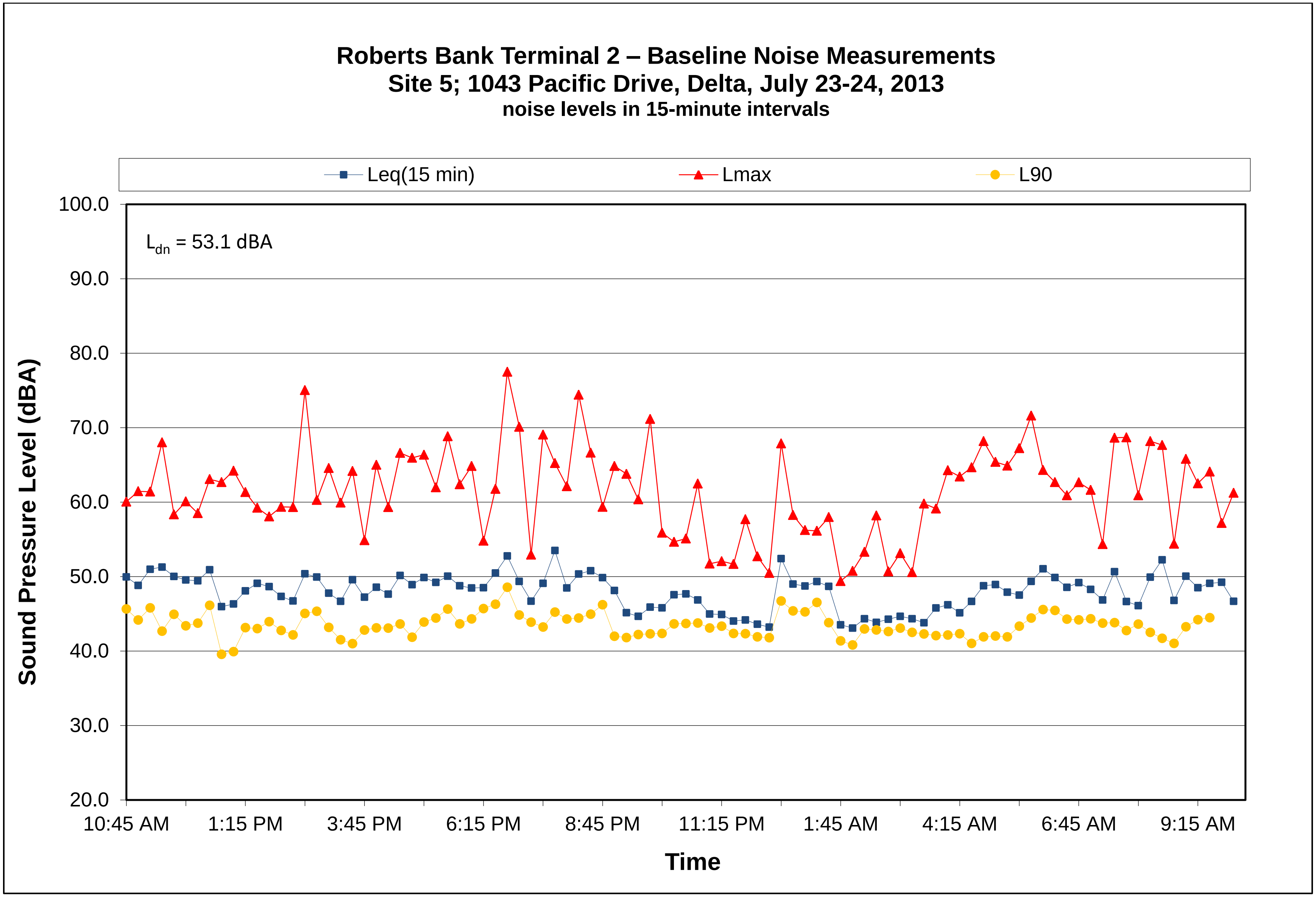

Roberts Bank Terminal 2t – Baseline Noise Measurements
Site 3; 3044 41B St., Delta, July 22-23, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
L dn = 54.5 dBA
Sound Pressure Level (dBA)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
11:15 AM
1:45 PM
4:15 PM
6:45 PM
9:15 PM
11:45 PM
2:15 AM
4:45 AM
7:15 AM
9:45 AM
Time


Roberts Bank Terminal 2 – Baseline Noise Measurements
Site 3; 3044 41B St., Delta, July 23-24, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
L dn = 56.9 dBA
Sound Pressure Level (dBA)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
12:00 PM
2:30 PM
5:00 PM
7:30 PM
10:00 PM
12:30 AM
3:00 AM
5:30 AM
8:00 AM
10:30 AM
Time


Roberts Bank Terminal 2 – Baseline Noise Measurements
Site 4; 2148 Tsawwassen Drive North, Delta, July 22-23, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
L_{dn} = 52.7 dBA
Sound Pressure Level (dBA)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
11:30 AM
2:00 PM
4:30 PM
7:00 PM
9:30 PM
12:00 AM
2:30 AM
5:00 AM
7:30 AM
10:00 AM
Time


Roberts Bank Terminal 2 – Baseline Noise Measurements
Site 4; 2148 Tsawwassen Drive North, Delta, July 23-24, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
Ldn = 52.8 dBA
Sound Pressure Level (dBA)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
11:30 AM
2:00 PM
4:30 PM
7:00 PM
9:30 PM
12:00 AM
2:30 AM
5:00 AM
7:30 AM
10:00 AM
Time

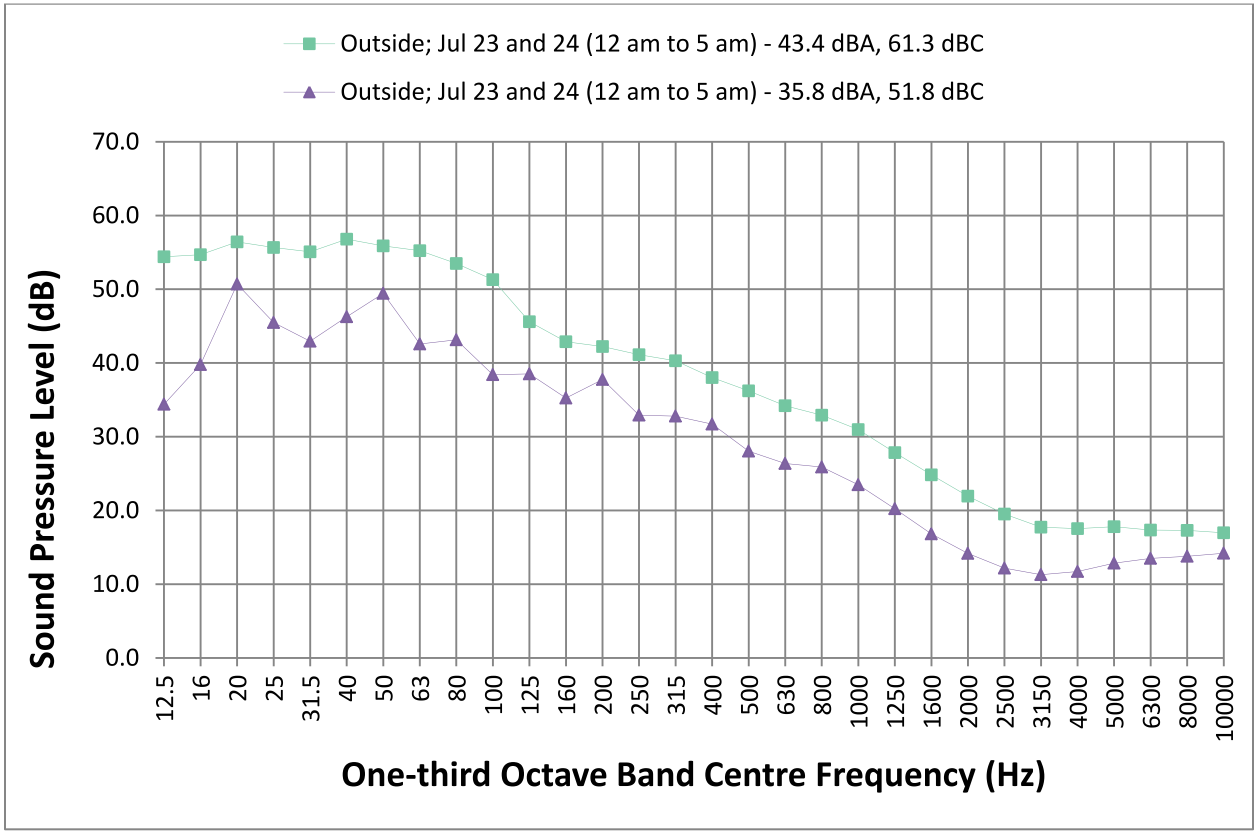

Roberts Bank Terminal 2 – Baseline Noise Measurements
Site 5; 1043 Pacific Drive, Delta, July 22-23, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
Ldn = 53.7 dBA
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
Sound Pressure Level (dBA)
10:30 AM
1:00 PM
3:30 PM
6:00 PM
8:30 PM
11:00 PM
1:30 AM
4:00 AM
6:30 AM
9:00 AM
Time


Roberts Bank Terminal 2 – Baseline Noise Measurements
Site 5; 1043 Pacific Drive, Delta, July 23-24, 2013
noise levels in 15-minute intervals
Leq(15 min)
Lmax
L90
L_{dn} = 53.1 dBA
Sound Pressure Level (dBA)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10:45 AM
1:15 PM
3:45 PM
6:15 PM
8:45 PM
11:15 PM
1:45 AM
4:15 AM
6:45 AM
9:15 AM
Time

APPENDIX C

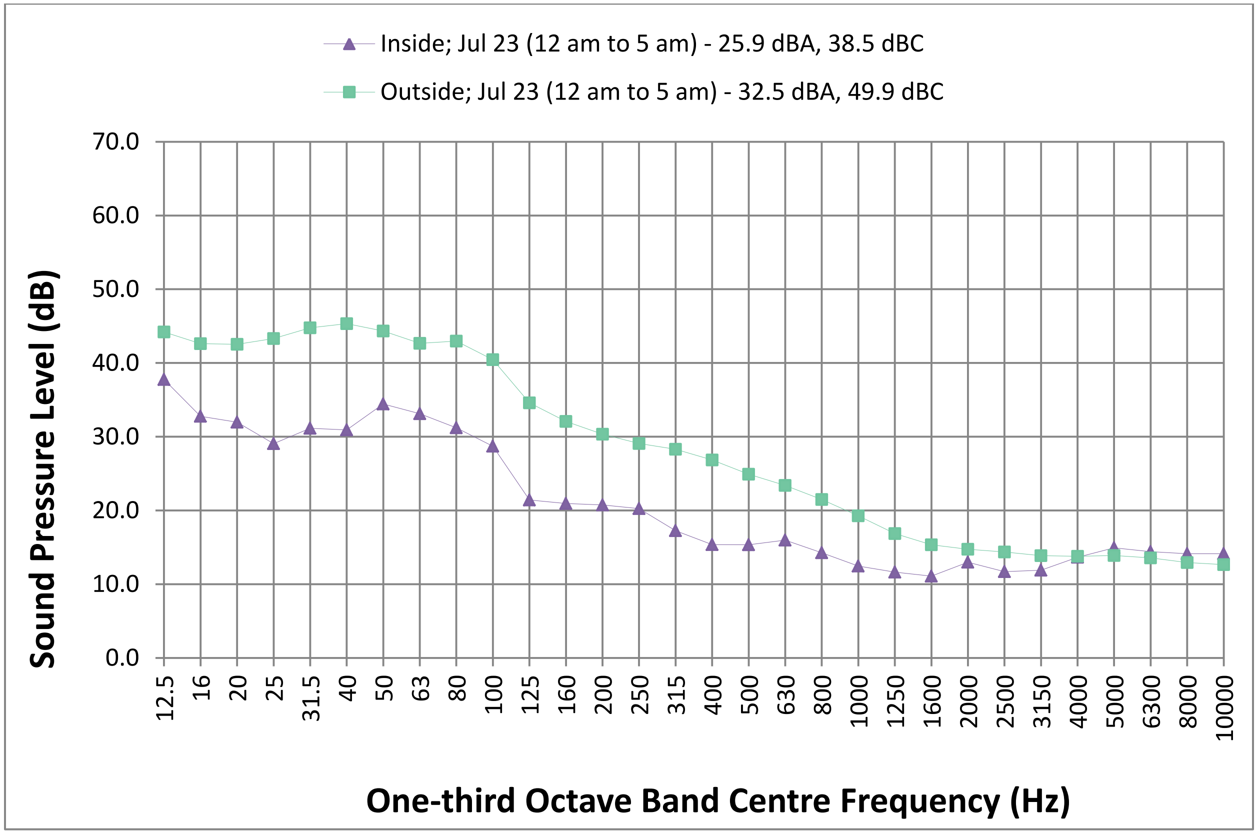
Measured Low-frequency Noise Spectra

Site 5 1043 Pacific Drive, Delta, B.C. July 23 and July 24, 2013



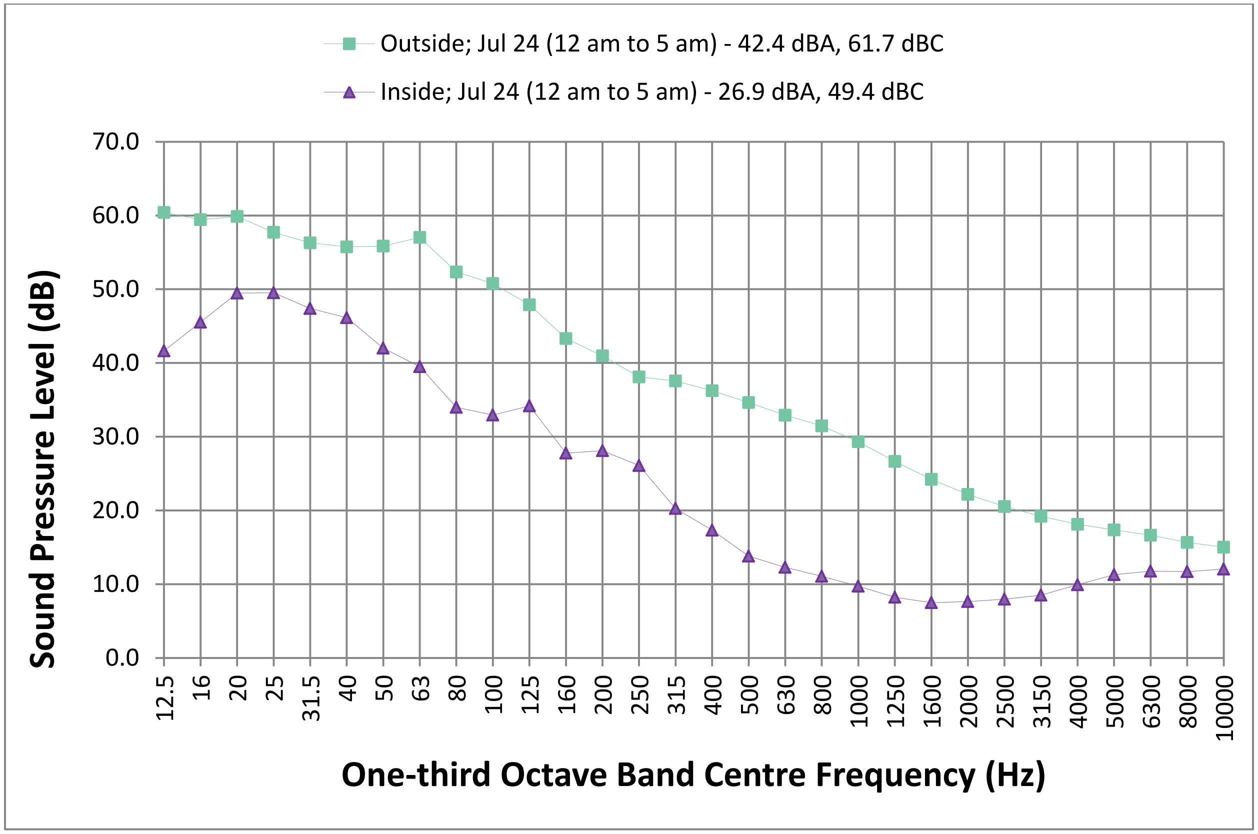
Measurement Location	Average Noise Level (dB) in One-Third Octave Band(Hz)												
	12.5	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**
Outside	54.4	54.7	56.4	55.7	55.1	56.8	55.9	55.2	53.5	51.3	45.6	42.9	42.2
Inside	34.4	39.8	50.7	45.5	42.9	46.3	49.4	42.6	43.1	38.4	38.5	35.2	37.8

Site 6 965 Underhill Dr., Delta, B.C., July 23, 2013



Measurement Location	Average Noise Level (dB) in One-Third Octave Band(Hz)												
	12.5	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**
Outside	44.2	42.6	42.5	43.3	44.8	45.3	44.3	42.7	43.0	40.5	34.6	32.1	30.3
Inside	37.8	32.8	32.0	29.1	31.1	30.9	34.4	33.1	31.2	28.7	21.4	20.9	20.7

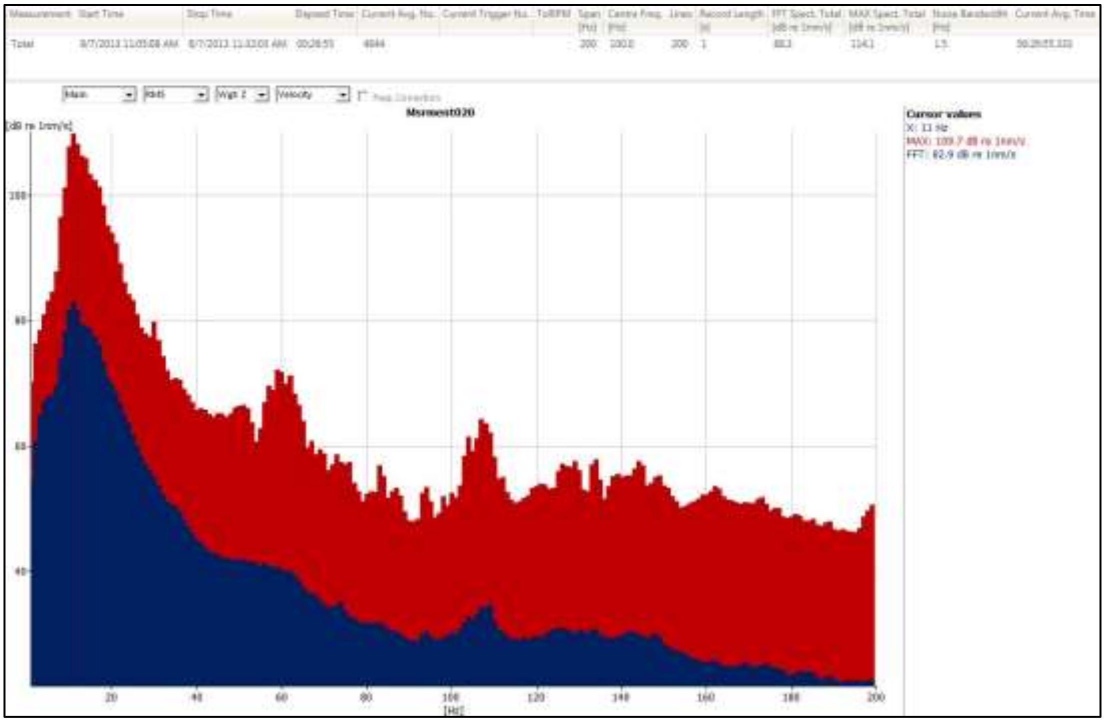
Site 7 77 English Bluff Rd., Delta, B.C., July 24, 2013



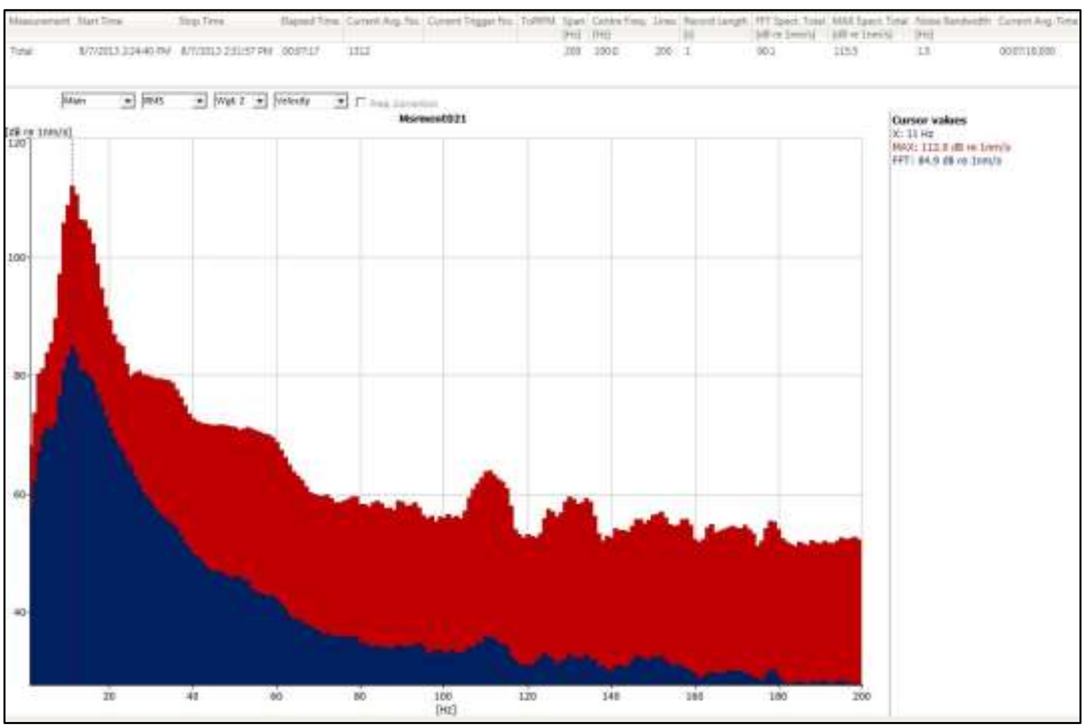
Measurement Location	Average Noise Level (dB) in One-Third Octave Band (Hz)												
	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Outside	60.4	59.4	59.9	57.7	56.3	55.7	55.9	57.0	52.3	50.8	47.9	43.3	41.0
Inside	41.6	45.5	49.5	49.5	47.4	46.1	42.0	39.5	34.0	32.9	34.2	27.8	28.1

APPENDIX D
Measured Vibration Spectra

Site 1 3449 Arthur Drive, Delta, B.C.

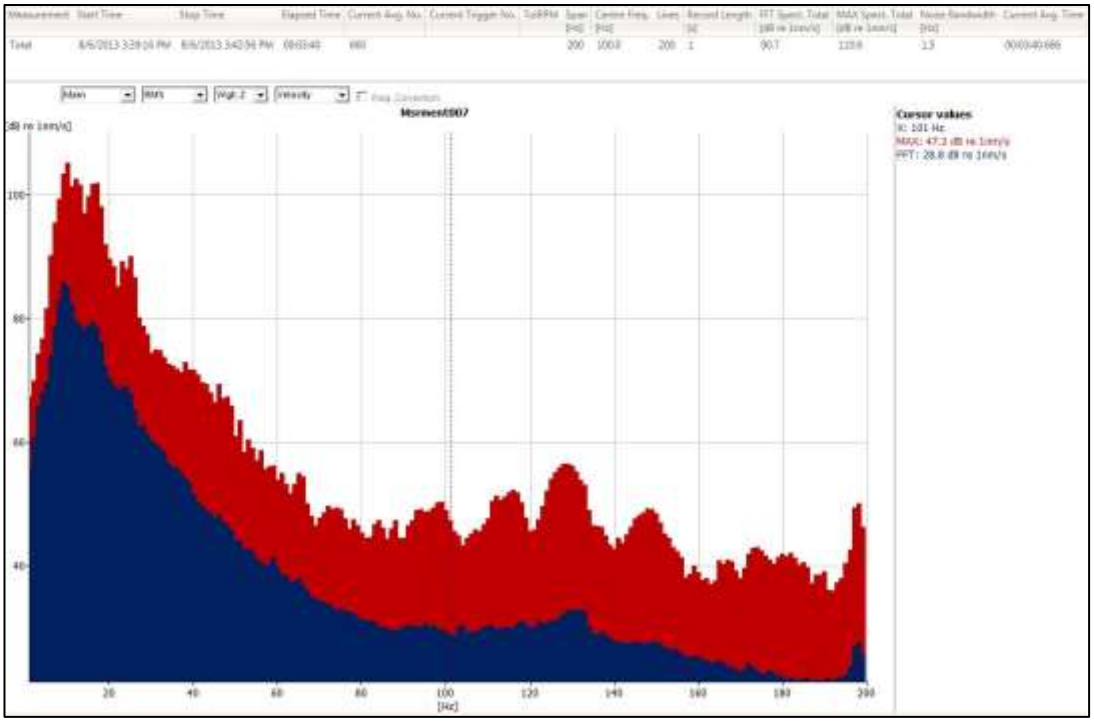


Site 1 Ambient Vibration Spectra – Heavy Trucks on Arthur Drive and Deltaport Way

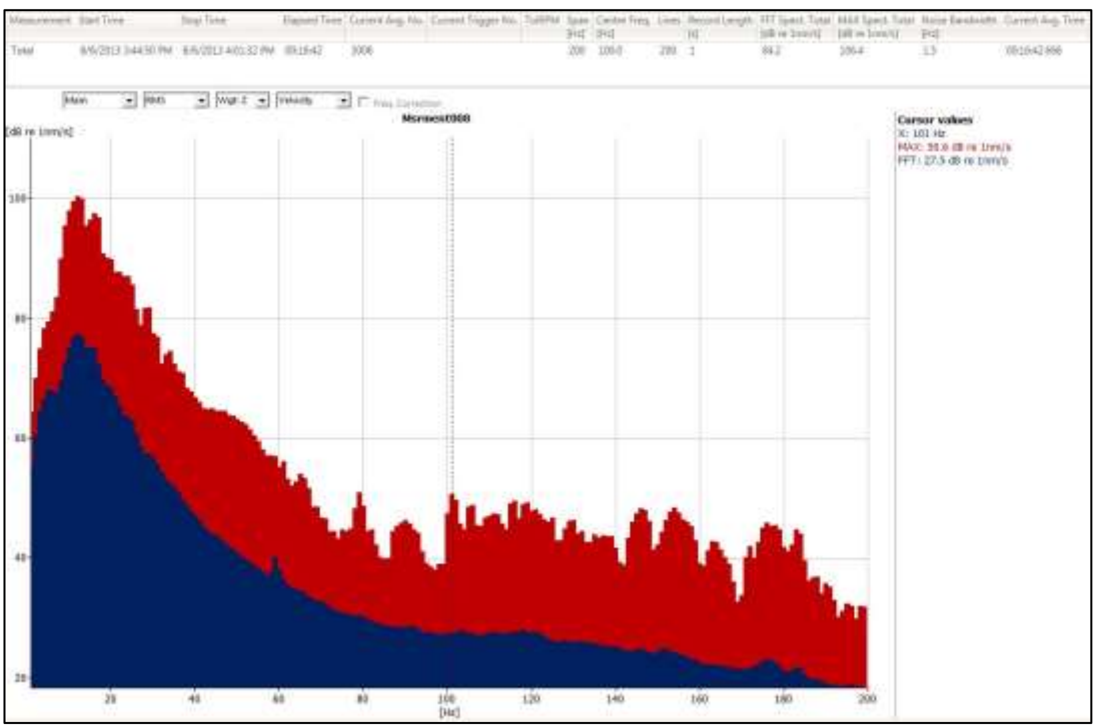


Site 1 Maximum Vibration Spectra – Heavy Truck Pass-by on Arthur Drive

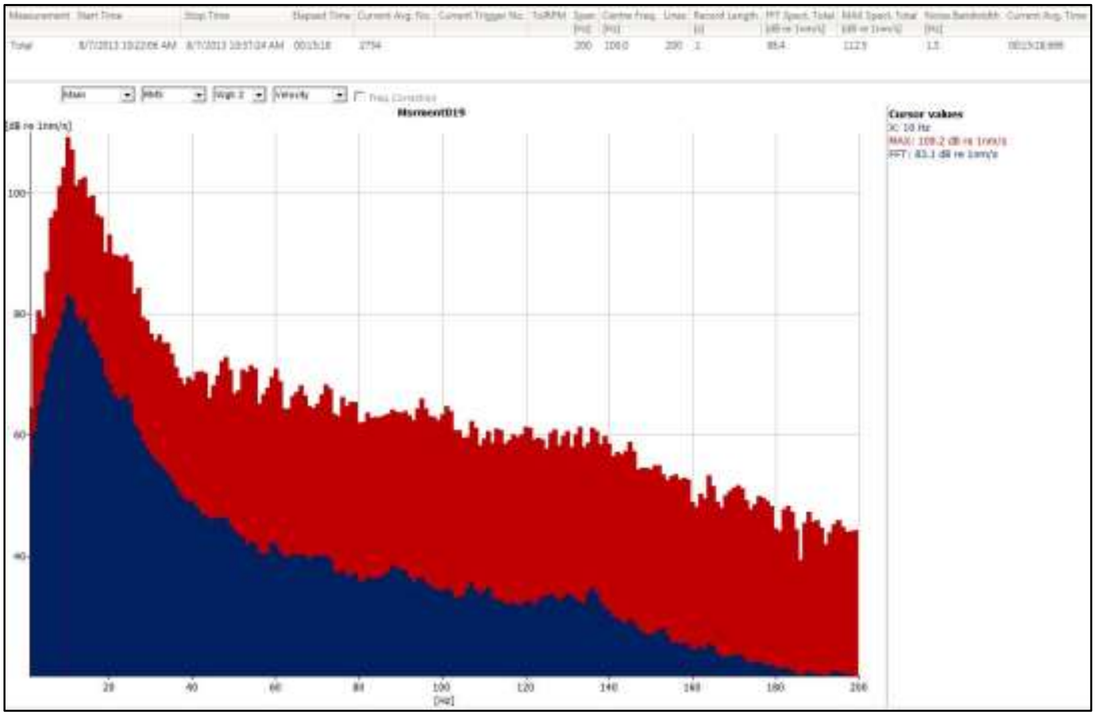
Site 2   3395 41B St, Delta, B.C.



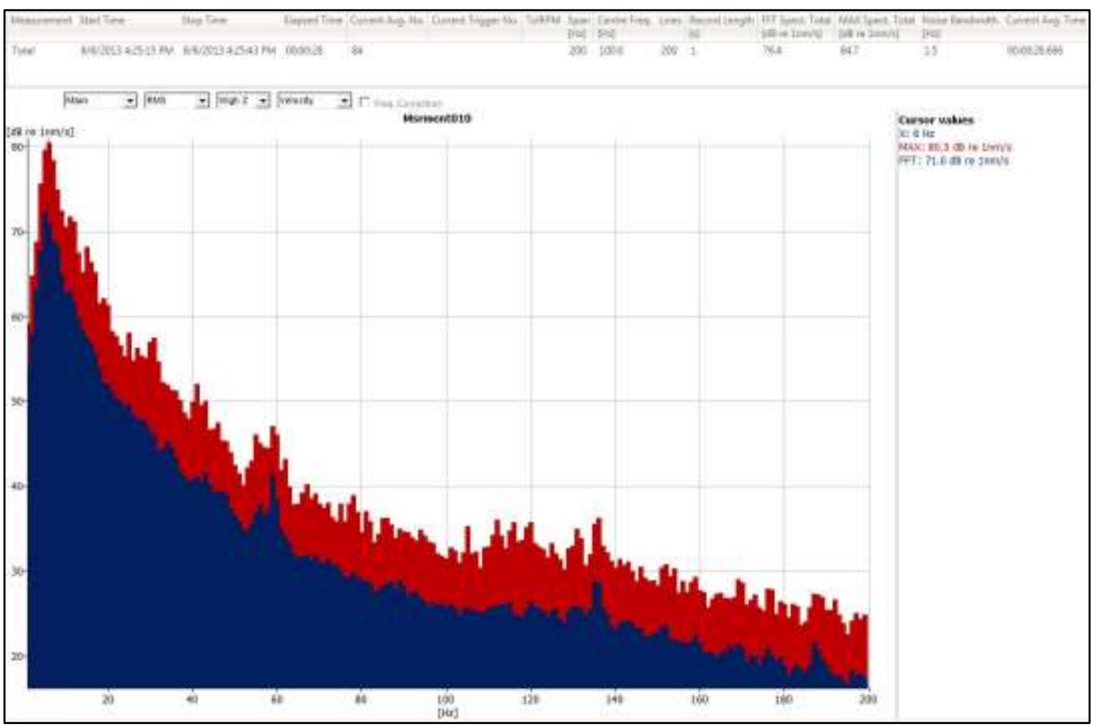
Site 2   Ambient Vibration Spectra 1 – Heavy Trucks on 41B St and Deltaport Way



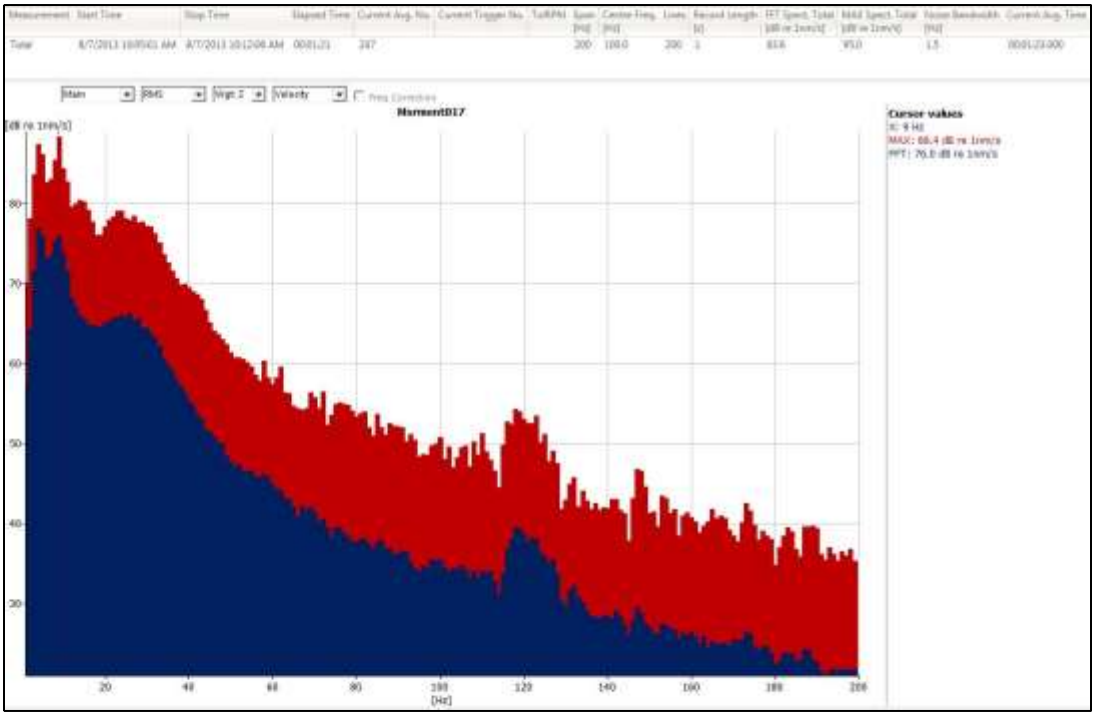
Site 2   Ambient Vibration Spectra 2 – Heavy Trucks on 41B St and Deltaport Way



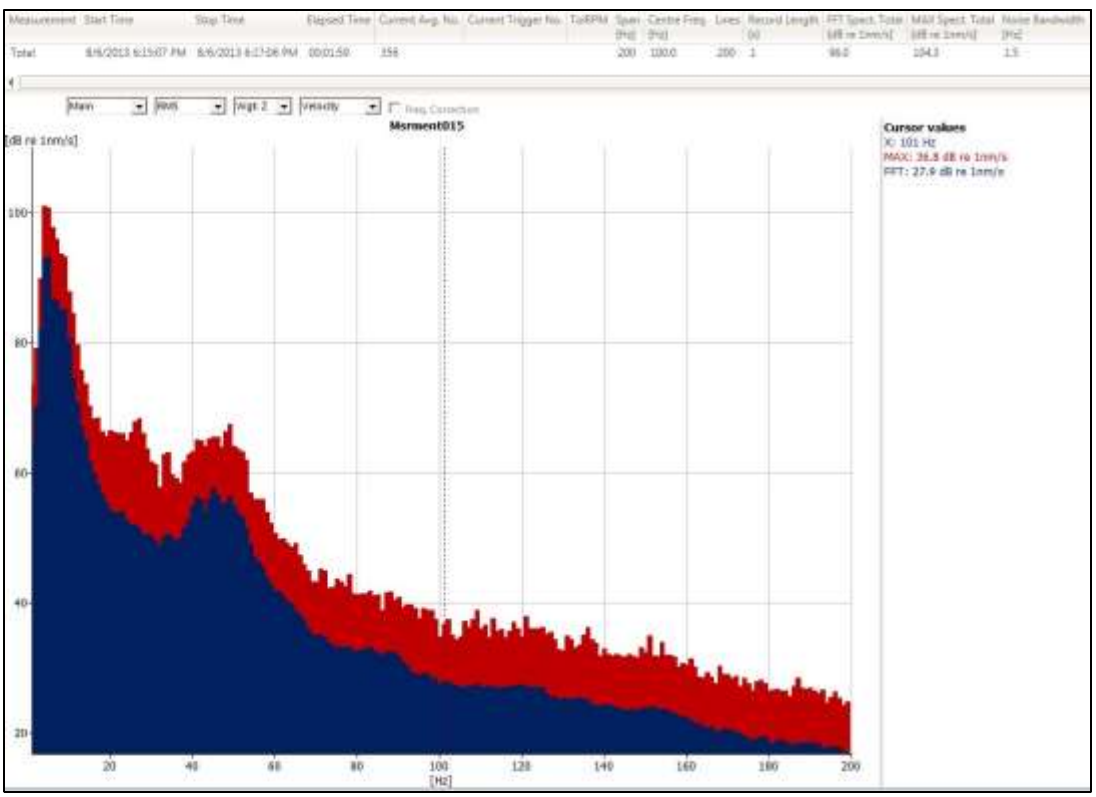
Site 2 Ambient Vibration Spectra 3 – Heavy Trucks on 41B St and Deltaport Way



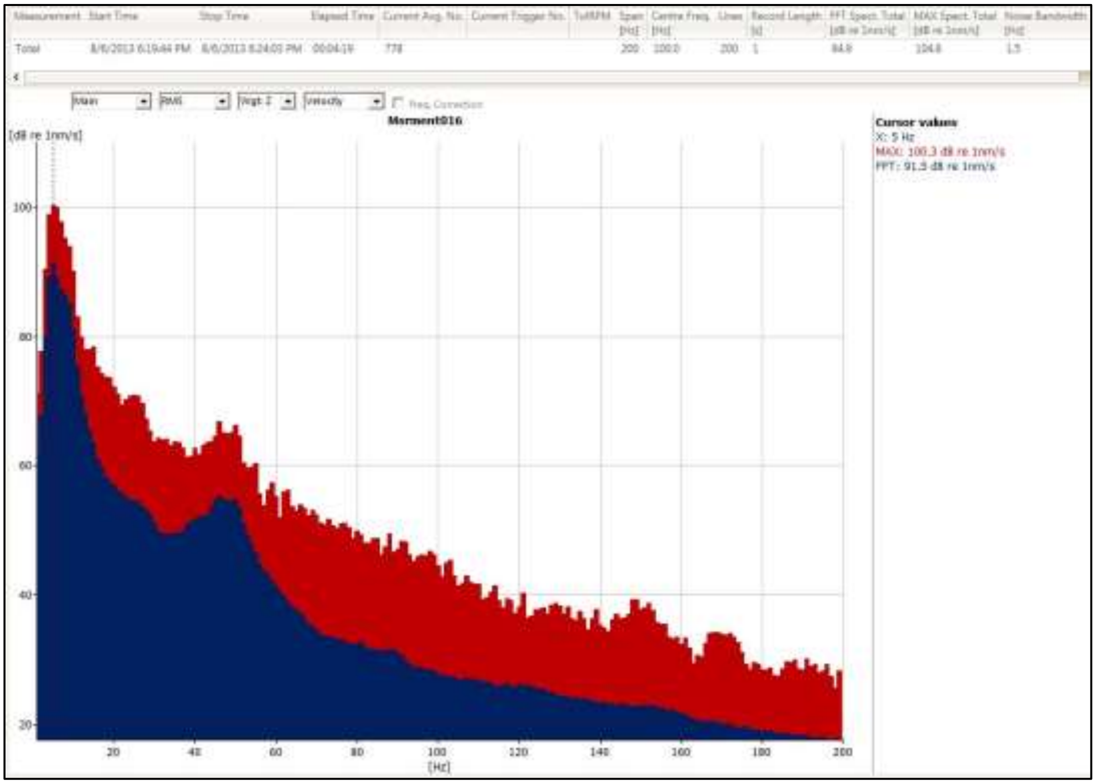
Site 2 Train Pass-by Spectra



Site 2 Train Pass-by Spectra #2



Site 3 Train Pass-by Spectra #1



Site 4 Train Pass-by Spectra #2

APPENDIX E

Monthly Average Construction Noise Levels

Table E-1 Monthly Average Construction L_d

Site	Average Construction L_d (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	14.7	29.4	25.9	25.9	42.0	42.0	49.3	46.5	46.5	43.5	43.5	43.5	43.5	43.5	43.6	43.6	29.9	29.9
4	16.1	30.8	27.3	27.3	40.3	40.3	47.5	44.7	44.7	41.8	41.8	41.8	41.8	41.9	42.0	42.0	31.3	31.3
5	17.3	32.0	28.5	28.5	34.5	34.5	40.6	38.0	37.8	35.8	35.8	35.8	35.8	36.0	36.5	36.7	32.5	32.5

Site	Average Construction L_d (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	29.9	33.3	32.0	38.9	39.1	39.1	39.1	43.7	43.7	43.9	42.3	42.3	46.2	47.4	47.0	48.6	47.4	44.3
4	31.3	34.7	33.4	37.4	37.8	37.8	37.8	42.1	42.0	42.4	40.9	40.9	44.6	45.8	45.4	46.9	45.9	43.1
5	32.5	35.9	34.6	32.7	33.9	34.0	34.0	36.4	36.1	37.8	36.7	36.9	39.0	39.8	40.1	41.1	40.7	39.7

Site	Average Construction L_d (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	44.2	45.2	45.0	45.0	47.1	47.1	47.1	47.1	47.0	46.4	46.3	46.2	46.2	46.1	46.1	43.3	31.8	34.0
4	43.0	43.8	43.7	43.7	45.6	45.7	45.6	45.6	45.5	44.9	45.0	44.7	44.7	44.6	44.7	41.9	33.2	35.4
5	39.5	39.6	39.6	39.6	41.0	41.2	41.1	41.0	40.7	40.4	41.2	40.2	40.0	39.9	40.0	37.6	34.4	36.6

Site	Average Construction L_d (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	33.2	33.5	33.6	32.3	31.2	28.6	27.0	29.5	29.5	29.5	23.9
4	34.6	34.9	35.0	33.7	32.6	30.0	28.4	30.9	30.9	30.9	25.3
5	35.8	36.1	36.2	34.9	33.8	31.2	29.6	32.1	32.1	32.1	26.5

Table E-2 Monthly Average Combined Construction L_d

Site	Average Combined L_d (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	51.9	51.9	51.9	51.9	52.3	52.3	53.8	53.0	53.0	52.5	52.5	52.5	52.5	52.5	52.5	52.5	51.9	51.9
4	48.4	48.5	48.4	48.4	49.0	49.0	51.0	49.9	49.9	49.3	49.3	49.3	49.3	49.3	49.3	49.3	48.5	48.5
5	52.3	52.3	52.3	52.3	52.4	52.4	52.6	52.5	52.5	52.4	52.4	52.4	52.4	52.4	52.4	52.4	52.3	52.3

Site	Average Combined L_d (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	51.9	52.0	51.9	52.1	52.1	52.1	52.1	52.5	52.5	52.5	52.3	52.4	52.9	53.2	53.1	53.6	53.2	52.6
4	48.5	48.6	48.5	48.7	48.8	48.8	48.8	49.3	49.3	49.4	49.1	49.1	49.9	50.3	50.2	50.7	50.3	49.5
5	52.3	52.4	52.3	52.3	52.4	52.4	52.4	52.4	52.4	52.5	52.4	52.4	52.5	52.5	52.6	52.6	52.6	52.5

Site	Average Combined L_d (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	52.6	52.7	52.7	52.7	53.1	53.1	53.1	53.1	53.1	53.0	53.1	52.9	52.9	52.9	52.9	52.5	51.9	52.0
4	49.5	49.7	49.7	49.7	50.2	50.3	50.2	50.2	50.2	50.0	50.2	50.0	49.9	49.9	49.9	49.3	48.5	48.6
5	52.5	52.5	52.5	52.5	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.5	52.5	52.5	52.4	52.4	52.4

Site	Average Combined L_{dn} (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	52.0	52.0	52.0	51.9	51.9	51.9	51.9	51.9	51.9	51.9	51.9
4	48.6	48.6	48.6	48.5	48.5	48.5	48.4	48.5	48.5	48.5	48.4
5	52.4	52.4	52.4	52.4	52.4	52.3	52.3	52.3	52.3	52.3	52.3

Table E-3 Increases in Monthly Average L_d due to Construction Noise

Site	Average Increase in L_d (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	0.0	0.0	0.0	0.0	0.4	0.4	1.9	1.1	1.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0
4	0.0	0.1	0.0	0.0	0.6	0.6	2.6	1.5	1.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.1	0.1
5	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0

Site	Average Increase in L_d (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	0.0	0.1	0.0	0.2	0.2	0.2	0.2	0.6	0.6	0.6	0.4	0.5	1.0	1.3	1.2	1.7	1.3	0.7
4	0.1	0.2	0.1	0.3	0.4	0.4	0.4	0.9	0.9	1.0	0.7	0.7	1.5	1.9	1.8	2.3	1.9	1.1
5	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2

Site	Average Increase in L_d (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	0.7	0.8	0.8	0.8	1.2	1.2	1.2	1.2	1.2	1.1	1.2	1.0	1.0	1.0	1.0	0.6	0.0	0.1
4	1.1	1.3	1.3	1.3	1.8	1.9	1.8	1.8	1.8	1.6	1.8	1.6	1.5	1.5	1.5	0.9	0.1	0.2
5	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1

Site	Average Increase in L_d (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0
5	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Table E-4 Monthly Average Construction L_n

Site	Average Construction L_n (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	14.7	29.4	25.9	25.9	42.0	42.0	49.3	46.5	46.5	43.5	43.5	43.5	43.5	43.5	43.6	43.6	29.2	29.2
4	16.1	30.8	27.3	27.3	40.3	40.3	47.5	44.7	44.7	41.8	41.8	41.8	41.8	41.9	42.0	42.0	30.6	30.6
5	17.3	32.0	28.5	28.5	34.5	34.5	40.6	38.0	37.8	35.8	35.8	35.8	35.8	35.9	36.4	36.5	31.8	31.8

Site	Average Construction L_n (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	29.2	33.0	31.6	39.4	39.5	39.5	39.5	43.9	43.8	43.9	42.3	42.3	46.2	47.4	46.9	46.9	45.0	34.3
4	30.6	34.4	33.0	38.4	38.5	38.6	38.6	42.4	42.3	42.4	40.9	40.9	44.6	45.8	45.2	45.2	43.3	34.4
5	31.8	35.6	34.2	35.7	36.1	36.1	36.1	37.8	37.5	38.0	36.9	37.0	39.1	39.9	39.1	38.8	37.5	34.1

Site	Average Construction L_n (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	34.6	40.0	39.4	39.4	44.3	44.4	44.4	44.5	44.4	43.0	43.2	43.2	43.2	43.1	43.1	31.0	30.5	32.2
4	34.8	38.9	38.3	38.2	42.7	42.8	42.9	43.0	42.8	41.6	41.8	41.9	41.8	41.8	41.8	32.4	31.9	33.6
5	34.7	35.7	35.3	35.3	37.2	37.8	38.2	38.5	37.8	37.0	37.9	38.1	37.9	37.7	37.8	33.6	33.1	34.8

Site	Average Construction L_n (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	31.6	31.8	31.9	30.0	28.9	26.0	24.4	27.0	27.0	27.0	21.3
4	33.0	33.2	33.3	31.4	30.3	27.4	25.8	28.4	28.4	28.4	22.7
5	34.2	34.4	34.5	32.5	31.5	28.6	27.0	29.6	29.6	29.6	23.9

Table E-5 Monthly Average Combined Construction L_n

Site	Average Combined L_n (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	51.5	51.5	51.5	51.5	52.0	52.0	53.5	52.7	52.7	52.1	52.1	52.1	52.1	52.1	52.1	52.2	51.5	51.5
4	44.5	44.7	44.6	44.6	45.9	45.9	49.3	47.6	47.6	46.4	46.4	46.4	46.4	46.4	46.4	46.4	44.7	44.7
5	48.5	48.6	48.5	48.5	48.7	48.7	49.1	48.9	48.9	48.7	48.7	48.7	48.7	48.7	48.8	48.8	48.6	48.6
Site	Average Combined L_n (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	51.5	51.6	51.5	51.8	51.8	51.8	51.8	52.2	52.2	52.2	52.0	52.0	52.6	52.9	52.8	52.8	52.4	51.6
4	44.7	44.9	44.7	45.5	45.5	45.5	45.5	46.6	46.6	46.6	46.1	46.1	47.5	48.2	47.9	47.8	47.0	44.9
5	48.6	48.7	48.6	48.7	48.7	48.7	48.7	48.9	48.8	48.9	48.8	48.8	49.0	49.1	49.0	48.9	48.8	48.7
Site	Average Combined L_n (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	51.6	51.8	51.8	51.8	52.3	52.3	52.3	52.3	52.3	52.1	52.3	52.1	52.1	52.1	52.1	51.5	51.5	51.6
4	44.9	45.6	45.4	45.4	46.7	46.8	46.8	46.8	46.8	46.3	46.8	46.4	46.4	46.4	46.4	44.8	44.7	44.8
5	48.7	48.7	48.7	48.7	48.8	48.9	48.9	48.9	48.9	48.8	48.9	48.9	48.9	48.8	48.9	48.6	48.6	48.7

Site	Average Combined L_n (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5
4	44.8	44.8	44.8	44.7	44.7	44.6	44.6	44.6	44.6	44.6	44.5
5	48.7	48.7	48.7	48.6	48.6	48.5	48.5	48.6	48.6	48.6	48.5

Table E-6 Increases in Monthly Average L_n due to Construction Noise

Site	Average Increase in L_n (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	0.0	0.0	0.0	0.0	0.5	0.5	2.0	1.2	1.2	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.0	0.0
4	0.0	0.2	0.1	0.1	1.4	1.4	4.8	3.1	3.1	1.9	1.9	1.9	1.9	1.9	1.9	1.9	0.2	0.2
5	0.0	0.1	0.0	0.0	0.2	0.2	0.6	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.1	0.1

Site	Average Increase in L_n (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	0.0	0.1	0.0	0.3	0.3	0.3	0.3	0.7	0.7	0.7	0.5	0.5	1.1	1.4	1.3	1.3	0.9	0.1
4	0.2	0.4	0.2	1.0	1.0	1.0	1.0	2.1	2.1	2.1	1.6	1.6	3.0	3.7	3.4	3.3	2.5	0.4
5	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.4	0.3	0.4	0.3	0.3	0.5	0.6	0.5	0.4	0.3	0.2

Site	Average Increase in L_n (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	0.1	0.3	0.3	0.3	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.6	0.6	0.6	0.6	0.0	0.0	0.1
4	0.4	1.1	0.9	0.9	2.2	2.3	2.3	2.3	2.3	1.8	2.3	1.9	1.9	1.9	1.9	0.3	0.2	0.3
5	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.1	0.1	0.2

Site	Average Increase in L_n (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
5	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0

Table E-7 Monthly Average Construction L_{dn}

Site	Average Construction L_{dn} (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	21.1	35.9	32.3	32.3	48.4	48.4	55.7	52.9	52.9	49.9	49.9	49.9	49.9	49.9	50.0	50.0	35.7	35.7
4	22.5	37.3	33.7	33.7	46.7	46.7	53.9	51.1	51.1	48.2	48.2	48.2	48.2	48.3	48.4	48.4	37.1	37.1
5	23.7	38.5	34.9	34.9	40.9	40.9	47.0	44.4	44.2	42.2	42.2	42.2	42.2	42.3	42.8	42.9	38.3	38.3

Site	Average Construction L_{dn} (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	35.7	39.4	38.8	45.9	46.0	46.0	46.0	50.3	50.2	50.3	48.7	48.8	52.6	53.9	53.3	53.6	51.8	44.3
4	37.1	40.8	40.2	44.8	45.0	45.0	45.0	48.8	48.7	48.9	47.4	47.4	51.0	52.2	51.6	51.9	50.2	43.6
5	38.3	42.0	41.4	42.1	42.5	42.6	42.6	44.2	44.0	44.5	43.6	43.6	45.6	46.4	45.6	45.6	44.6	41.9

Site	Average Construction L_{dn} (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	44.4	47.7	47.2	47.2	51.2	51.3	51.3	51.4	51.3	53.2	53.3	53.3	53.3	53.3	50.2	43.1	38.6	40.0
4	43.8	46.4	46.0	46.0	49.7	49.8	49.8	49.9	49.7	49.8	50.0	50.1	50.0	50.0	48.9	42.8	40.0	41.4
5	42.2	42.9	42.7	42.7	44.4	44.9	45.2	45.3	44.7	49.3	49.6	49.9	49.7	49.7	45.2	42.1	41.2	42.6

Site	Average Construction L_{dn} (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	38.7	38.9	39.0	37.4	36.5	32.9	31.3	33.9	33.9	33.9	28.2
4	40.1	40.3	40.4	38.8	37.9	34.3	32.7	35.3	35.3	35.3	29.6
5	41.3	41.5	41.6	40.0	39.1	35.5	33.9	36.5	36.5	36.5	30.8

Table E-8 Monthly Average Combined Construction L_{dn}

Site	Average Combined L_{dn} (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	58.0	58.0	58.0	58.0	58.5	58.5	60.0	59.2	59.2	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.0	58.0
4	51.7	51.9	51.8	51.8	52.9	52.9	56.0	54.4	54.4	53.3	53.3	53.3	53.3	53.3	53.4	53.4	51.8	51.8
5	55.7	55.8	55.7	55.7	55.8	55.8	56.2	56.0	56.0	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.8	55.8

Site	Average Combined L_{dn} (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	58.0	58.1	58.0	58.3	58.3	58.3	58.3	58.7	58.7	58.7	58.5	58.5	59.1	59.4	59.3	59.3	58.9	58.2
4	51.8	52.0	51.8	52.5	52.5	52.5	52.5	53.5	53.5	53.5	53.1	53.1	54.4	55.0	54.7	54.8	54.0	52.3
5	55.8	55.9	55.8	55.9	55.9	55.9	55.9	56.0	56.0	56.0	56.0	56.0	56.1	56.2	56.1	56.1	56.0	55.9

Site	Average Combined L_{dn} (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	58.2	58.4	58.3	58.3	58.8	58.8	58.8	58.9	58.8	59.2	58.8	59.3	59.3	59.3	58.7	58.1	58.0	58.1
4	52.3	52.8	52.7	52.7	53.8	53.9	53.9	53.9	53.8	53.9	53.8	54.0	54.0	53.9	53.5	52.2	52.0	52.1
5	55.9	55.9	55.9	55.9	56.0	56.0	56.1	56.1	56.0	56.6	56.0	56.7	56.7	56.7	56.1	55.9	55.9	55.9

Site	Average Combined L_{dn} (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	58.1	58.1	58.1	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0
4	52.0	52.0	52.0	51.9	51.9	51.8	51.8	51.8	51.8	51.8	51.7
5	55.9	55.9	55.9	55.8	55.8	55.7	55.7	55.8	55.8	55.8	55.7

Table E-9 Increases in Monthly Average L_{dn} due to Construction Noise

Site	Average Increase in L_{dn} (dBA)																	
	2018						2019											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	0.0	0.0	0.0	0.0	0.5	0.5	2.0	1.2	1.2	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0
4	0.0	0.2	0.1	0.1	1.2	1.2	4.3	2.7	2.7	1.6	1.6	1.6	1.6	1.6	1.7	1.7	0.1	0.1
5	0.0	0.1	0.0	0.0	0.1	0.1	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1

Site	Average Increase in L_{dn} (dBA)																	
	2020												2021					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
3	0.0	0.1	0.0	0.3	0.3	0.3	0.3	0.7	0.7	0.7	0.5	0.5	1.1	1.4	1.3	1.3	0.9	0.2
4	0.1	0.3	0.1	0.8	0.8	0.8	0.8	1.8	1.8	1.8	1.4	1.4	2.7	3.3	3.0	3.1	2.3	0.6
5	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.4	0.4	0.3	0.2

Site	Average Increase in L_{dn} (dBA)																	
	2021						2022											
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	0.2	0.4	0.3	0.3	0.8	0.8	0.8	0.9	0.8	1.2	0.8	1.3	1.3	1.3	0.7	0.1	0.0	0.1
4	0.6	1.1	1.0	1.0	2.1	2.2	2.2	2.2	2.1	2.2	2.1	2.3	2.3	2.2	1.8	0.5	0.3	0.4
5	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.3	0.9	0.3	1.0	1.0	1.0	0.4	0.2	0.2	0.2

Site	Average Increase in L_{dn} (dBA)										
	2023										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
5	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0

APPENDIX F

Noise Model Figures

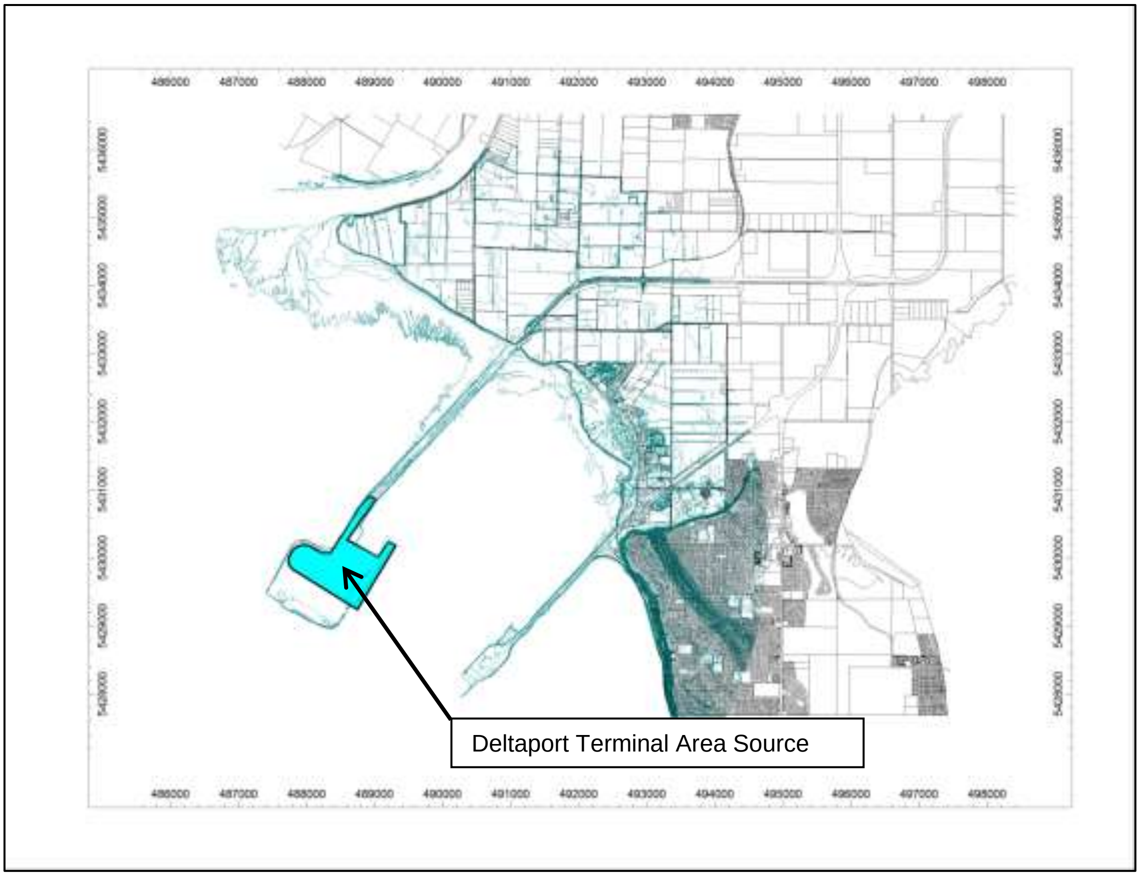


Figure F-1 Plan View of CadnaA Model showing Deltaport Terminal Area Source

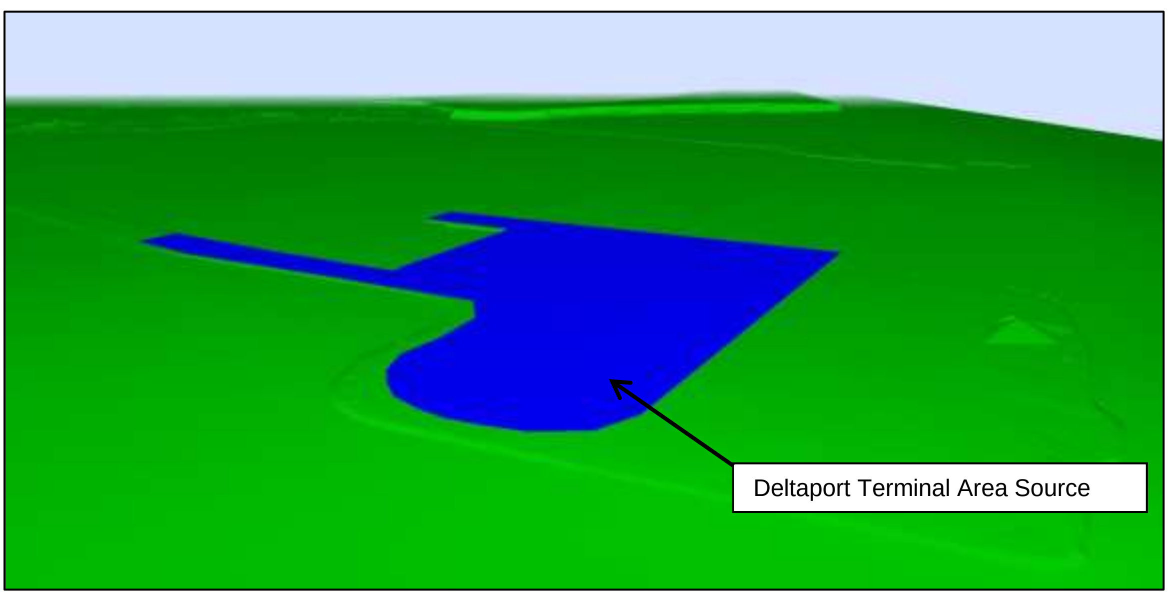


Figure F-2 Three-dimensional View of CadnaA Model showing Deltaport Terminal Area Source Looking to the East

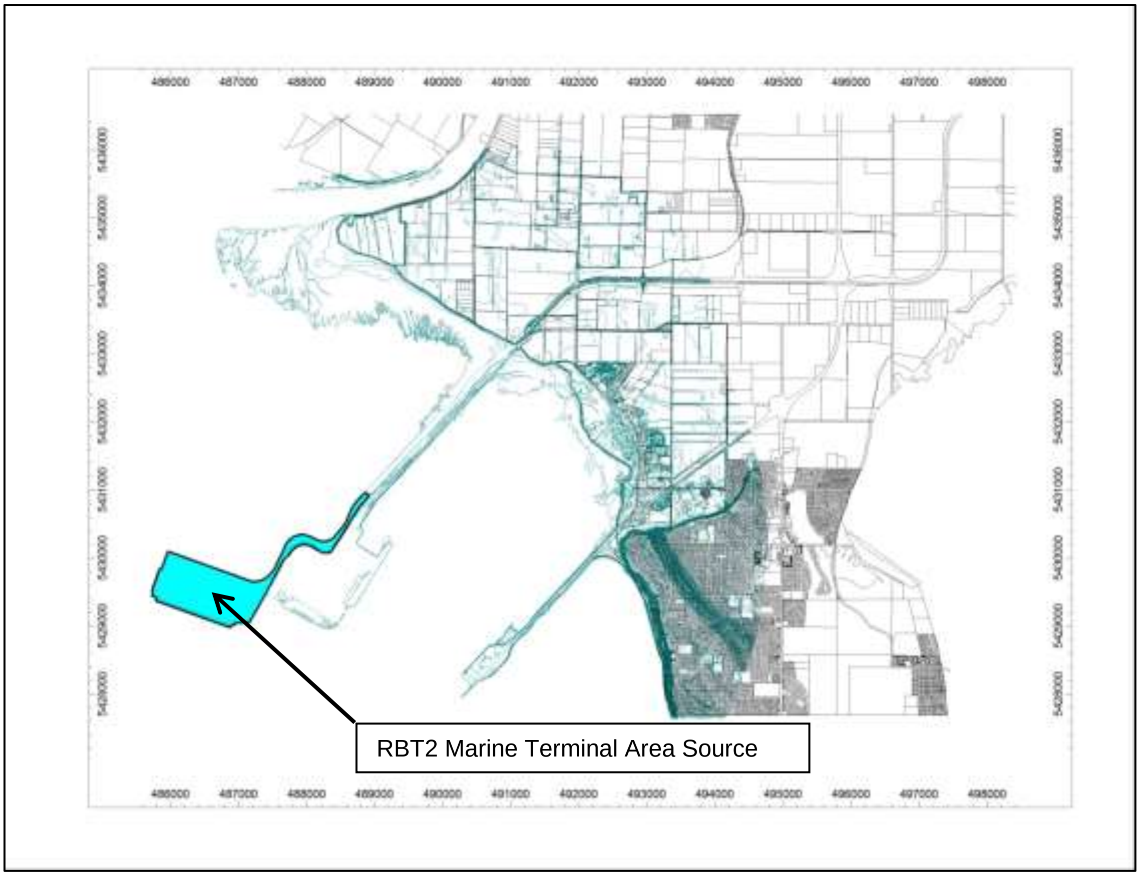


Figure F-3 **Plan View of CadnaA Model showing Roberts Bank Terminal 2 Terminal Area Source**

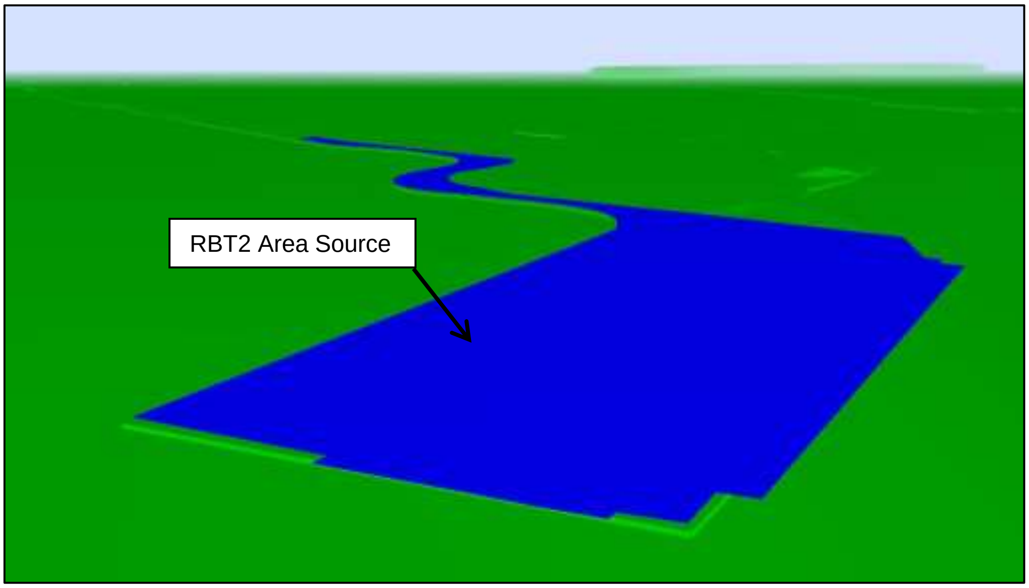


Figure F-4 **Three-dimensional View of CadnaA Model showing Roberts Bank Terminal 2 Terminal Area Source Looking to the East**

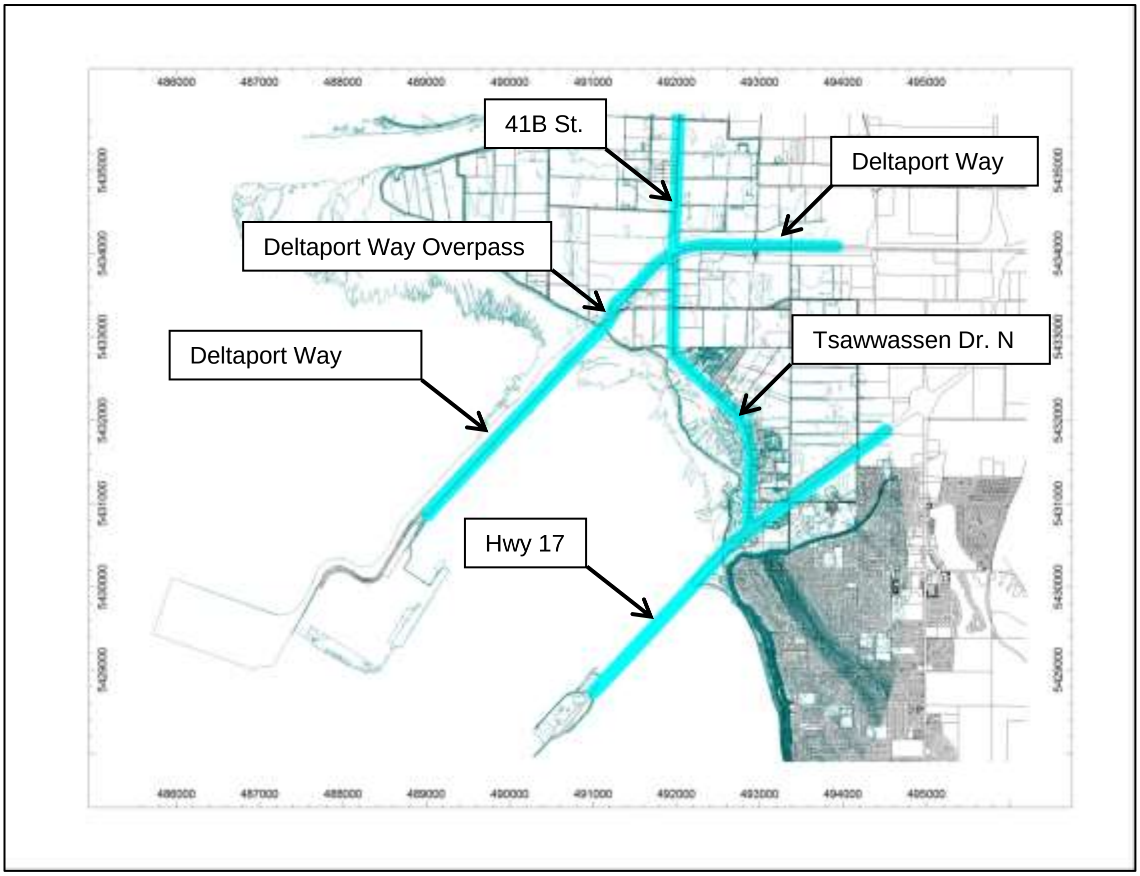


Figure F-5 Plan View of CadnaA Model Showing Roads

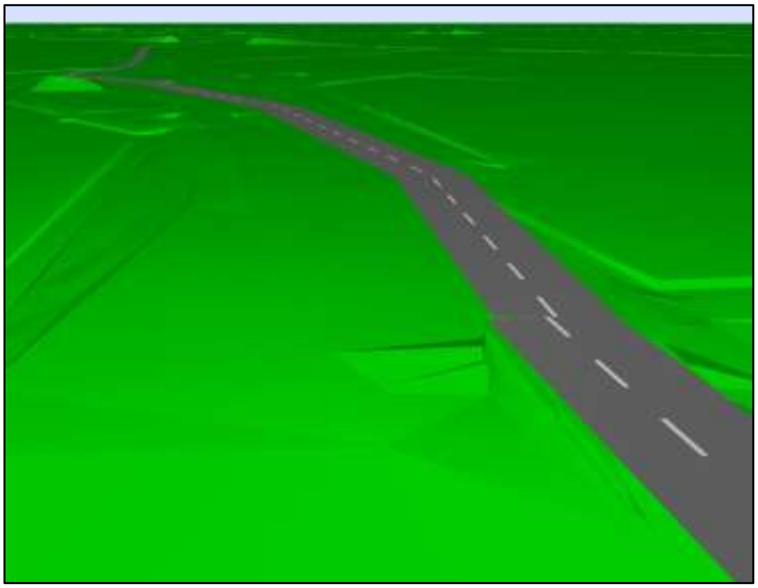


Figure F-6 Three-dimensional View of Deltaport Way Overpass at 27B Ave Looking Northeast

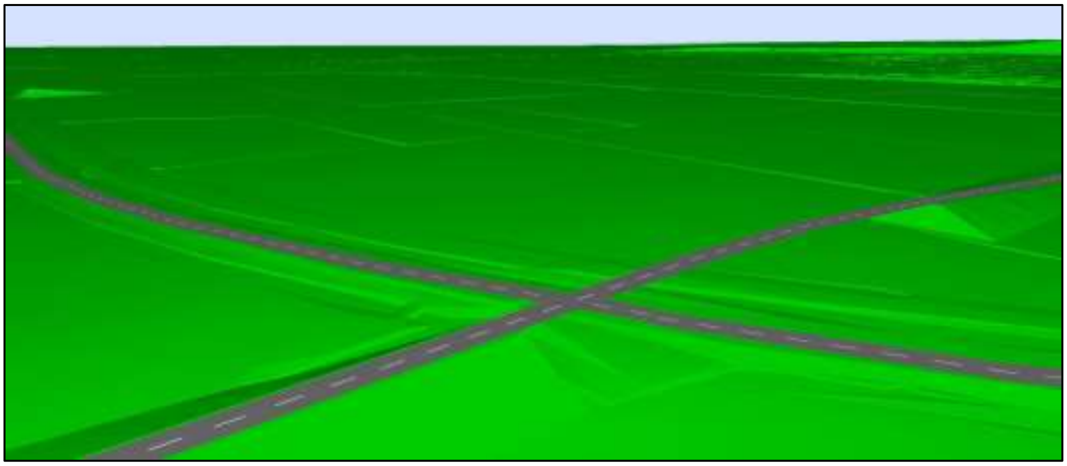


Figure F-7 Three-dimensional View of Deltaport Way and 41B St. Overpass Looking Southeast

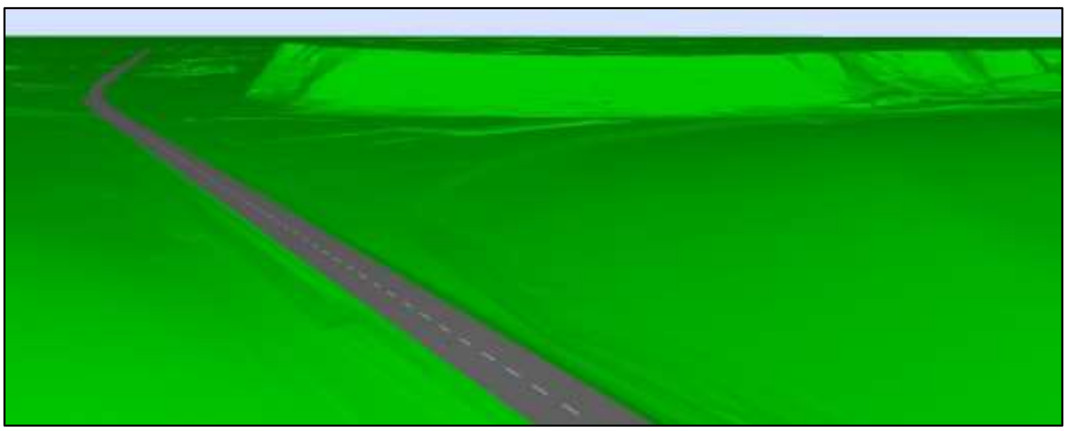


Figure F-8 Three-dimensional View of Highway 17 Looking Northeast

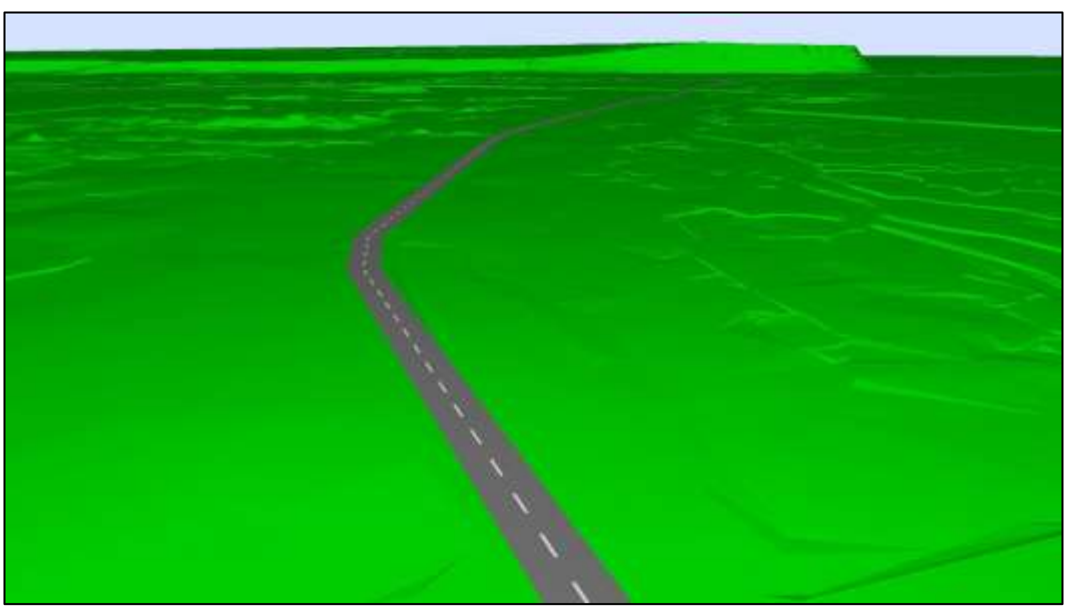


Figure F-9 Three-dimensional View of Tsawwassen Drive North Looking East

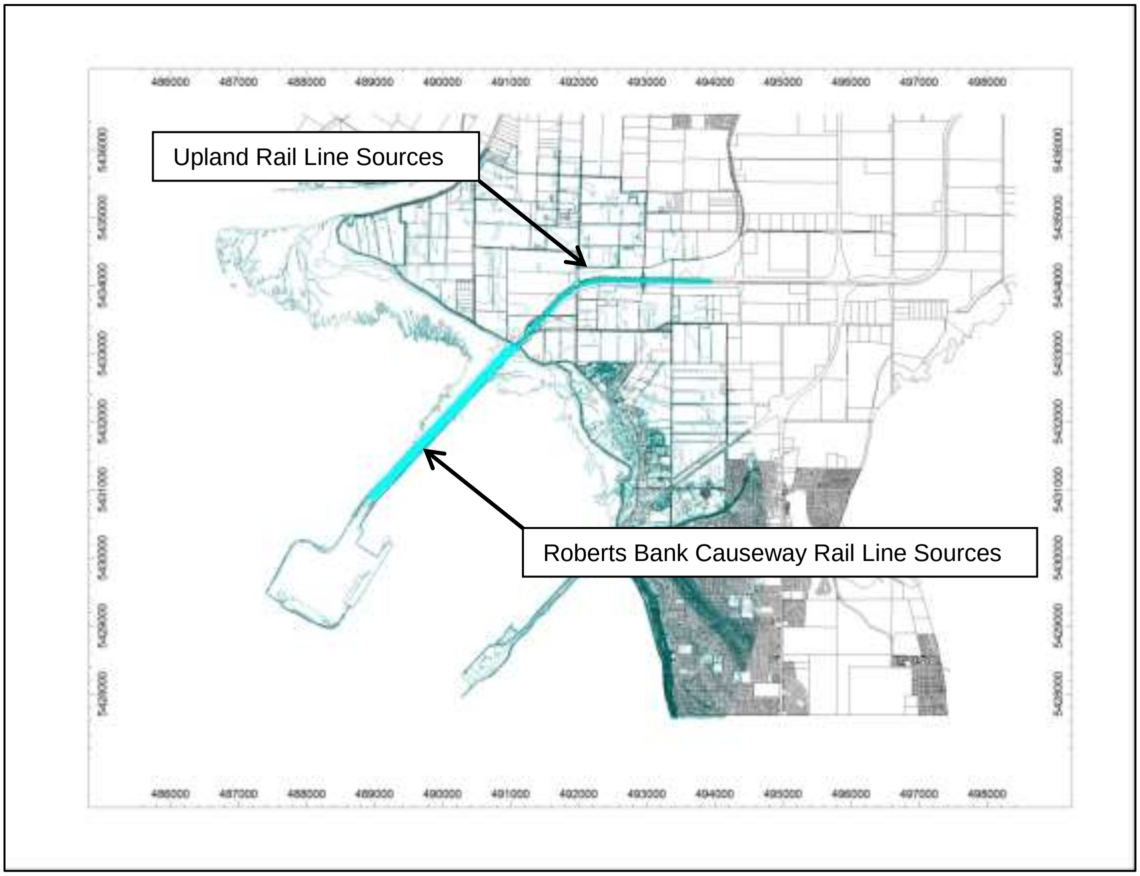


Figure F-10 Plan View of CadnaA Model showing Existing Rail Line Sources

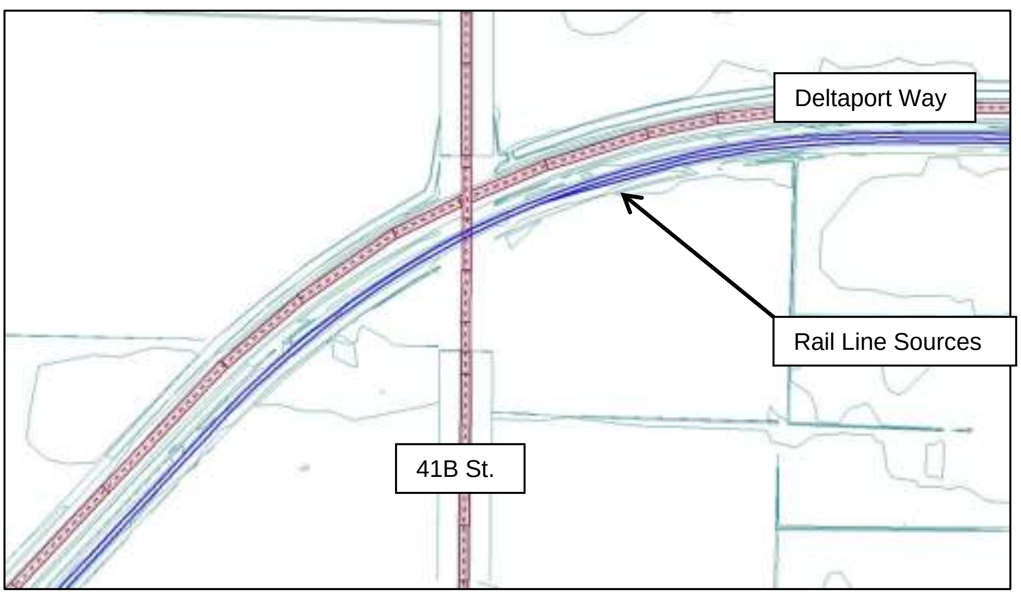


Figure F-11 Plan View of CadnaA Model showing Existing Rail Line Sources near 41B St. Overpass

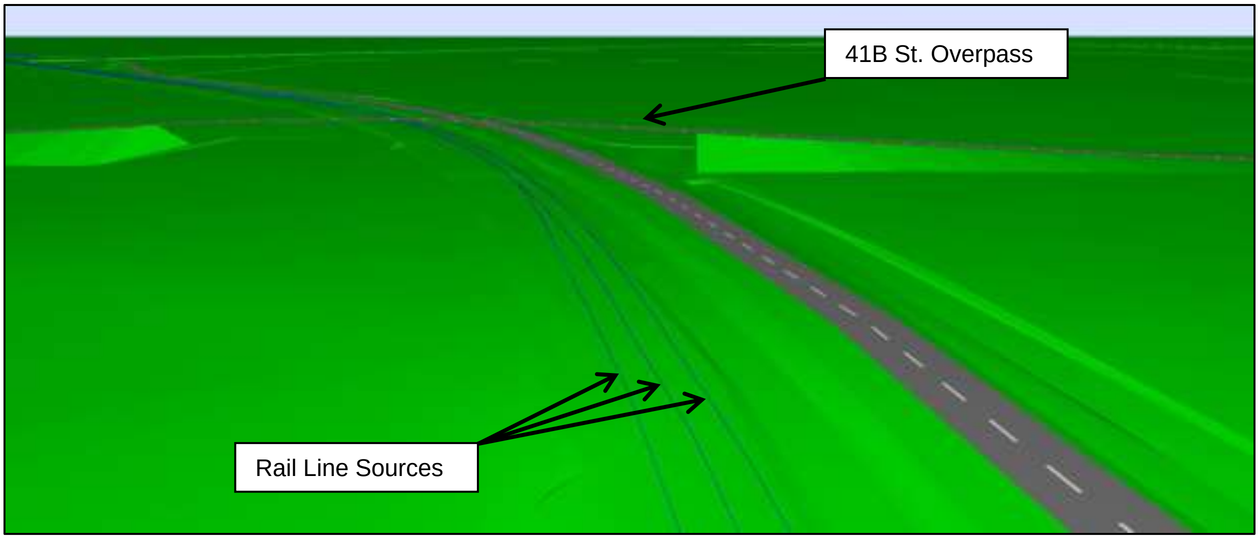


Figure F-12 Three-dimensional View of CadnaA Model showing Existing Rail Line Sources near 41B St. Overpass

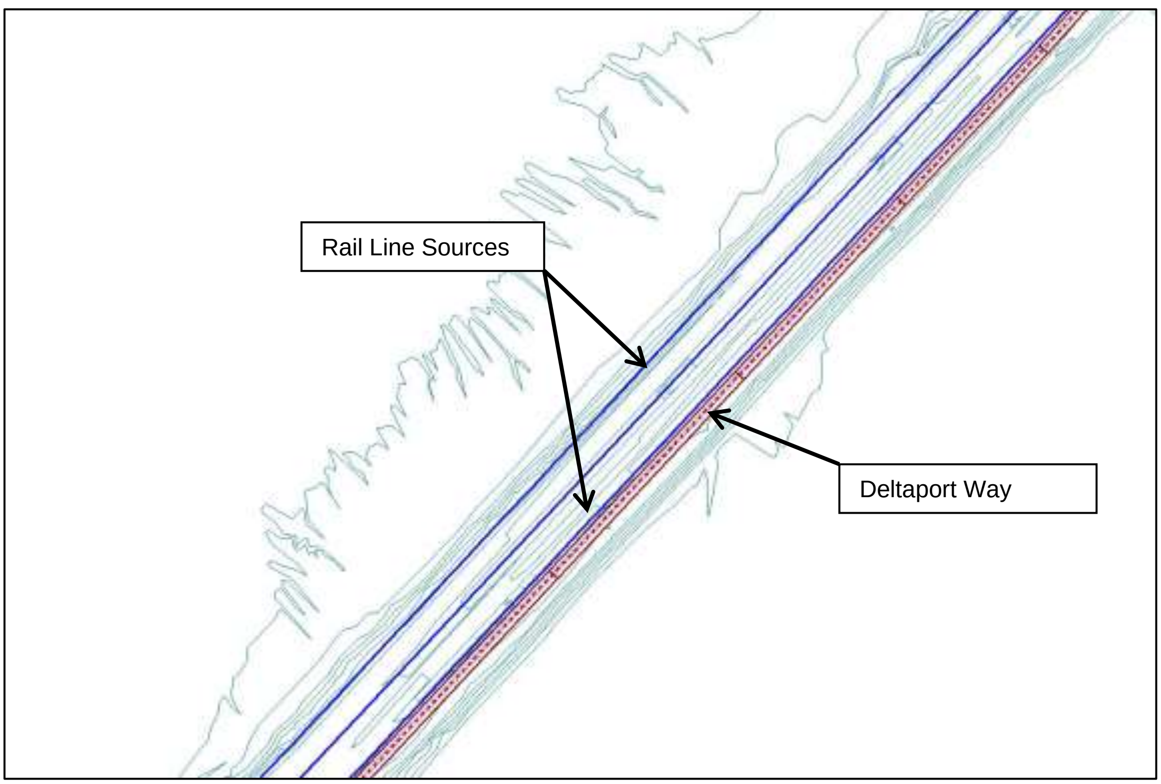


Figure F-13 Plan View of CadnaA Model showing Existing Rail Line Sources on the Roberts Bank Causeway

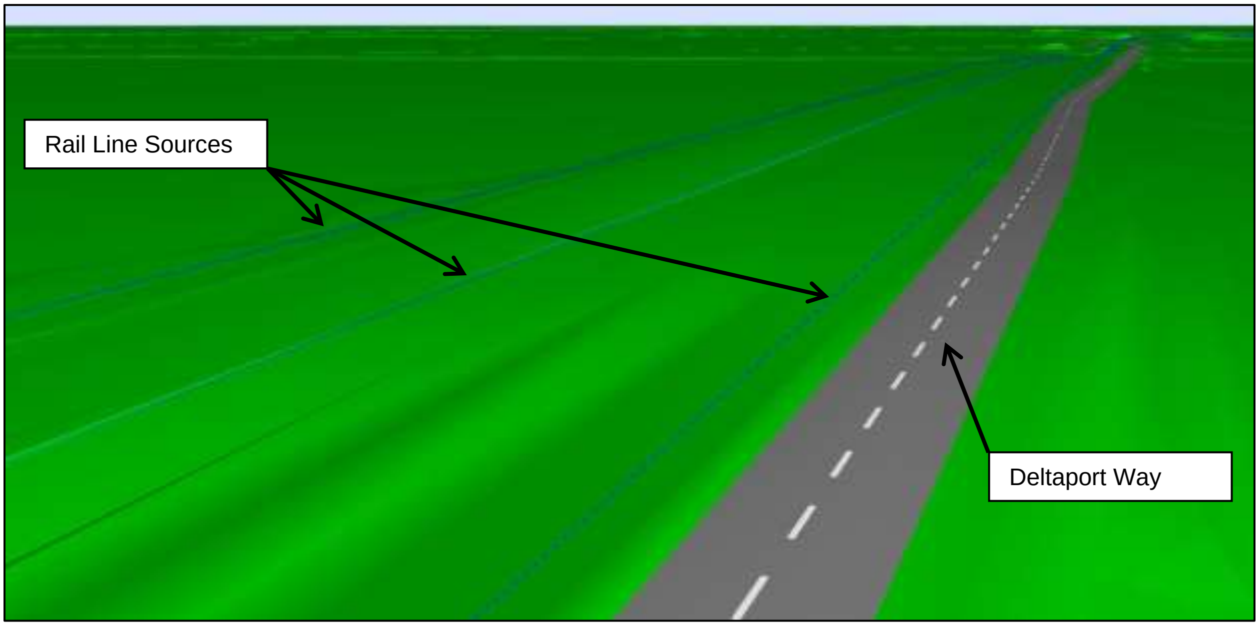


Figure F-14 Three-dimensional View of CadnaA Model showing Existing Rail Line Sources on the Roberts Bank Causeway

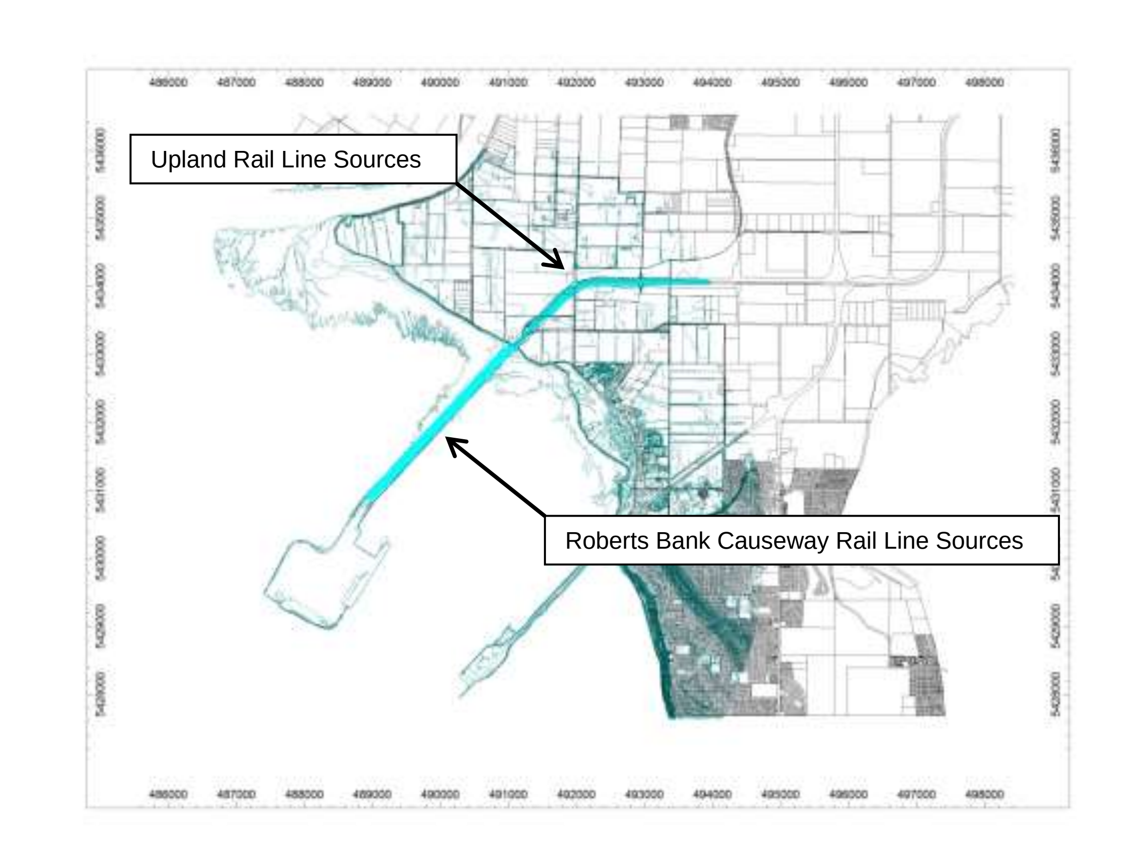


Figure F-15 Plan View of CadnaA Model showing Future (2025) Scenario 1 Rail Line

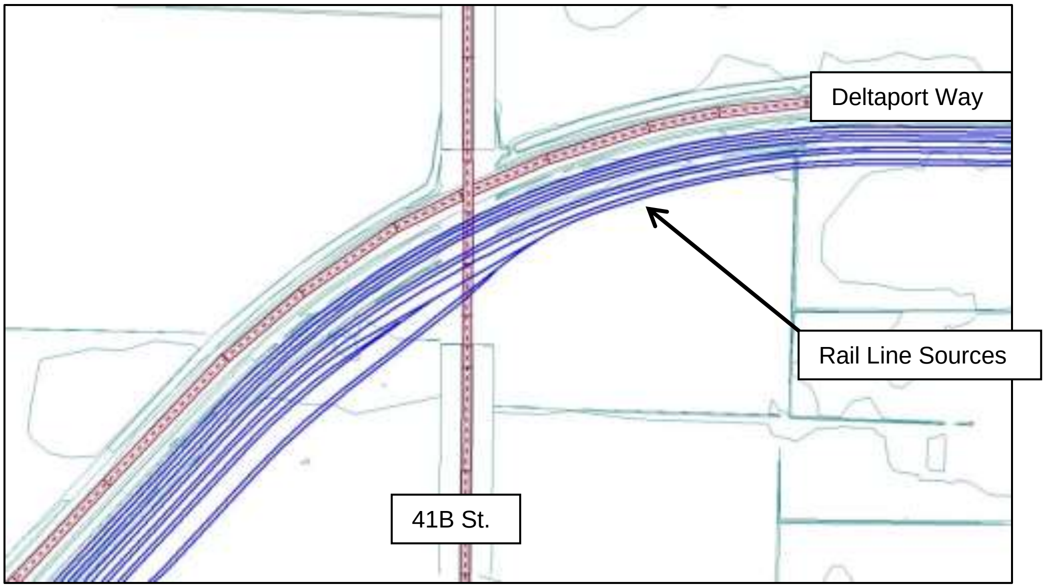


Figure F-16 Plan View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources near 41B St. Overpass

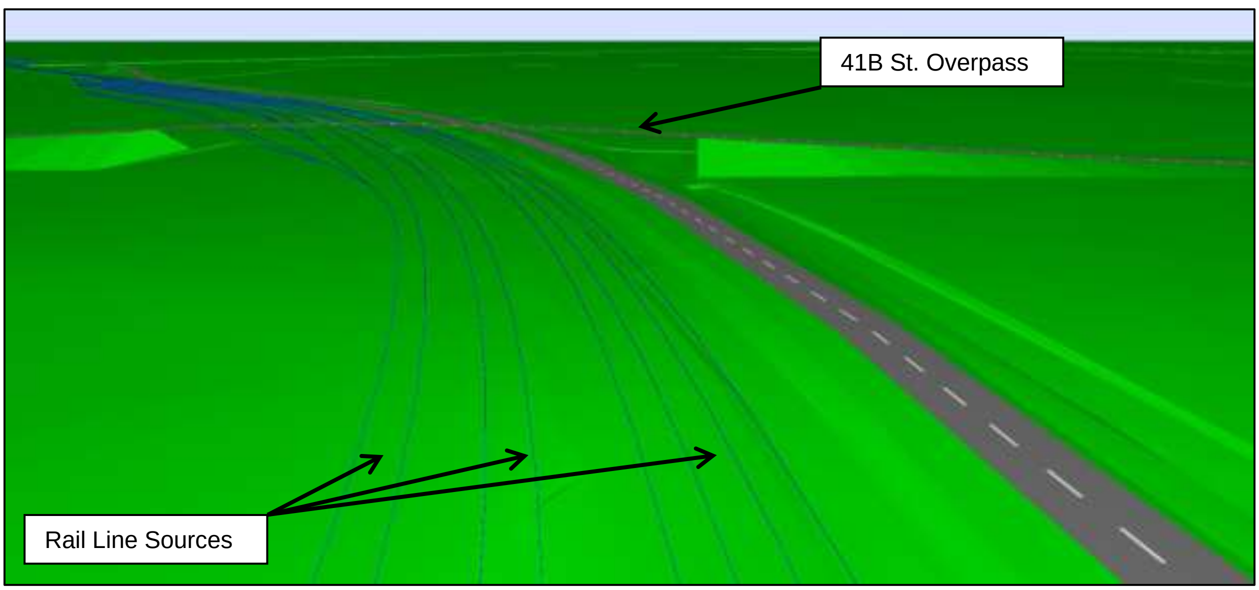


Figure F-17 Three-dimensional View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources near 41B St. Overpass

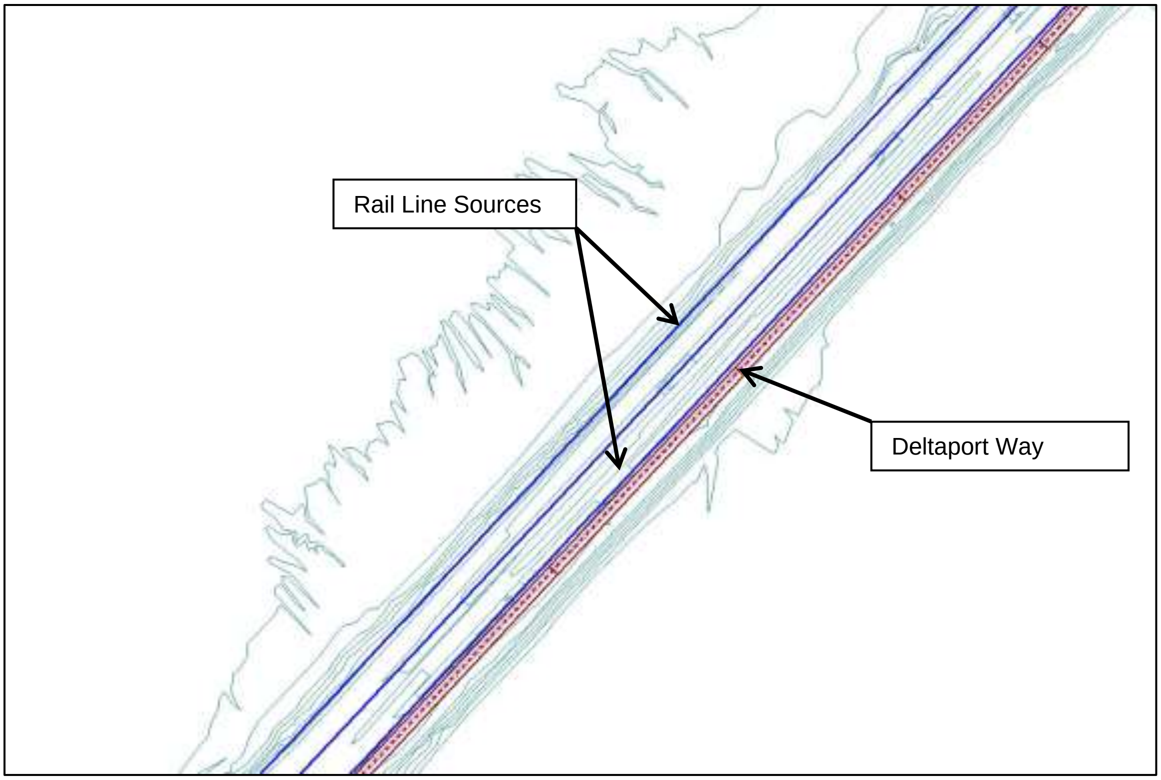


Figure F-18 Plan View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources on the Roberts Bank Causeway

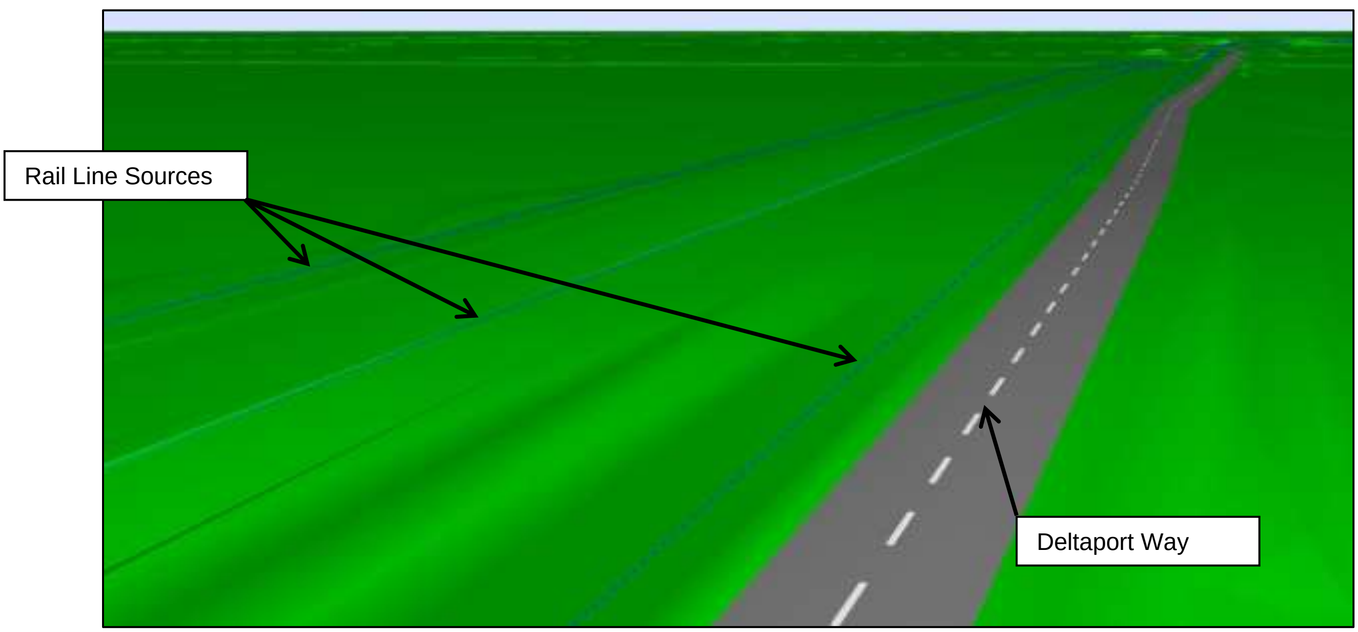


Figure F-19 Three-dimensional View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources on the Roberts Bank Causeway

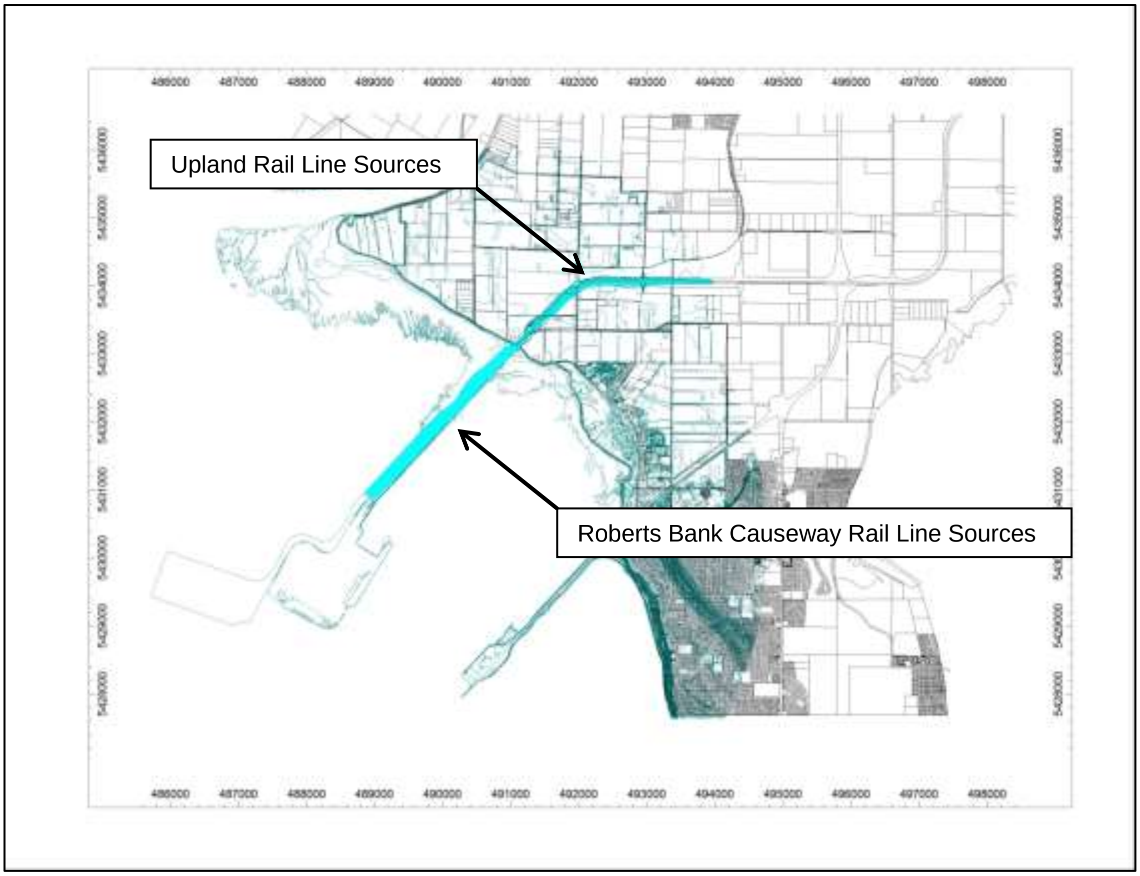


Figure F-20 Plan View of CadnaA Model showing Future (2025) Scenario 2 Rail Line Sources

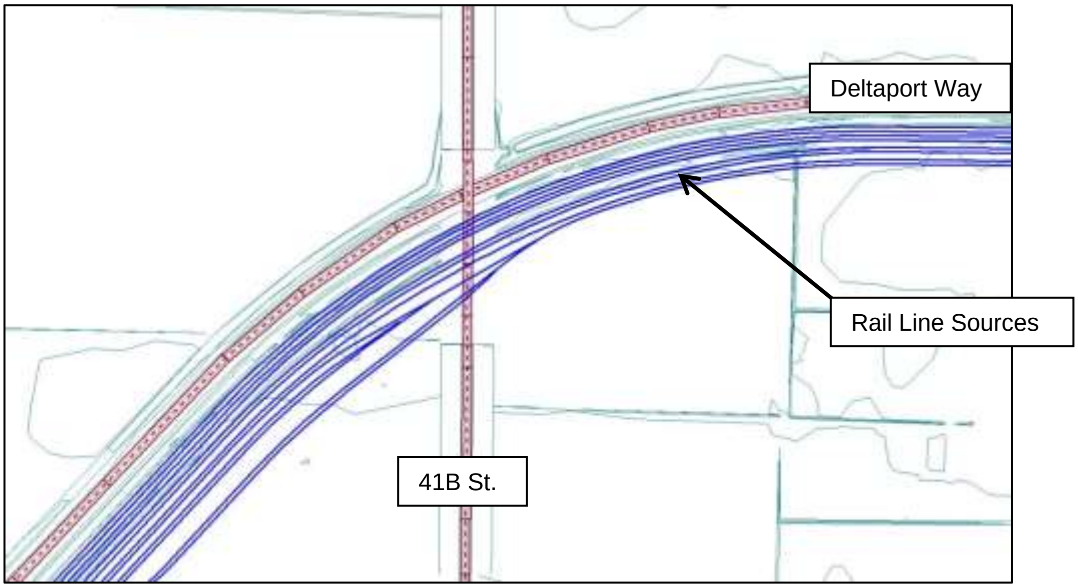


Figure F-21 Plan View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources near 41B St. Overpass

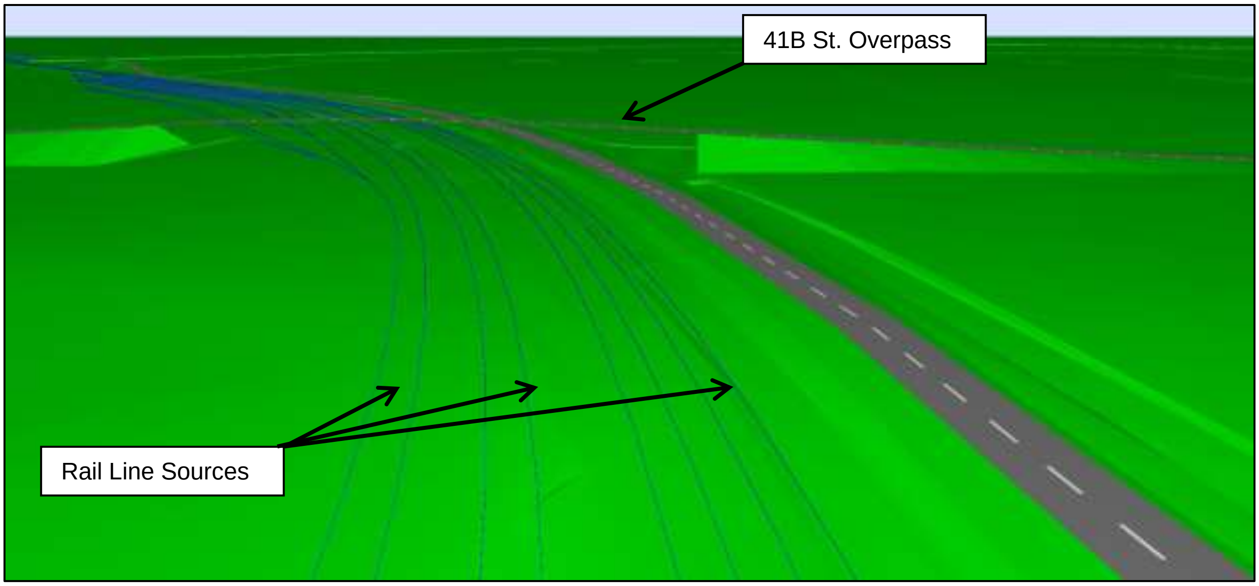


Figure F-22 **Three-dimensional View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources near 41B St. Overpass**

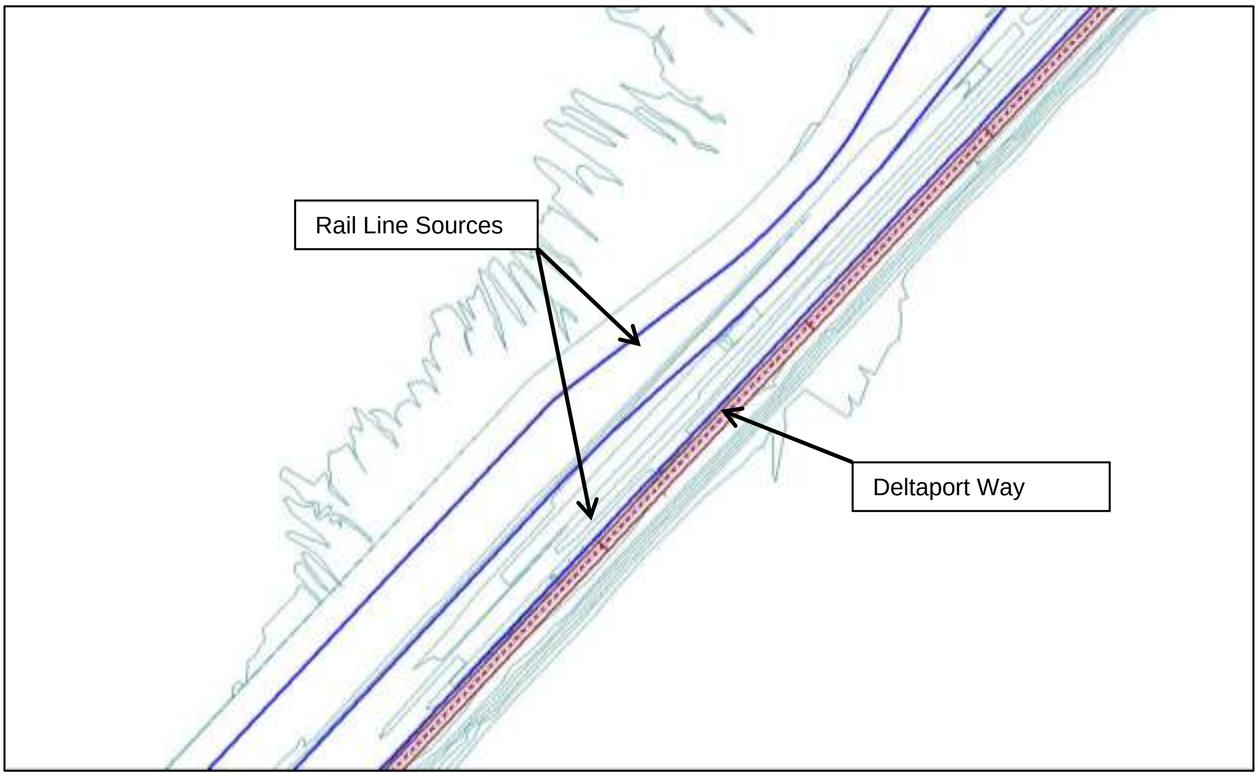


Figure F-23 **Plan View of CadnaA Model showing Future (2025) Scenario 1 Rail Line Sources on the Roberts Bank Causeway**

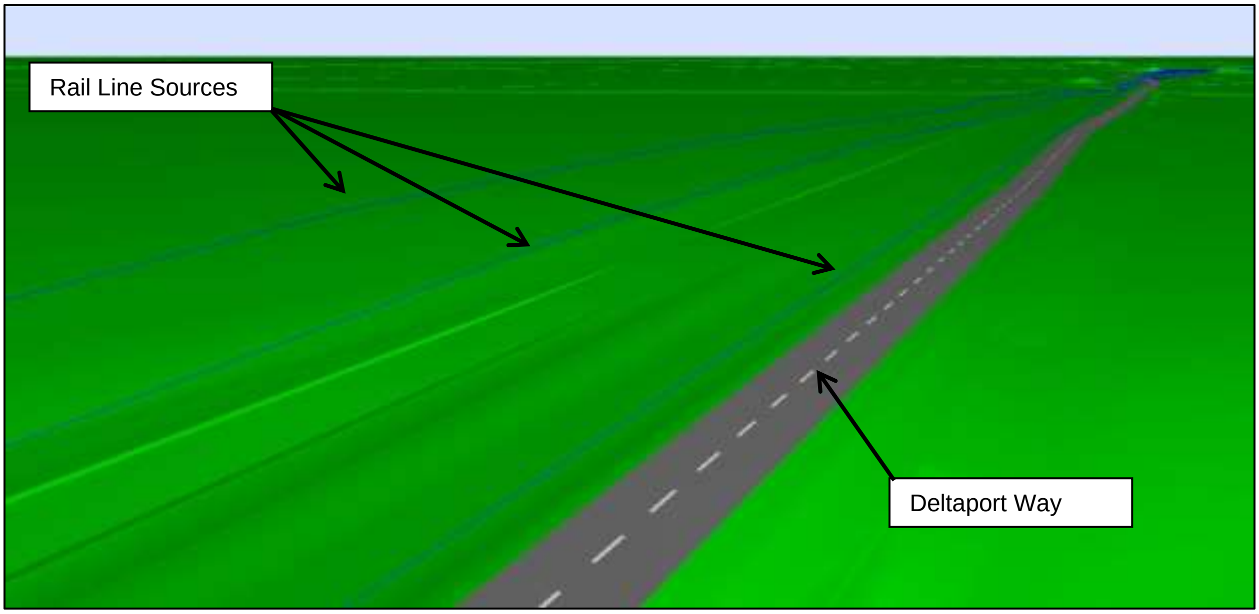


Figure F-24 Three-dimensional View of CadnaA Model showing Future (2025) Scenario 2 Rail Line Sources on the Roberts Bank Causeway

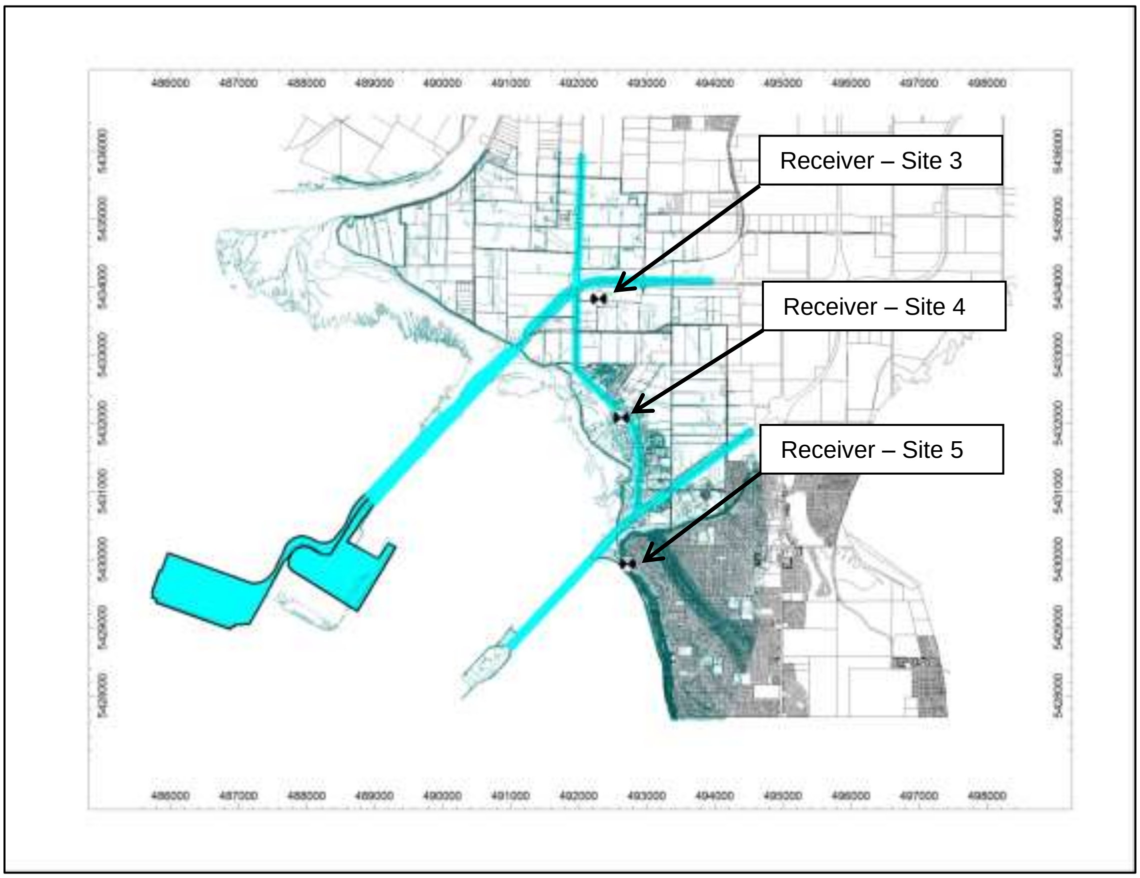


Figure F-25 Plan View of CadnaA Model showing Noise Calculation Points (Receivers)

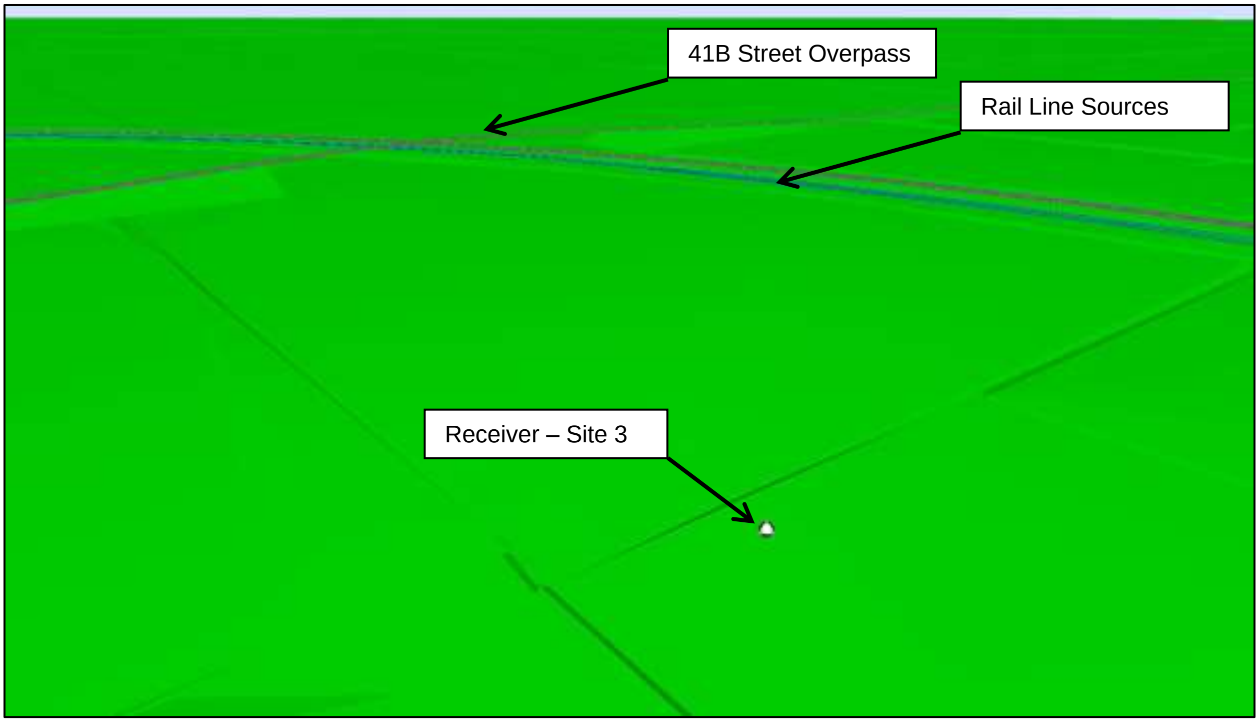


Figure F-26 Three-dimensional View of Site 3 Receiver – Existing conditions model

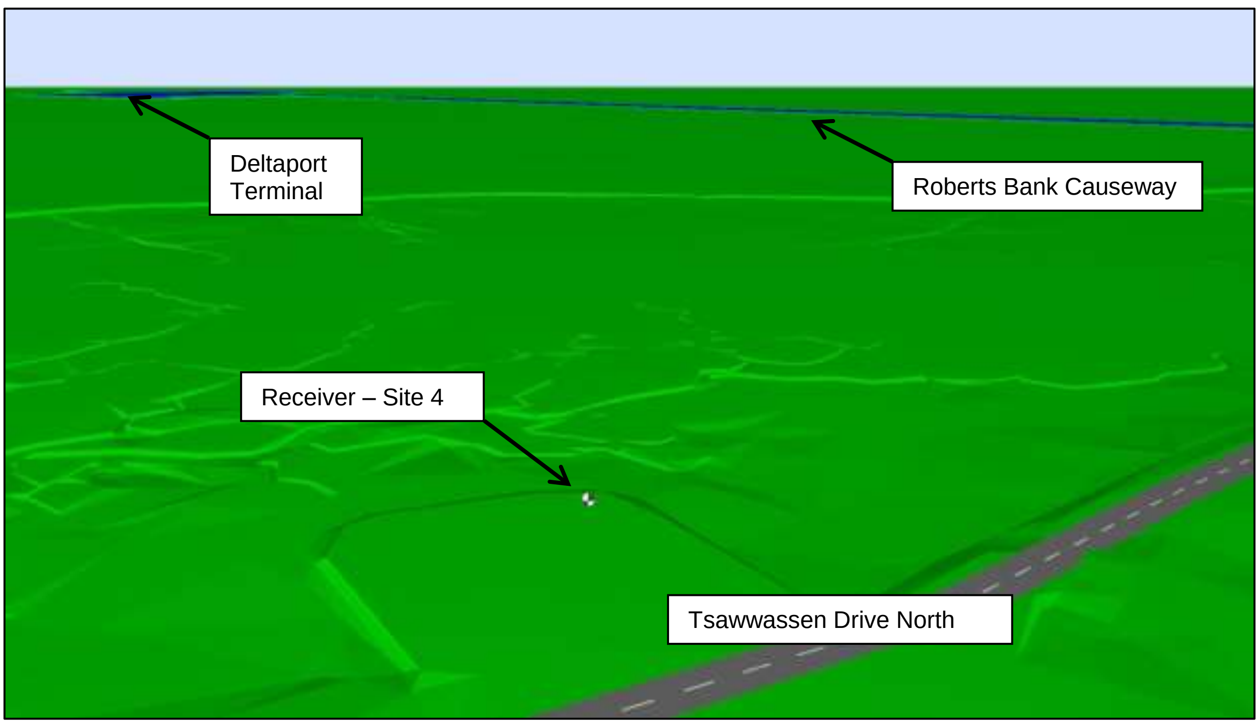


Figure F-27 Three-dimensional View of Site 4 Receiver – Existing conditions model

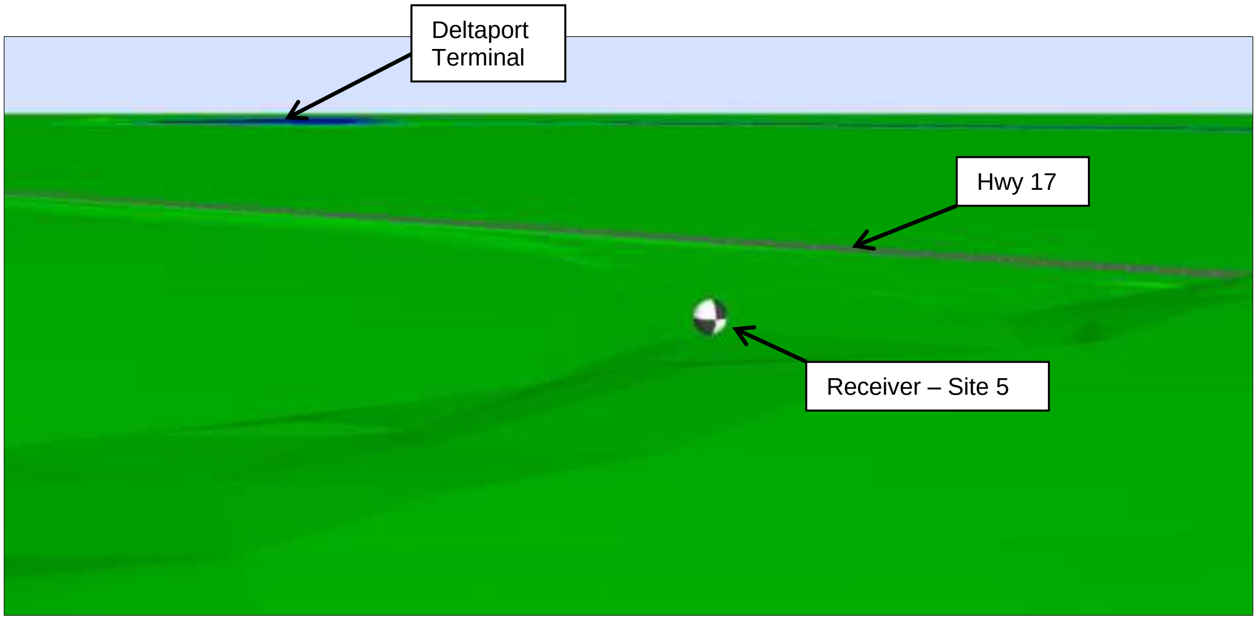


Figure F-28 Three-dimensional View of Site 5 Receiver – Existing conditions model

APPENDIX G

Noise Level Contour Maps

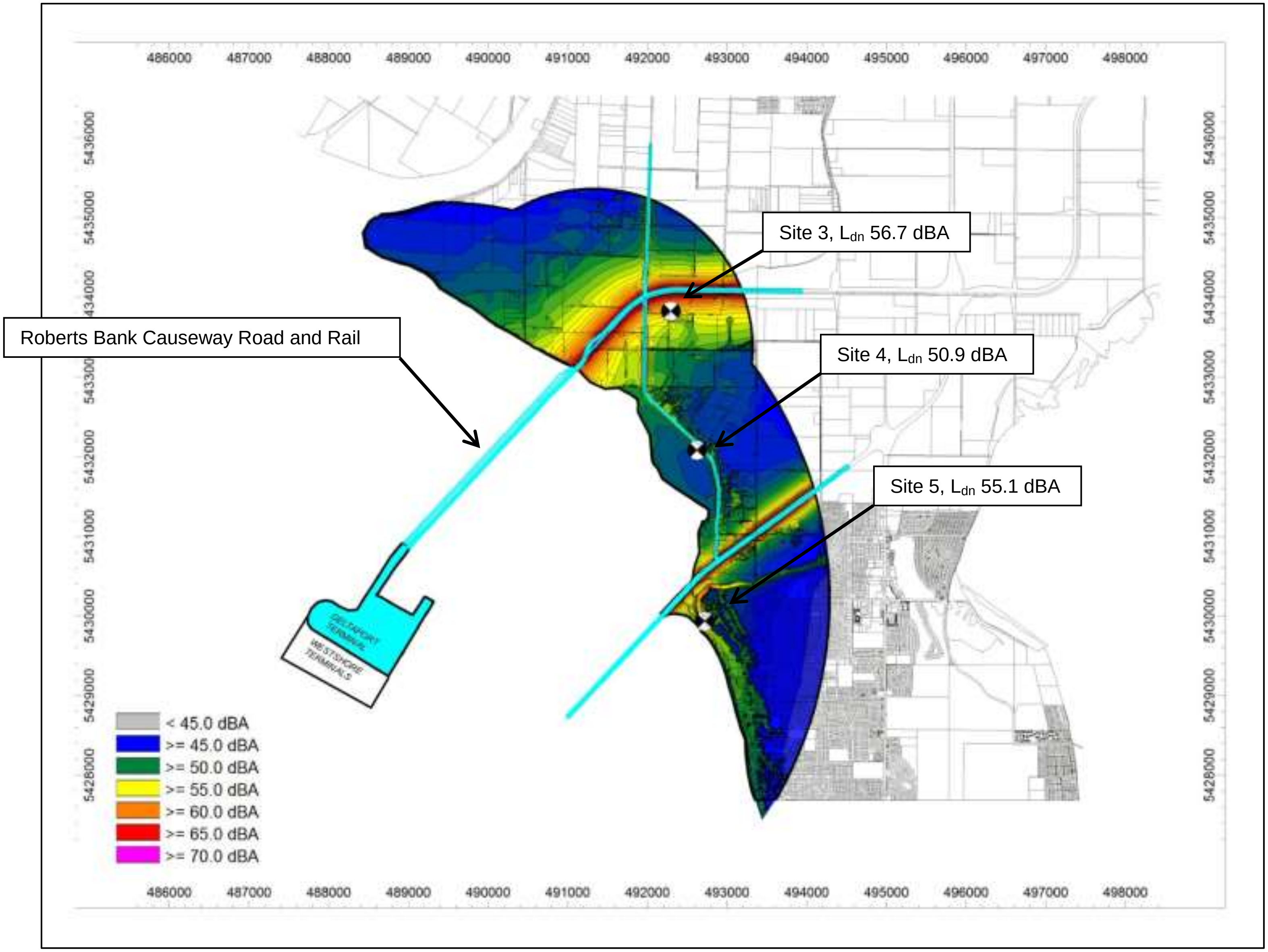


Figure G-1 Existing (2013) L_{dn} Contours

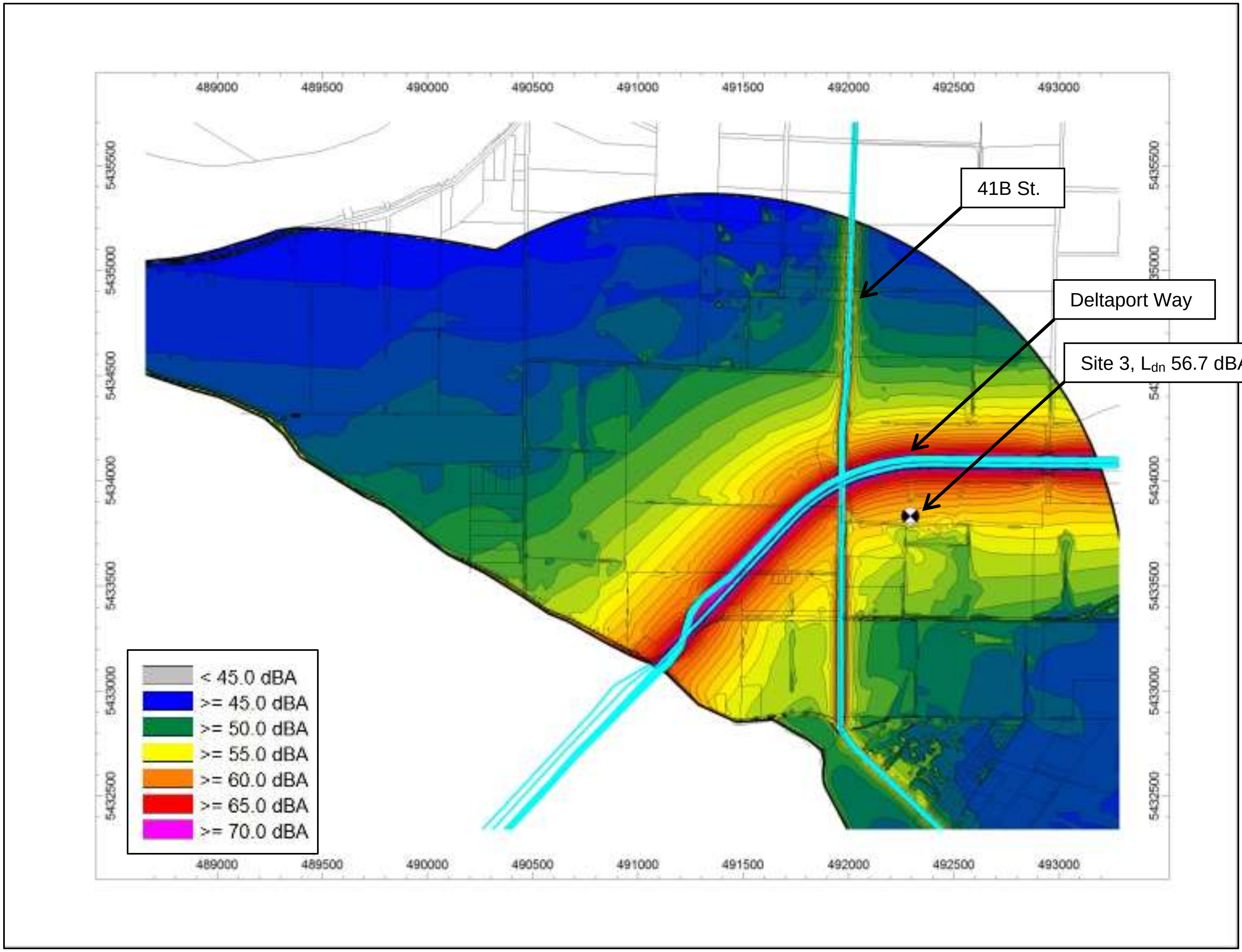


Figure G-2 Existing (2013) L_{dn} Contours - Delta near Site 3

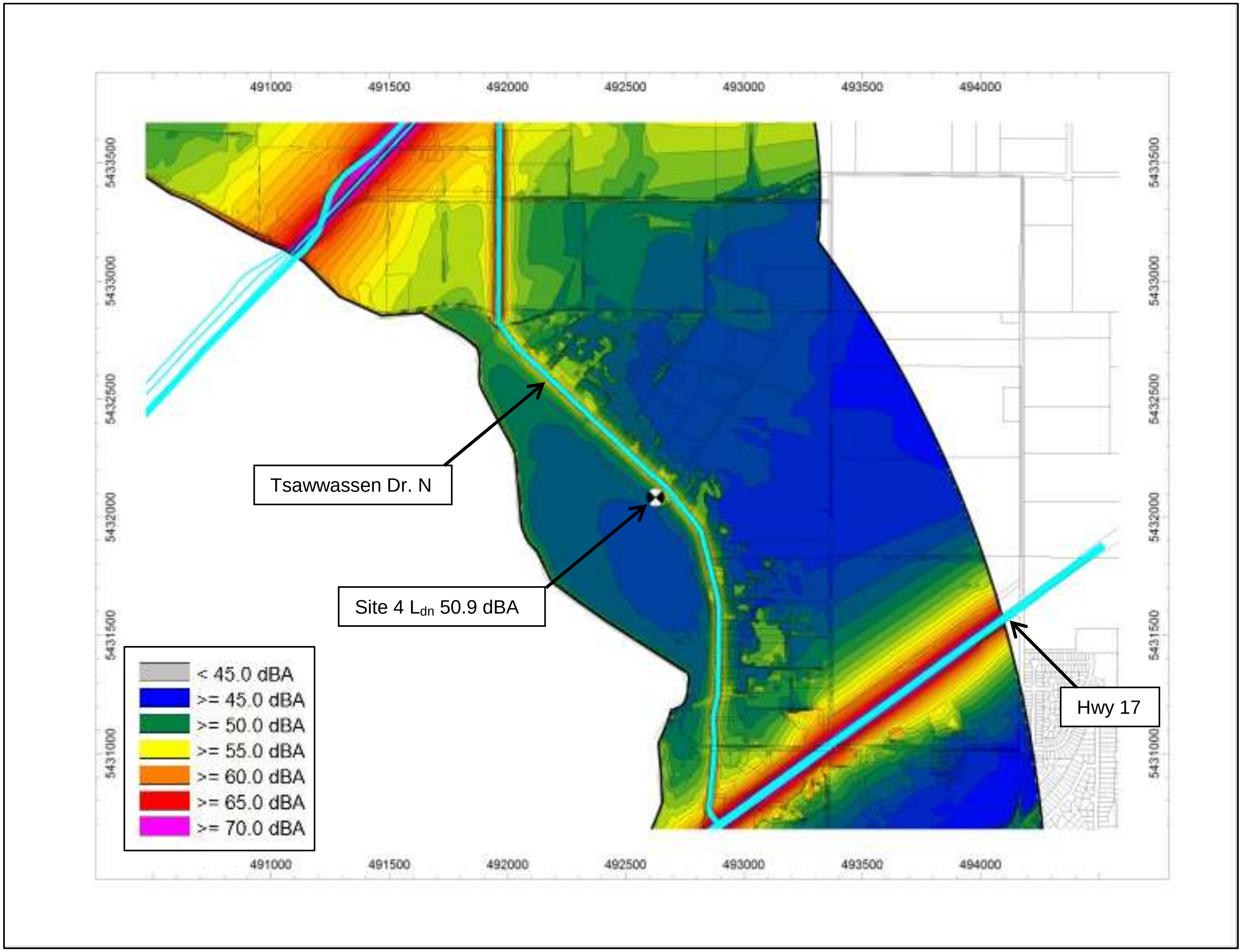


Figure G-3 Existing (2013) L_{dn} Contours - Tsawwassen First Nation

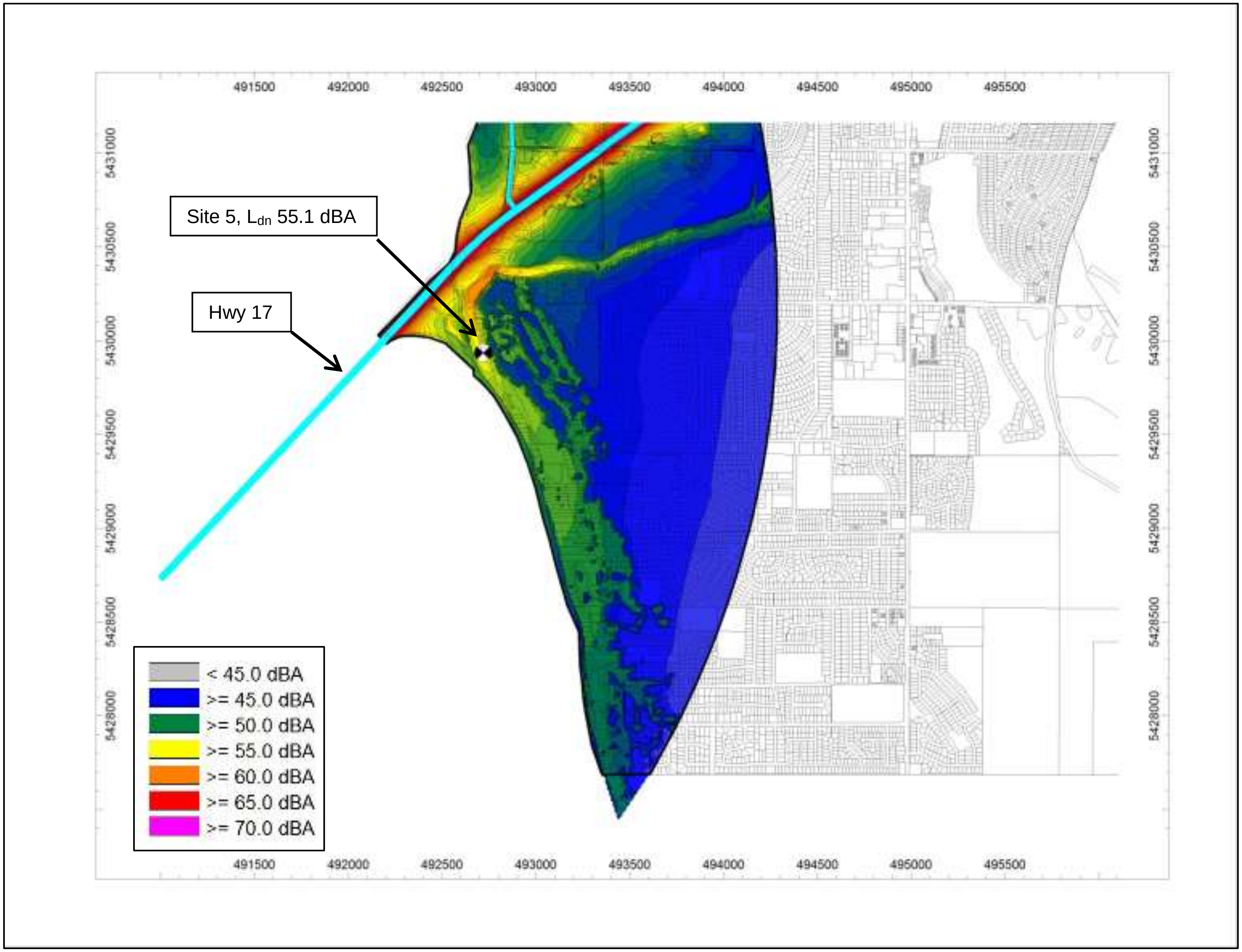


Figure G-4 Existing (2013) L_{dn} Contours - Tsawwassen

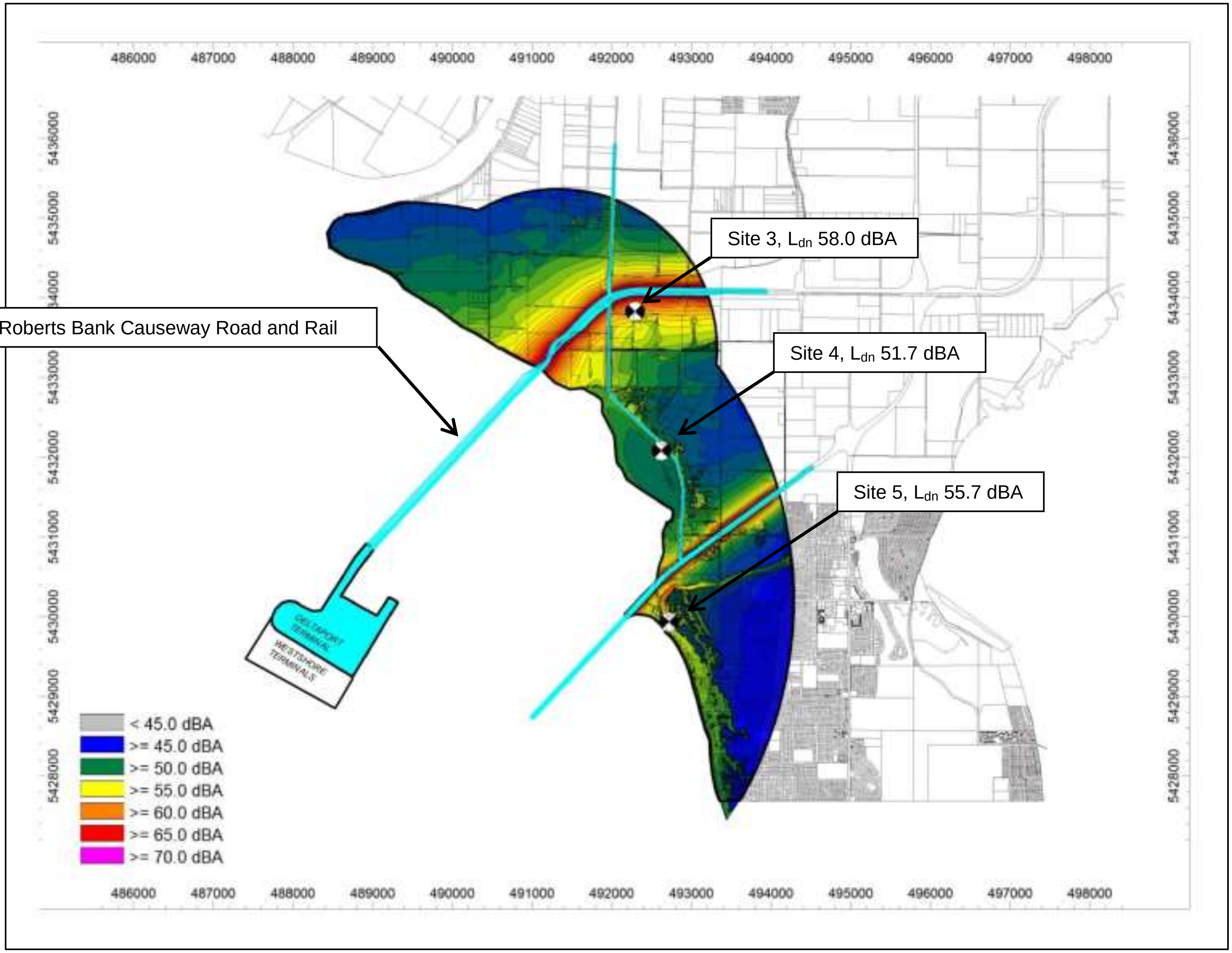
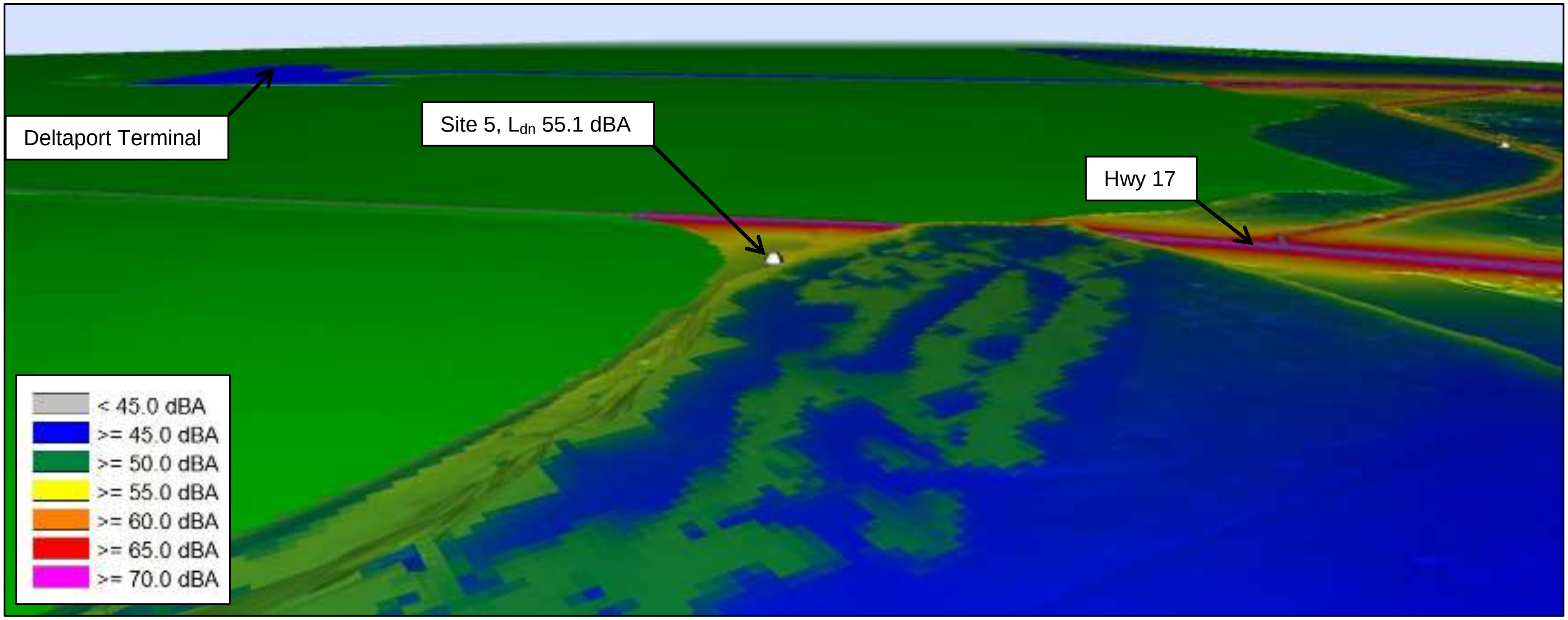


Figure G-5 Future (2025) Scenario 1 L_{dn} Contours



Note: Solid green regions in marine areas, and blue Deltaport Terminal source, do not represent sound contours.

Figure G-6 Existing (2013) L_{dn} Contours – Three-dimensional View from Tsawwassen to Northeast

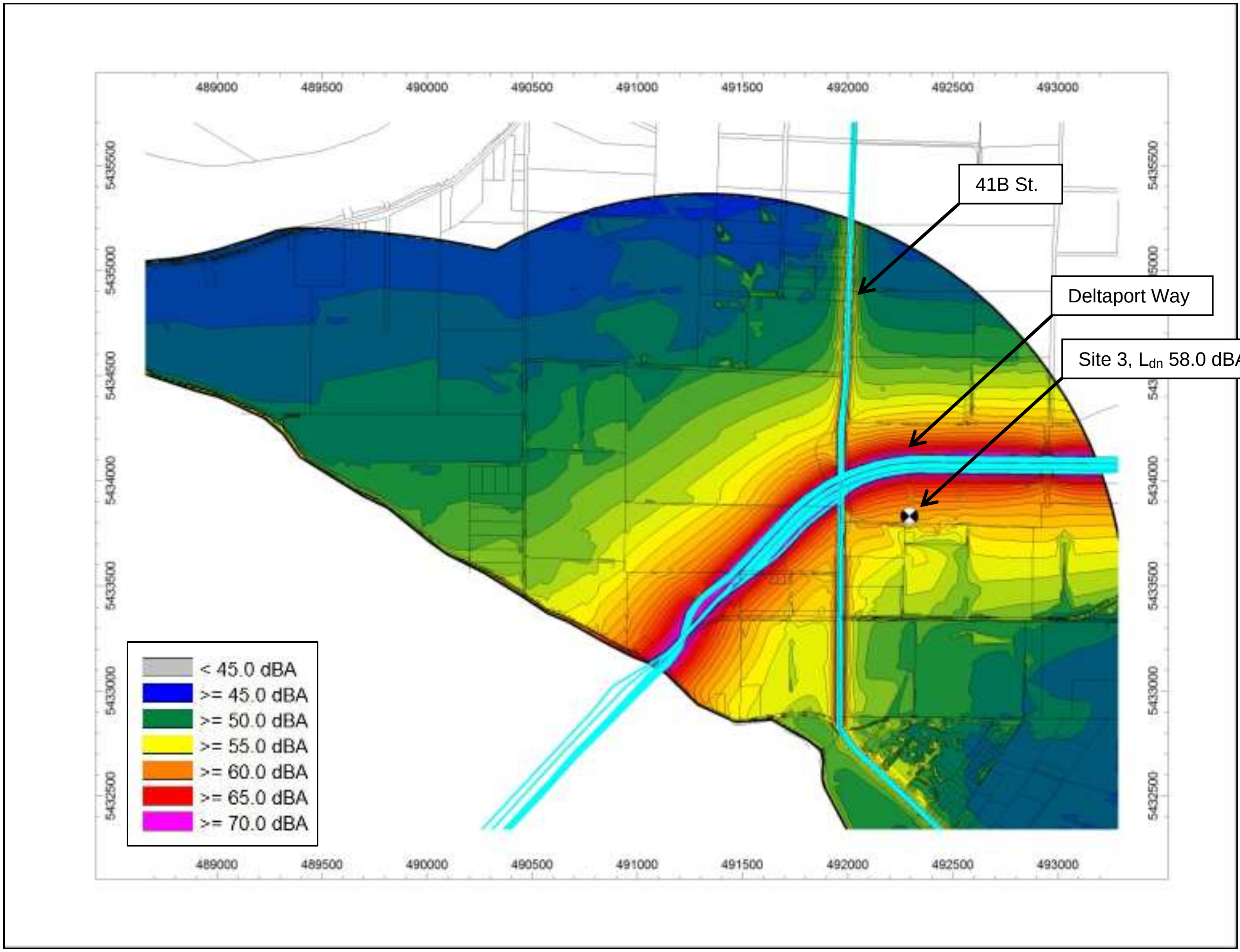


Figure G-7 Future (2025) Scenario 1 L_{dn} Contours – Delta near Site 3

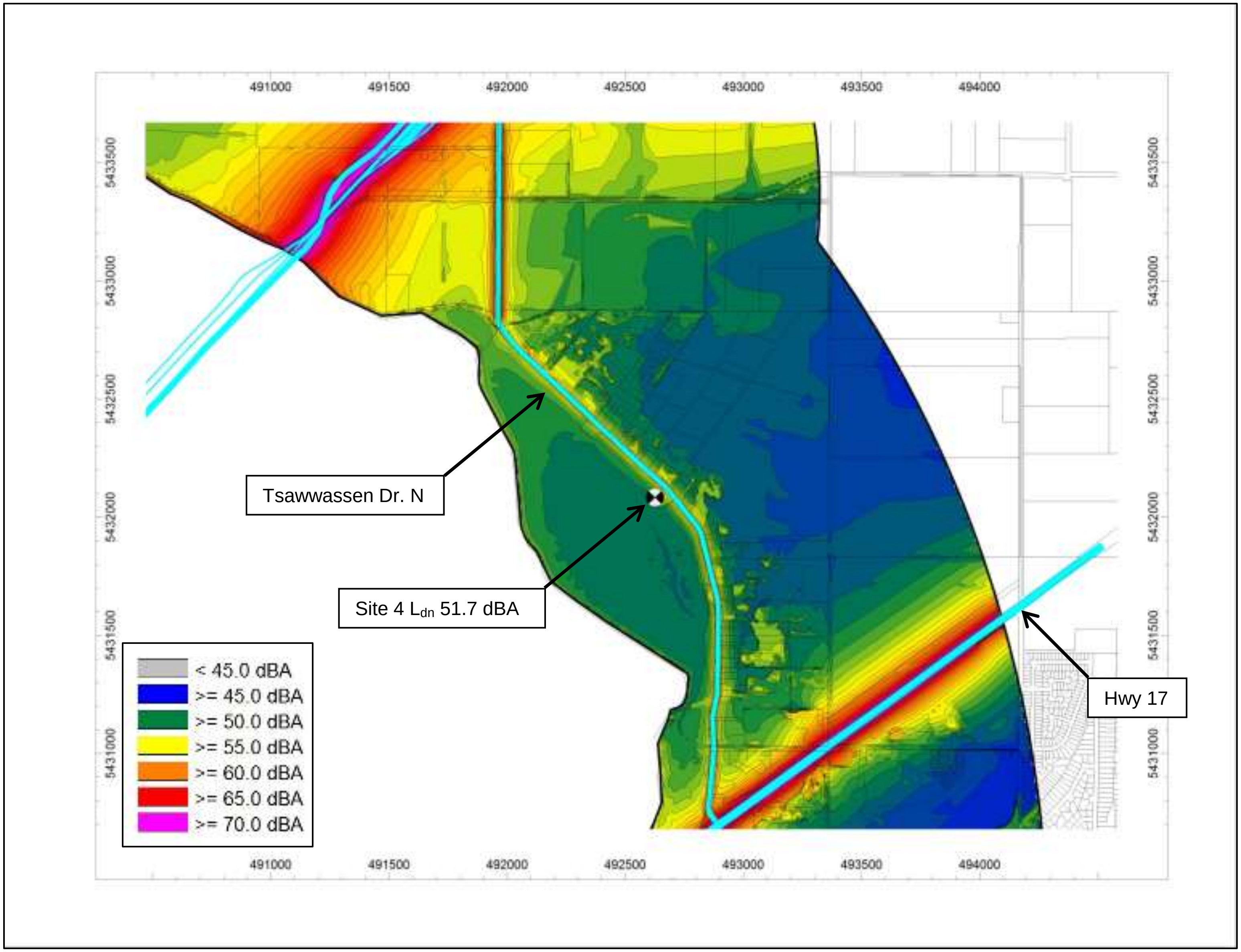


Figure G-8 Future (2025) Scenario 1 L_{dn} Contours – Tsawwassen First Nation

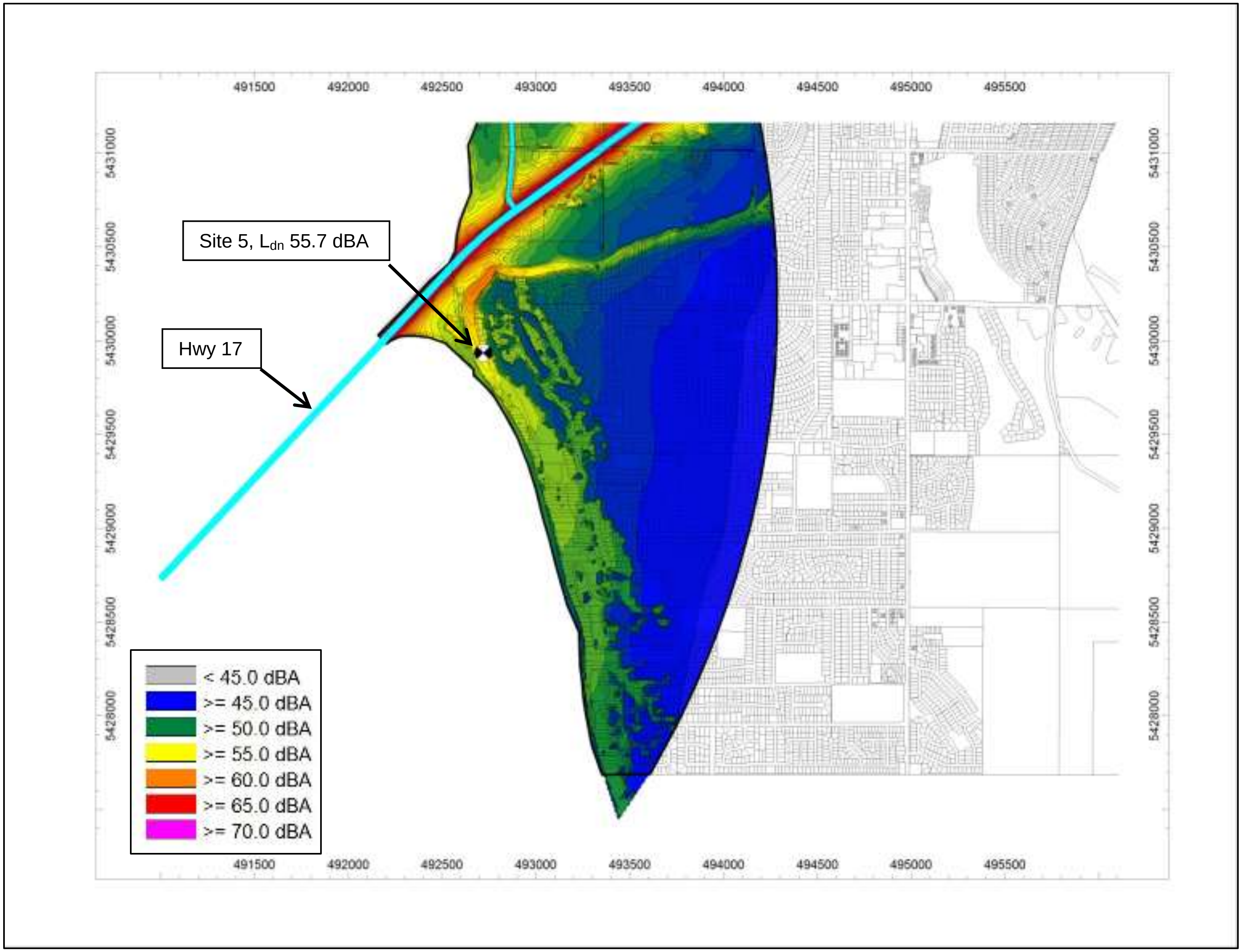
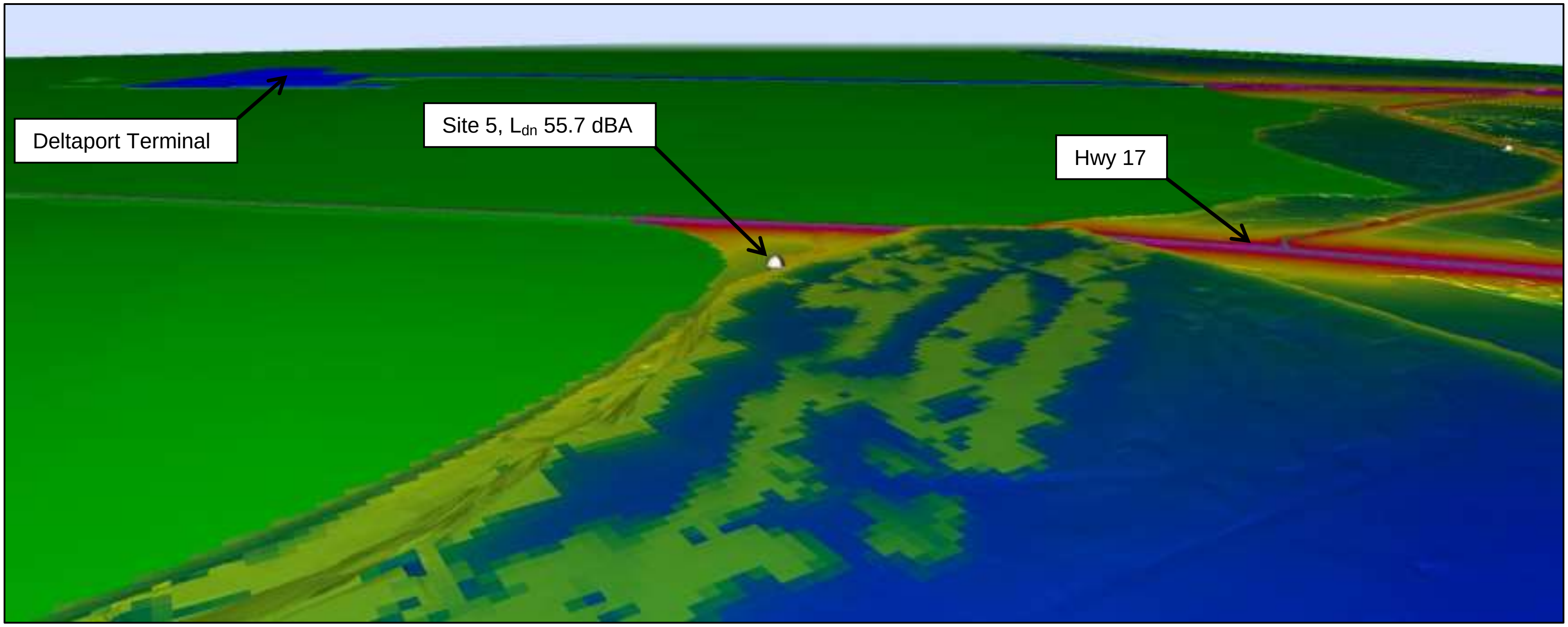


Figure G-9 Future (2025) Scenario 1 L_{dn} Contours – Tsawwassen



Note: Solid green regions in marine areas, and blue Deltaport Terminal source, do not represent sound contours.

Figure G-10 Future (2025) Scenario 1 L_{dn} Contours – Three-dimensional View from Tsawwassen to Northeast

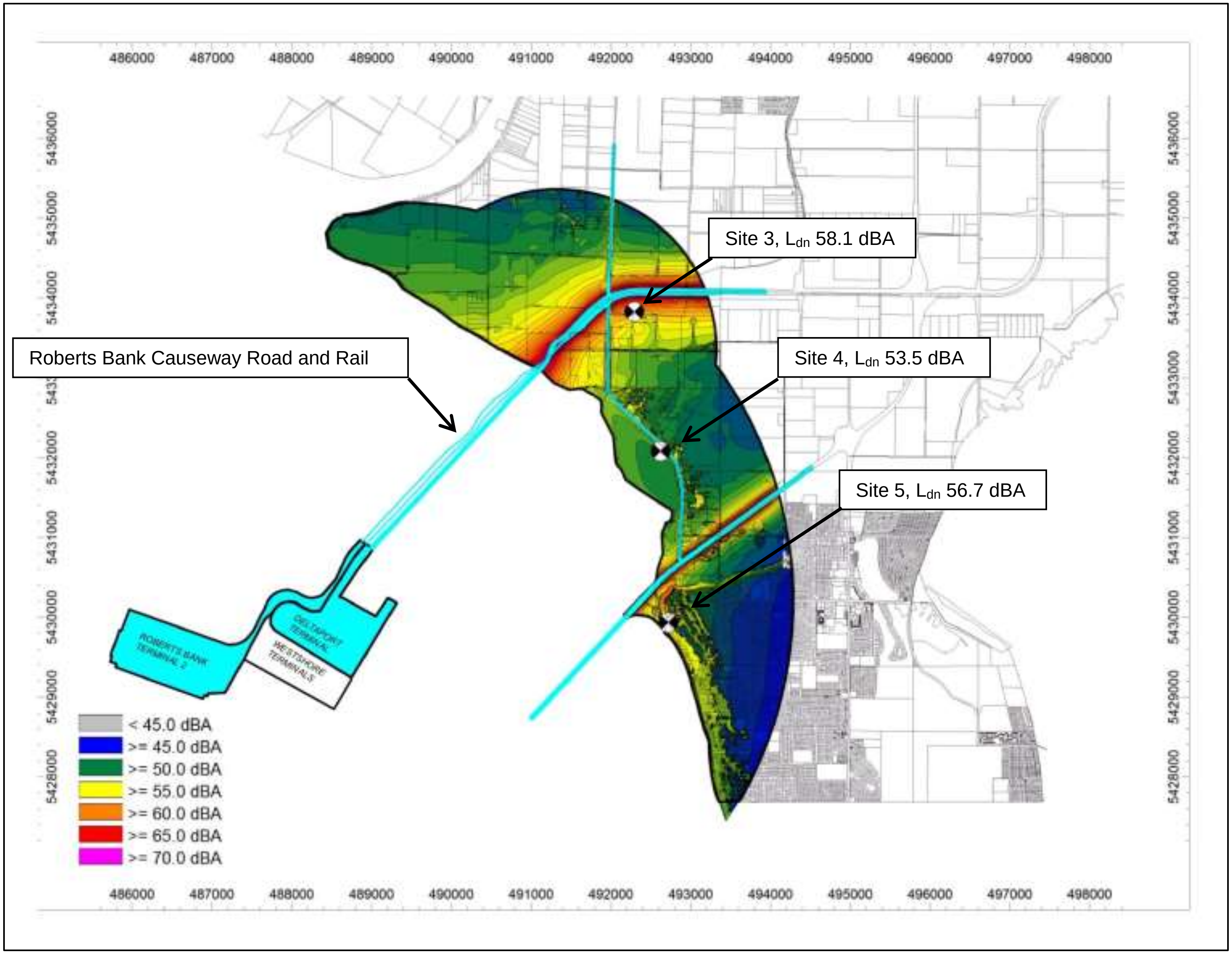


Figure G-11 Future (2025) Scenario 2 L_{dn} Contours

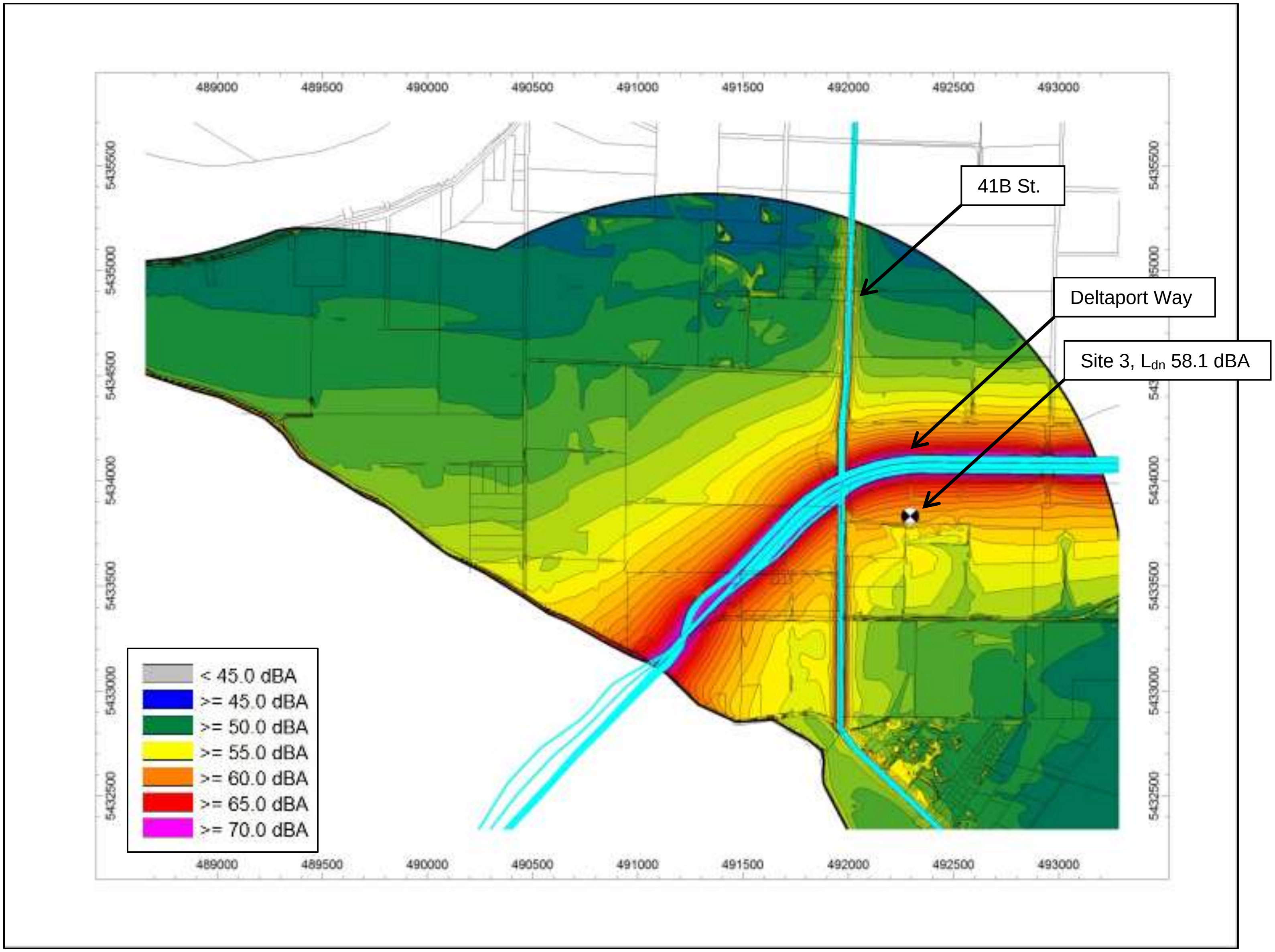


Figure G-12 Future (2025) Scenario 2 L_{dn} Contours – Delta near Site 3

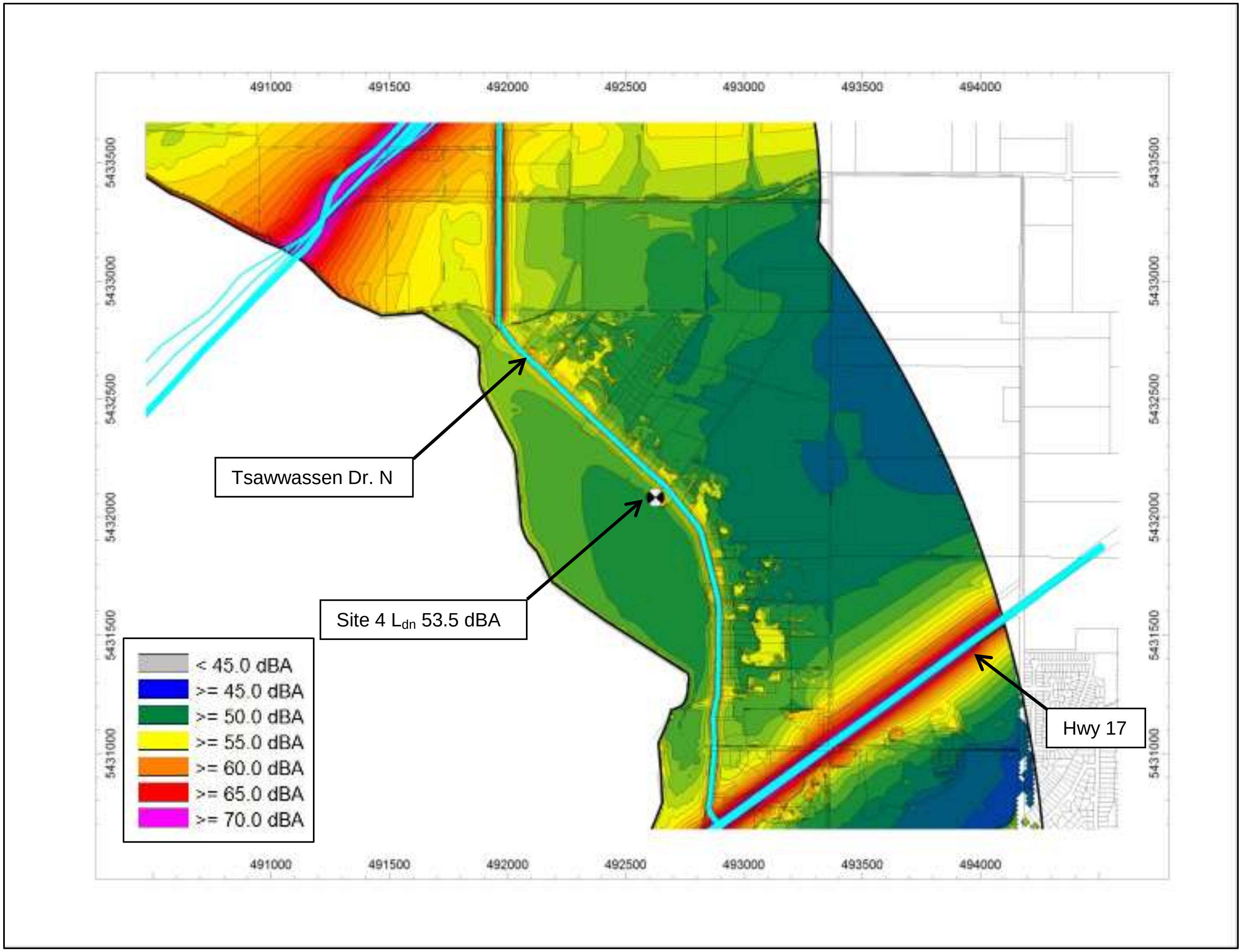


Figure G-13 Future (2025) Scenario 2 L_{dn} Contours – Tsawwassen First Nation

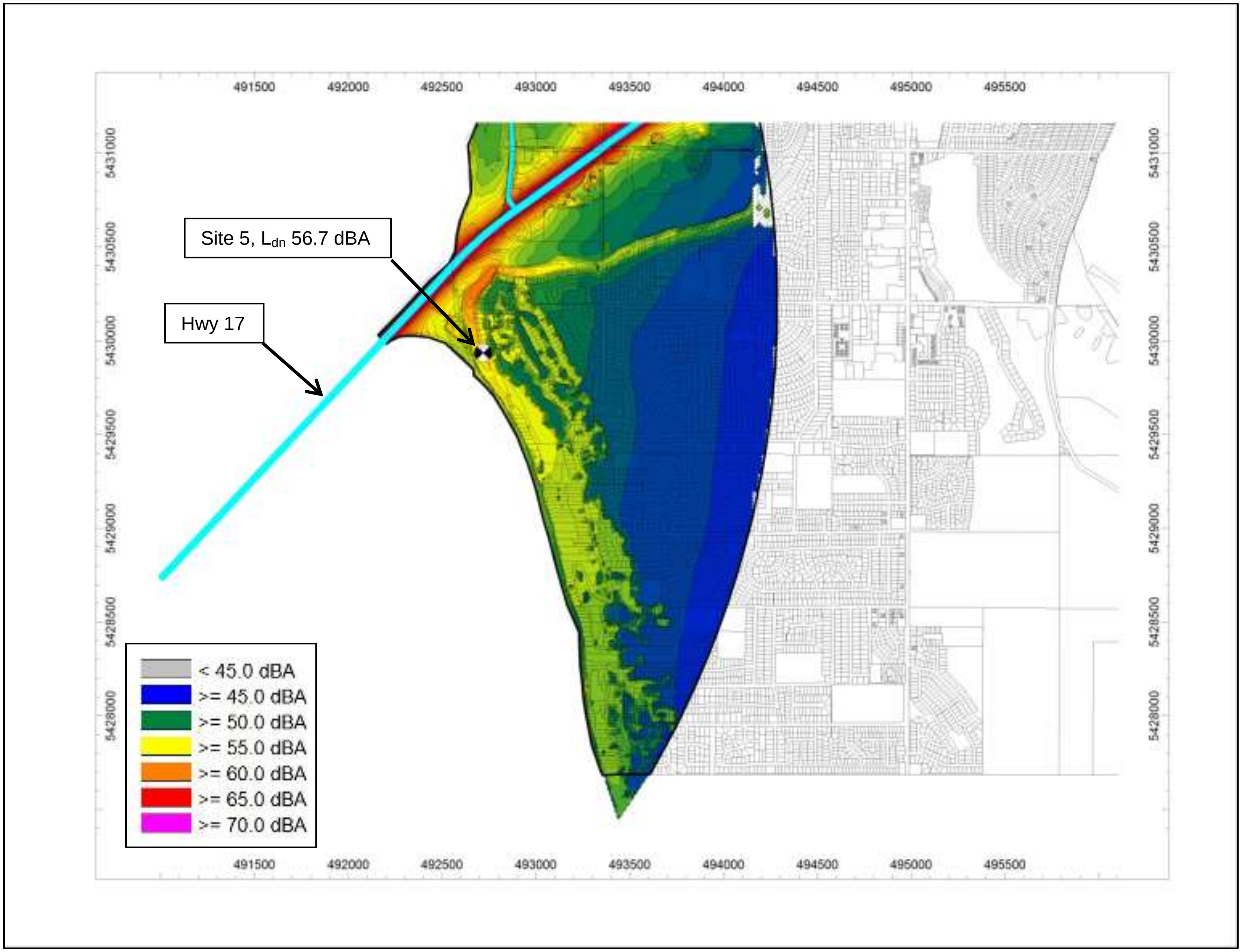
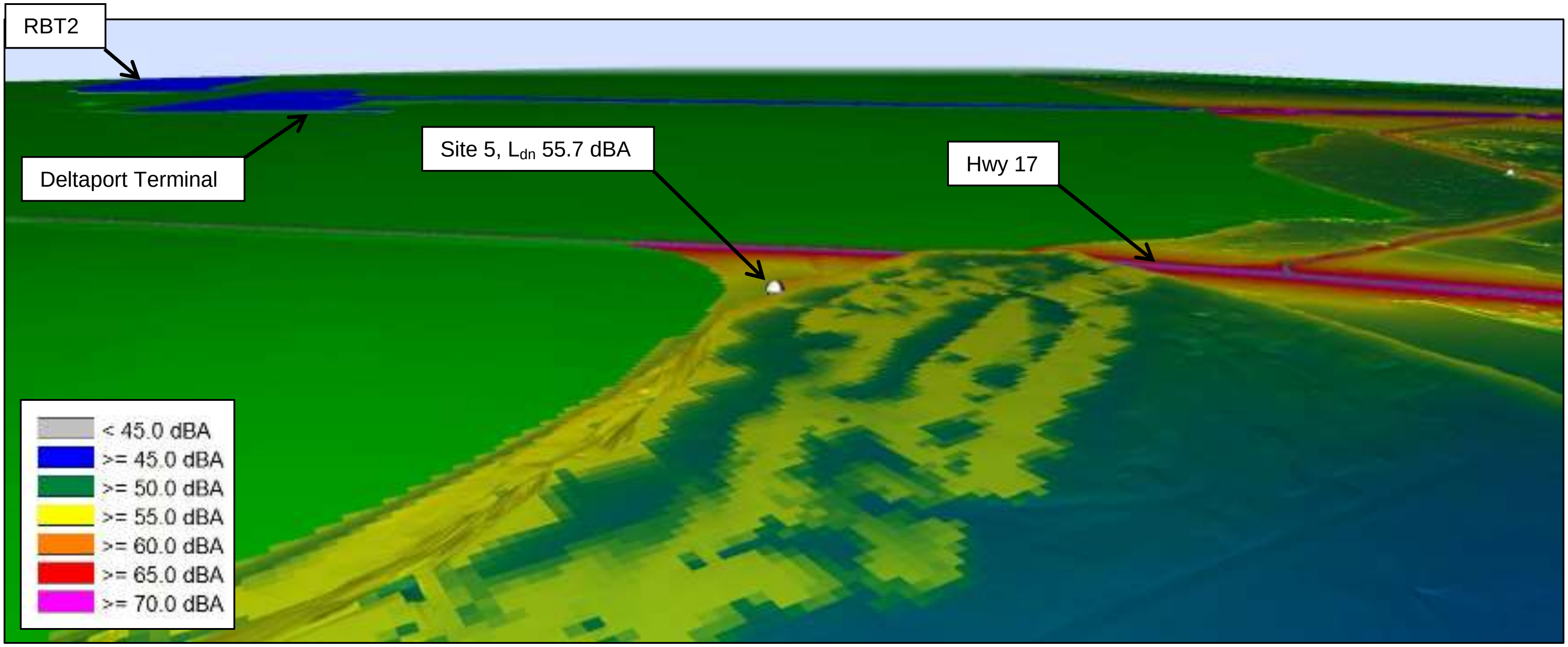


Figure G-14 Future (2025) Scenario 2 L_{dn} Contours – Tsawwassen



Note: Solid green regions in marine areas, and blue Deltaport Terminal source, do not represent sound contours.

Figure G-15 Future (2025) Scenario 2 L_{dn} Contours – Three-dimensional View from Tsawwassen to Northeast

APPENDIX H
Noise Levels in Marine Areas

Table H-1 Existing Annual Average Noise Levels in Marine Areas

Setback Distance from RBT2 (km)	Daytime Equivalent Noise Level, L_d (dBA)			
	Setback Direction			
	North	South	East	West
1	53.6	51.3		49.3
2	51.5	48.6		46.1
3	48.9	46.0	62.5	43.5
4	46.3	44.0	55.4	41.4
5	44.0	41.9	57.8	39.5
6	41.9	40.0	51.5	37.8
7	39.8	38.3		36.3
8	37.7	36.8		35.0
9	36.2	35.5		33.8
10	34.8	34.3		32.7

Note: Noise levels were not calculated at certain setback distances to the east as they corresponded to locations over land.

Table H-2 Future Annual Average Noise Levels in Marine Areas without the Project

Setback Distance from RBT2 (km)	Daytime Equivalent Noise Level, L_d (dBA)			
	Setback Direction			
	North	South	East	West
1	54.8	52.5	-	50.5
2	52.7	49.8	-	47.3
3	50.1	47.2	63.7	44.7
4	47.5	45.2	56.5	42.6
5	45.2	43.1	58.0	40.7
6	43.1	41.2	51.9	39.0
7	41.1	39.5	-	37.5
8	38.9	38.0	-	36.2
9	37.4	36.7	-	35.0
10	36.0	35.5	-	33.9

Note: Noise levels were not calculated at certain setback distances to the east as they corresponded to locations over land.

Table H-3 Future Annual Average Noise Levels in Marine Areas with the Project

Setback Distance from RBT2 (km)	Daytime Equivalent Noise Level, L_d (dBA)			
	Setback Direction			
	North	South	East	West
1	62.7	62.6	-	63.5
2	57.6	56.2	-	55.7
3	54.1	52.5	64.0	51.5
4	51.2	49.7	57.2	48.5
5	48.8	47.3	58.3	46.1
6	46.7	45.2	52.4	44.1
7	44.6	43.4	-	42.4
8	41.9	41.9	-	40.9
9	40.4	40.6	-	39.6
10	39.0	39.3	-	38.4

Note: Noise levels were not calculated at certain setback distances to the east as they corresponded to locations over land.

Table H-4 Predicted Noise Levels in Marine Areas during Project Construction

Setback Distance from RBT2 (km)	Daytime Equivalent Noise Level, L_d (Construction + Existing) (dBA)			
	Setback Direction			
	North	South	East	West
1	54.9 to 62.2	52.7 to 61.8	-	51.0 to 63.4
2	52.7 to 56.3	49.9 to 53.3	-	47.4 to 54.8
3	50.1 to 52.4	47.2 to 51.0	63.7 to 63.8	44.8 to 49.9
4	47.5 to 49.3	45.2 to 48.0	56.5 to 56.7	42.6 to 46.7
5	45.2 to 46.7	43.1 to 45.4	58.0 to 58.1	40.7 to 44.1
6	43.1 to 44.5	41.2 to 43.2	51.9 to 52.1	39.0 to 41.9
7	41.1 to 42.4	39.5 to 41.2	-	37.5 to 39.0
8	38.9 to 40.3	38.0 to 39.6	-	36.2 to 37.5
9	37.4 to 38.7	36.7 to 38.1	-	35.0 to 36.1
10	36.0 to 37.2	35.5 to 36.8	-	33.9 to 35.0

Note: Noise levels were not calculated at certain setback distances to the east as they corresponded to locations over land.

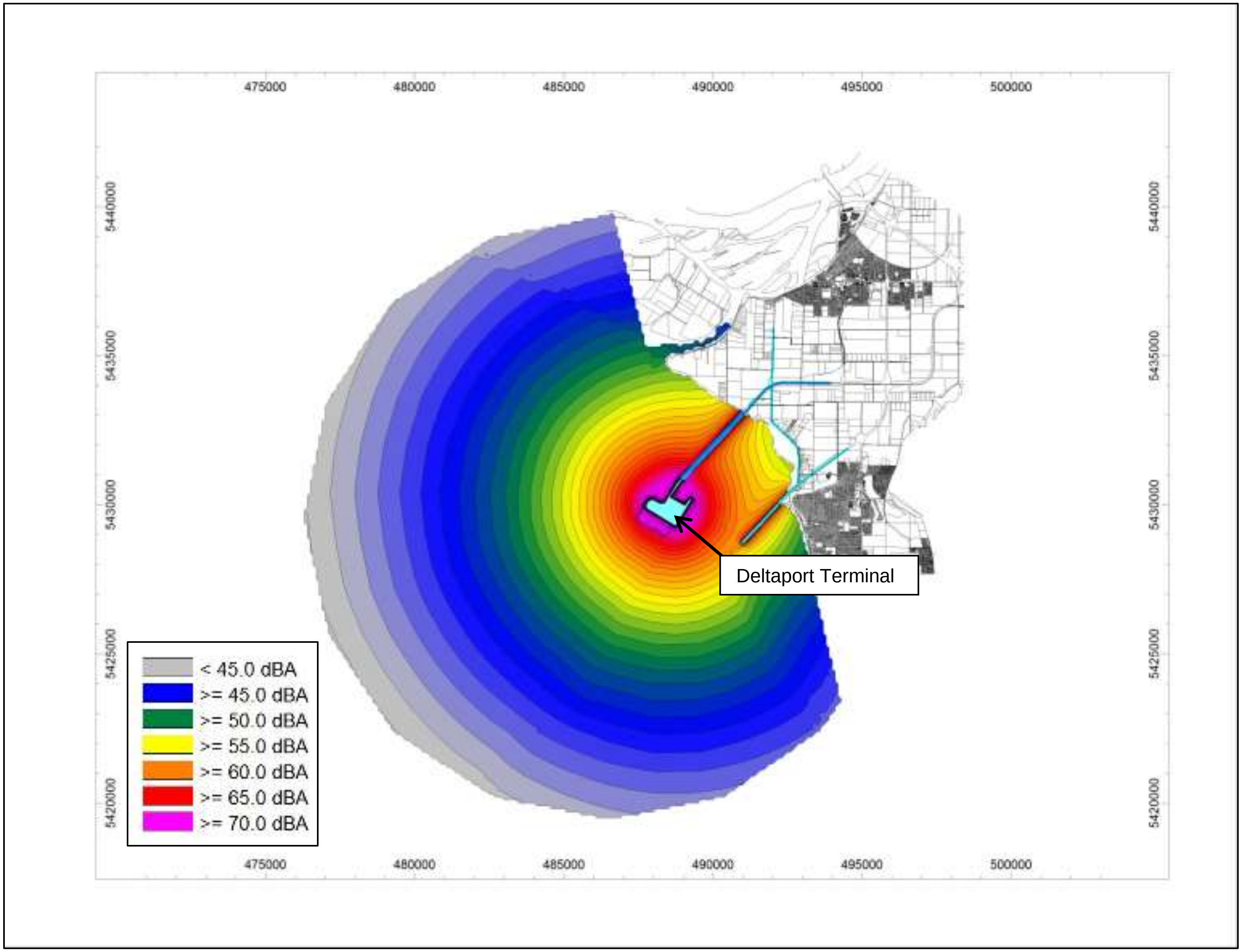


Figure H-1 Existing (2013) L_d Contours in Marine Areas

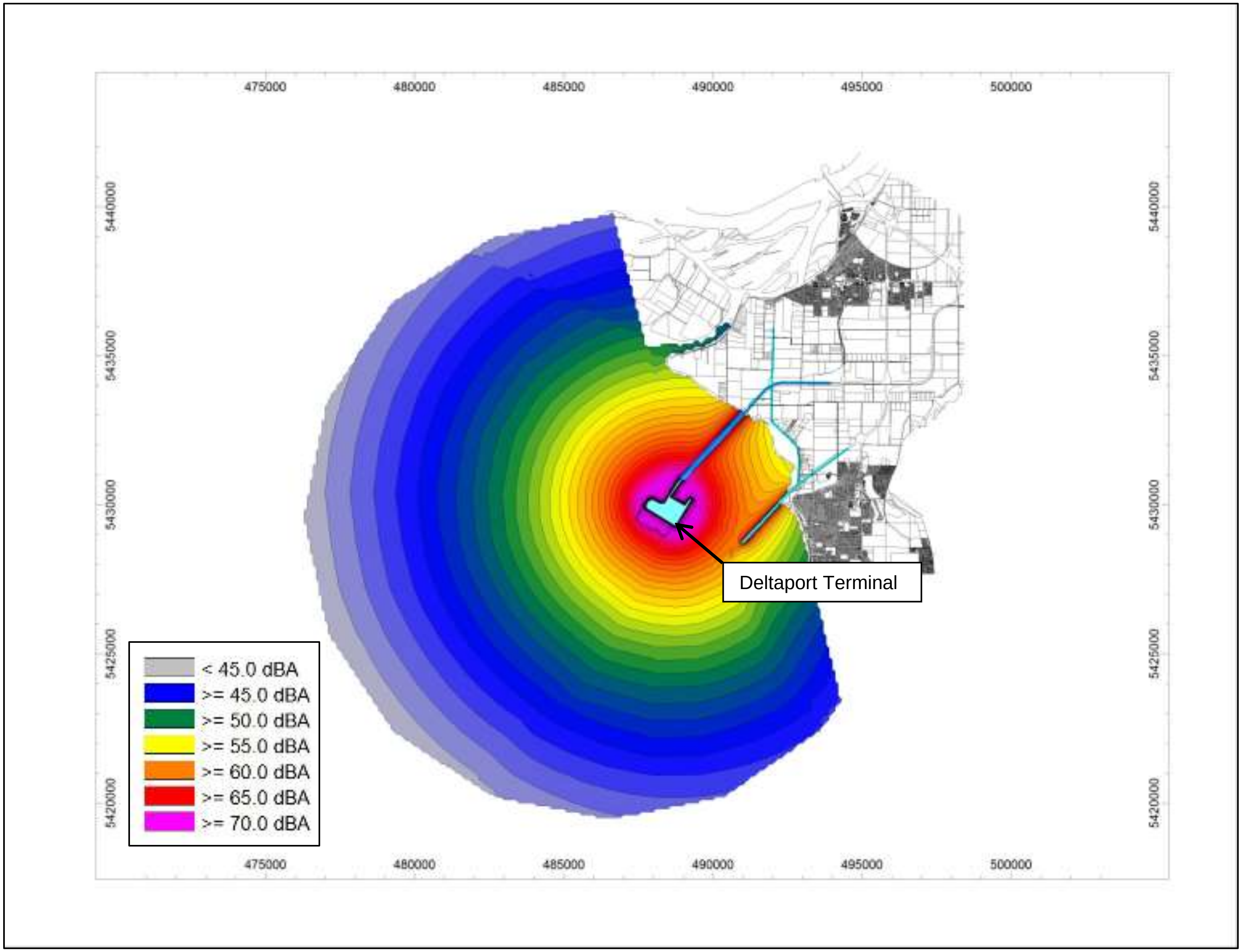


Figure H-2 Future (2025) Scenario 1 Ld Contours in Marine Areas

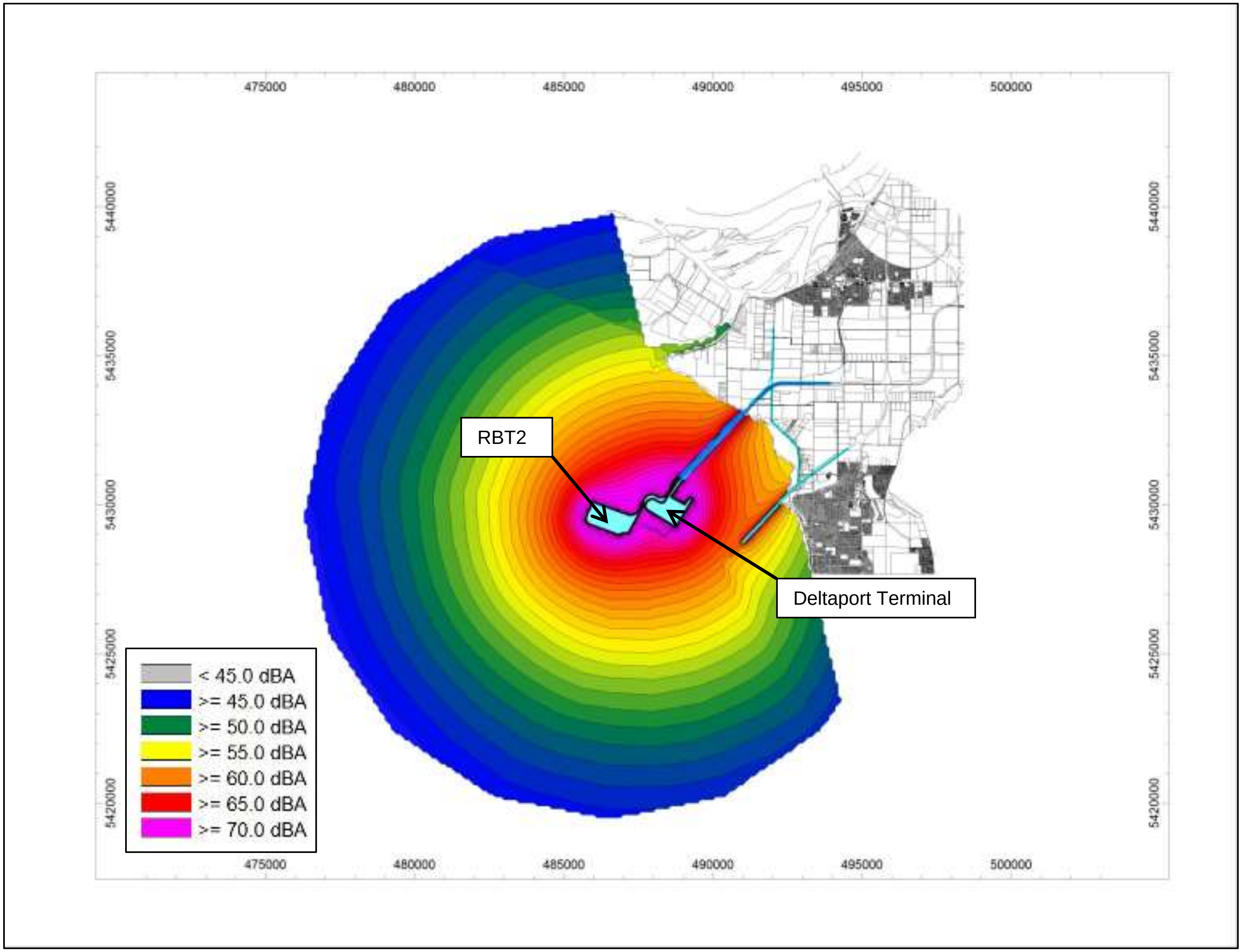


Figure H-3 Future (2025) Scenario 2 Ld Contours in Marine Areas

APPENDIX I

Noise Model Inputs

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Traffic Data

10 Year Annual Summary for 2013

Traffic Data in this report
- AADT — **Annual Average Daily Traffic**: A calculated daily estimate of the number of vehicles passing this site.
- SADT — **Summer Average Daily Traffic** (for the months of July and August)

TM Site ID: **16-213NS**

TM Site Name: **Tsawassen - 16-213NS, Tsawwassen Highway**

Location: Route 17, 0.3 km south of 52 Street, Tsawwassen

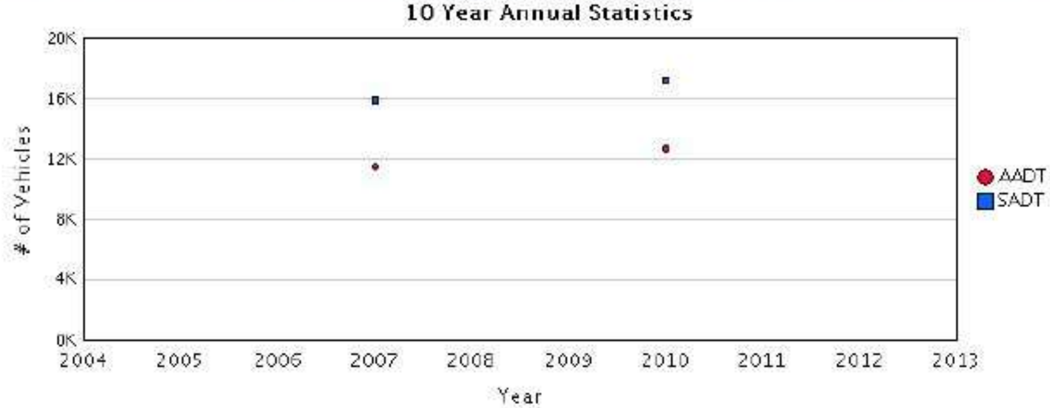
Posted Speed:

Report Run on: Tuesday January 7 2014 12:05 PM

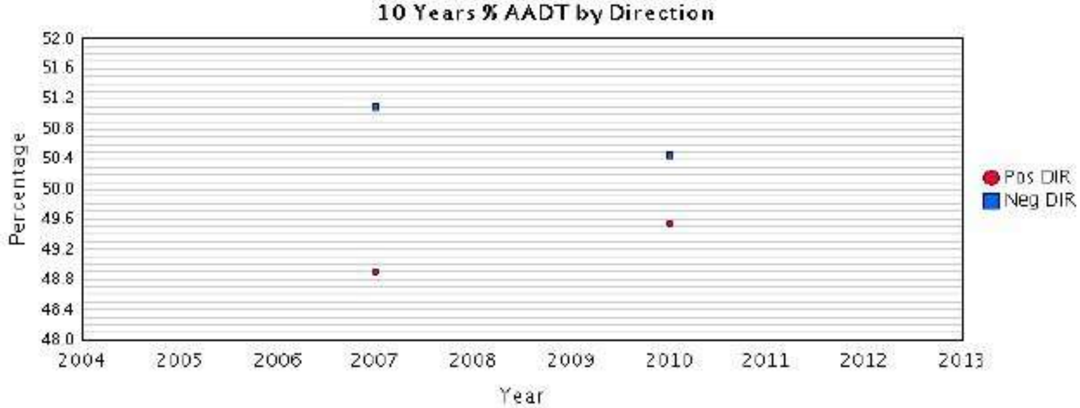
Average Daily Traffic Volumes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
AADT				11,546			12,725			
SADT				15,913			17,207			

10 Year Annual Statistics



10 Years % AADT by Direction



CAV05: Page 1 of 3

Figure I-1 Highway 17 Traffic Volume Data (MOTI 2014)

BC Ministry of Transportation and Infrastructure

Daily Volume from 07/04/2010 through 07/07/2010

Site Names: Tsawassen - 16-213NS - N. 16-213NS
County:
Funct.
Location: Route 17 Approx. 4.0 Km North Of The Tsawwassen Ferry Terminal And 0.3 Km South Of 5:

Seasonal Factor Type: Seasonal
Daily Factor Type: Seasonal
Axle Factor Type:
Growth Factor Type: Seasonal

	07/04/2010			07/05/2010			07/06/2010			07/07/2010			07/08/2010			07/09/2010			07/10/2010		
	Road	Neg	Pos	Road	Neg	Pos	Road	Neg	Pos	Road	Neg	Pos	Road	Neg	Pos	Road	Neg	Pos	Road	Neg	Pos
00:00				88	23	65	83	20	63	73	14	59									
01:00				173	7	166	26	12	14	40	14	26									
02:00				13	8	5	12	9	3	19	13	6									
03:00				27	25	2	27	26	1	18	15	3									
04:00				121	105	16	111	100	11	108	96	12									
05:00				186	167	19	179	158	21	196	180	16									
06:00				503	425	78	520	465	55												
07:00				576	374	202	599	420	179												
08:00				909	504	405	968	572	396												
09:00				1,223	759	464	1,373	769	604												
10:00				1,122	509	613	929	481	448												
11:00				843	482	361	824	501	323												
12:00				1,232	527	705	1,094	517	577												
13:00	1,304	737	567	804	514	290	735	467	268												
14:00	2,050	974	1,076	1,158	643	515	1,182	677	505												
15:00	1,580	644	936	847	407	440	841	431	410												
16:00	1,554	833	721	787	457	330	878	493	385												
17:00	1,904	795	1,109	944	432	512	950	372	578												
18:00	1,549	696	853	910	448	462	932	402	530												
19:00	1,323	517	806	936	306	630	651	300	351												
20:00	1,170	450	720	606	237	369	729	239	490												
21:00	528	186	342	195	85	110	191	85	106												
22:00	790	108	682	471	84	387	487	92	395												
23:00	143	28	115	71	17	54	70	18	52												
Volume	13,895	5,968	7,927	14,745	7,545	7,200	14,391	7,626	6,765	454	332	122									
AM Peak Vol				1,382	759	700	1,373	796	653												
AM Peak Fct				0.68	0.85	0.47	0.66	0.87	0.42												
AM Peak Hr				9:15	9:00	9:30	9:00	8:45	9:15												
PM Peak Vol				1,232	653	747	1,229	677	715												
PM Peak Fct				0.52	0.86	0.48	0.64	0.94	0.40												
PM Peak Hr				12:00	13:45	14:45	14:15	14:00	18:45												
Seasonal Fct	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741									
Daily Fct	1.019	1.019	1.019	1.027	1.027	1.027	1.052	1.052	1.052	1.032	1.032	1.032									
Axle Fct	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500									
Pulse Fct	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000									

Created 02/11/2011 12:53:31PM **ROAD AADT 6,362** **NEG AADT 3,210** **POS AADT 3,152** DV035: Page 1 of 1

Figure I-2 Highway 17 Traffic Volume Data (MOTI 2014)

Table 15: Daily Traffic Profiles (Average Day)

	Container Trucks			Deltaport and T2 Passenger Vehicles			Westshore Passenger Vehicles		Total Roberts Bank Traffic		
Hour	1.56 M TEU	2.4 M TEU	4.8 M TEU	1.56 M TEU	2.4 M TEU	4.8 M TEU	25 M t	35 M t	1.56 M TEU + 25 M t	2.4 M TEU + 35 M t	4.8 M TEU + 35 M t
0:00	0	0	0	136	209	418	28	39	164	248	458
1:00	0	0	0	179	275	551	0	0	179	275	551
2:00	0	0	0	0	0	0	0	0	0	0	0
3:00	0	0	0	0	0	0	0	0	0	0	0
4:00	0	0	0	0	0	0	0	0	0	0	0
5:00	0	0	0	0	0	0	0	0	0	0	0
6:00	0	0	0	0	0	0	0	0	0	0	0
7:00	128	194	388	251	386	772	82	115	461	695	1275
8:00	215	325	649	136	209	418	15	21	366	555	1089
9:00	209	316	631	0	0	0	0	0	209	316	631
10:00	200	302	604	0	0	0	0	0	200	302	604
11:00	180	271	543	0	0	0	0	0	180	271	543
12:00	133	202	403	0	0	0	0	0	133	202	403
13:00	227	343	686	0	0	0	0	0	227	343	686
14:00	190	287	573	0	0	0	0	0	190	287	573
15:00	126	191	382	179	275	551	28	39	333	506	972
16:00	102	155	309	251	386	772	82	115	435	656	1197
17:00	171	259	517	0	0	0	0	0	171	259	517
18:00	165	249	498	0	0	0	0	0	165	249	498
19:00	162	245	491	0	0	0	0	0	162	245	491
20:00	47	70	141	0	0	0	0	0	47	70	141
21:00	128	193	386	0	0	0	0	0	128	193	386
22:00	46	70	139	0	0	0	0	0	46	70	139
23:00	14	21	42	0	0	0	15	21	29	42	63
Total	2442	3692	7384	1132	1742	3483	250	350	3824	5784	11217

Figure I-3 Deltaport Way Traffic Volumes (Delcan 2013)

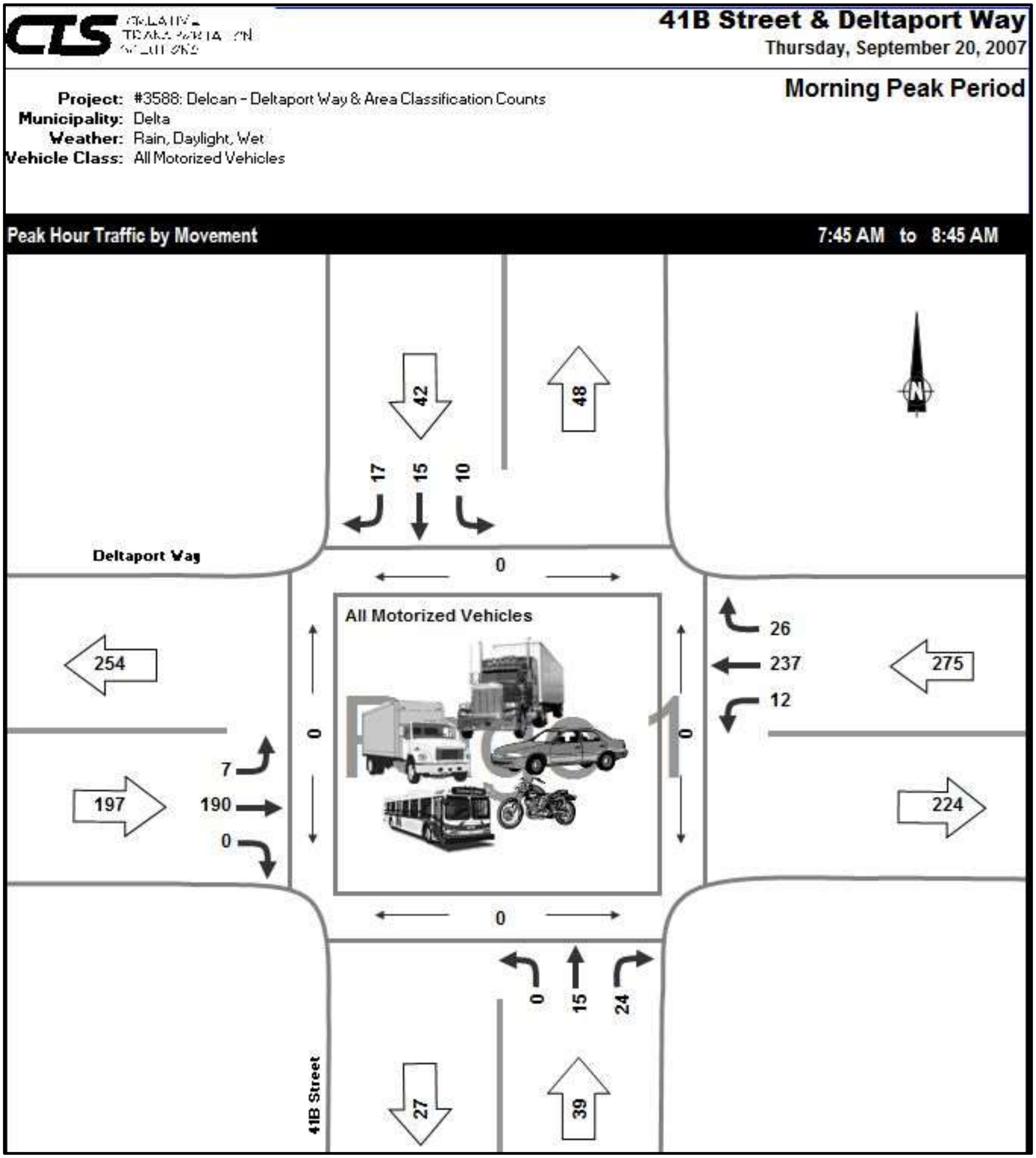


Figure I-4 41B St. Traffic Volumes – All Vehicles, Peak Hour, AM (CTS 2007)

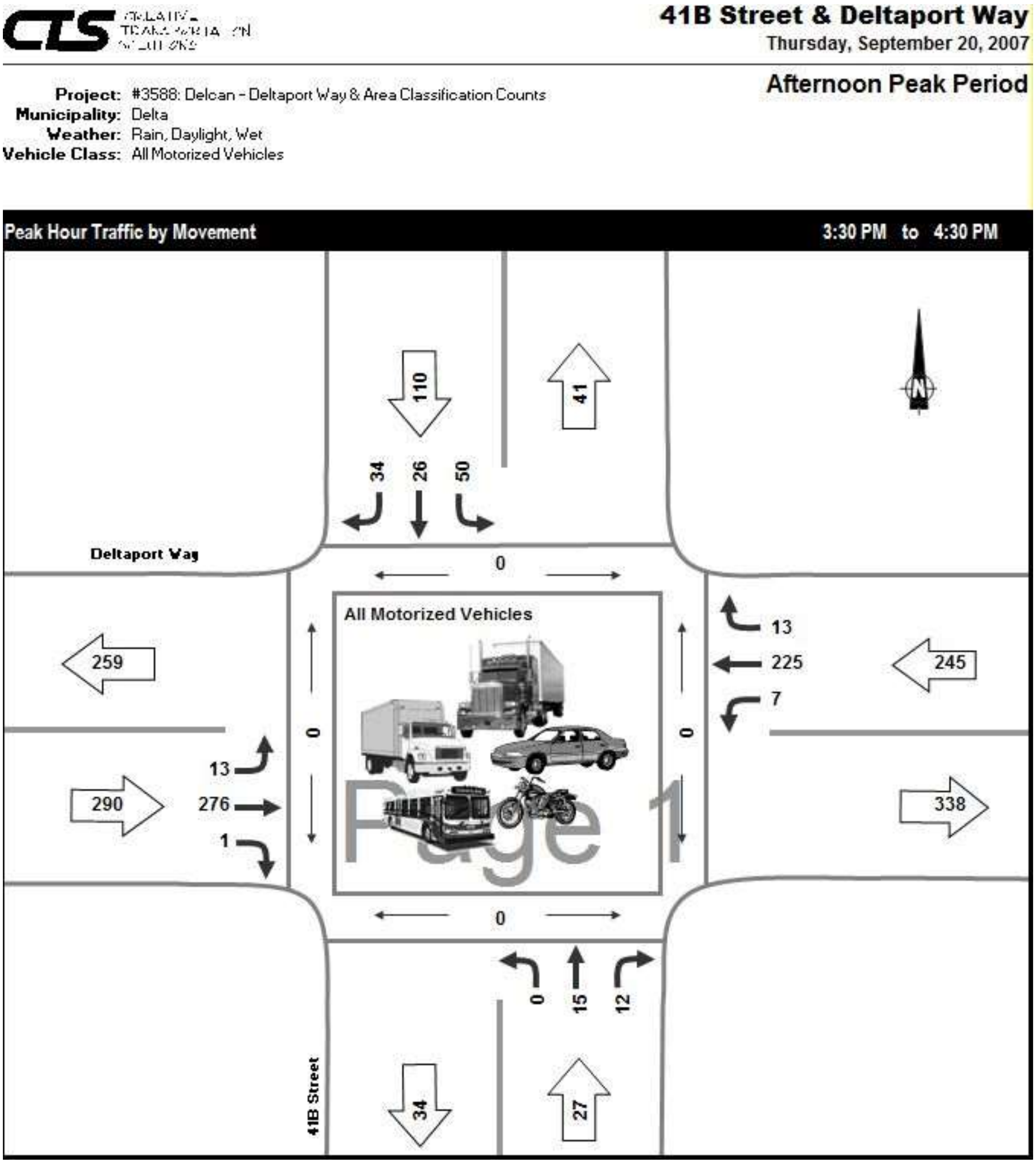


Figure I-5 41B St. Traffic Volumes – All Vehicles, Peak Hour, PM (CTS 2007)

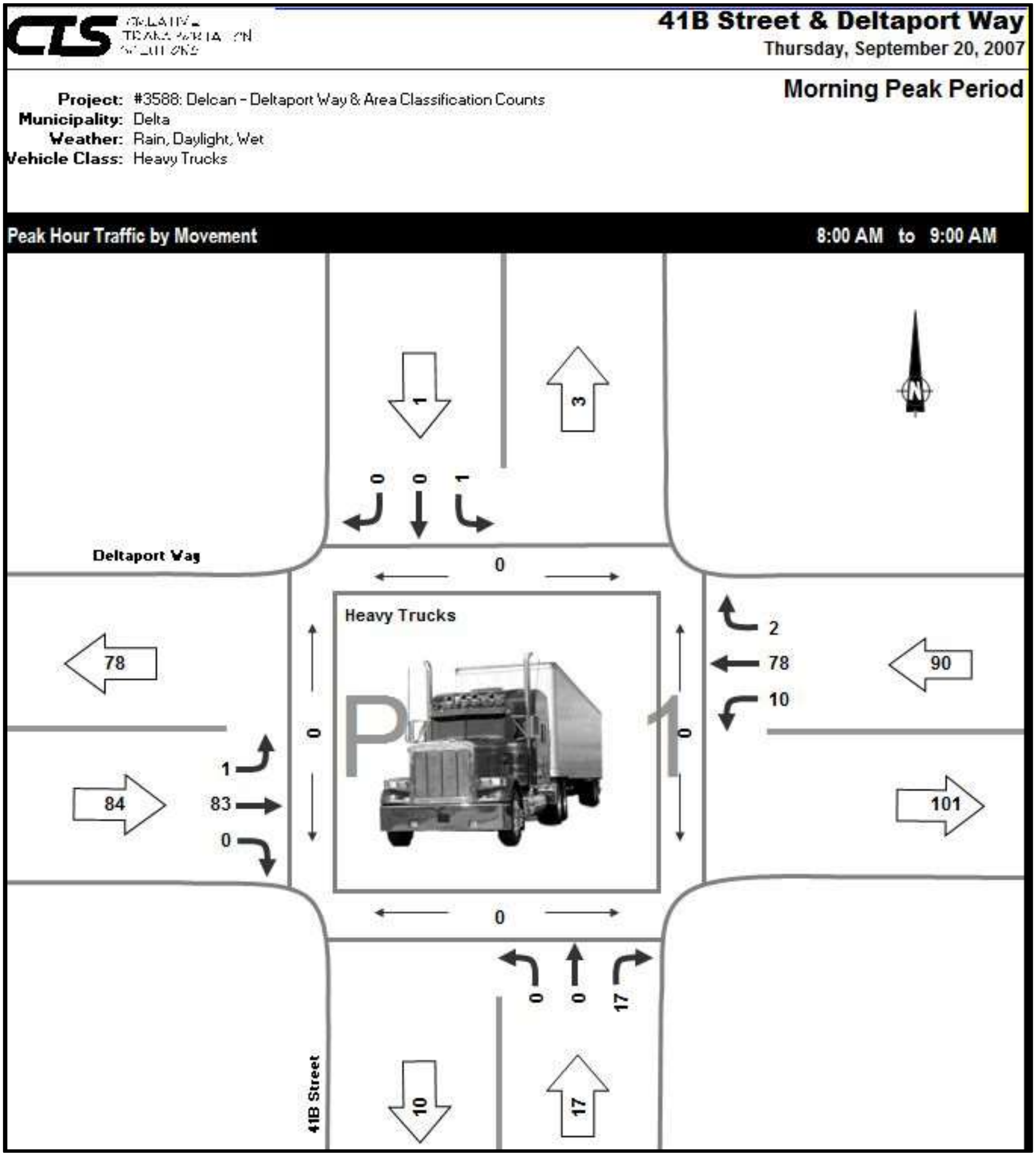


Figure I-6 41B St. Traffic Volumes – Heavy Trucks, Peak Hour, AM (CTS 2007)

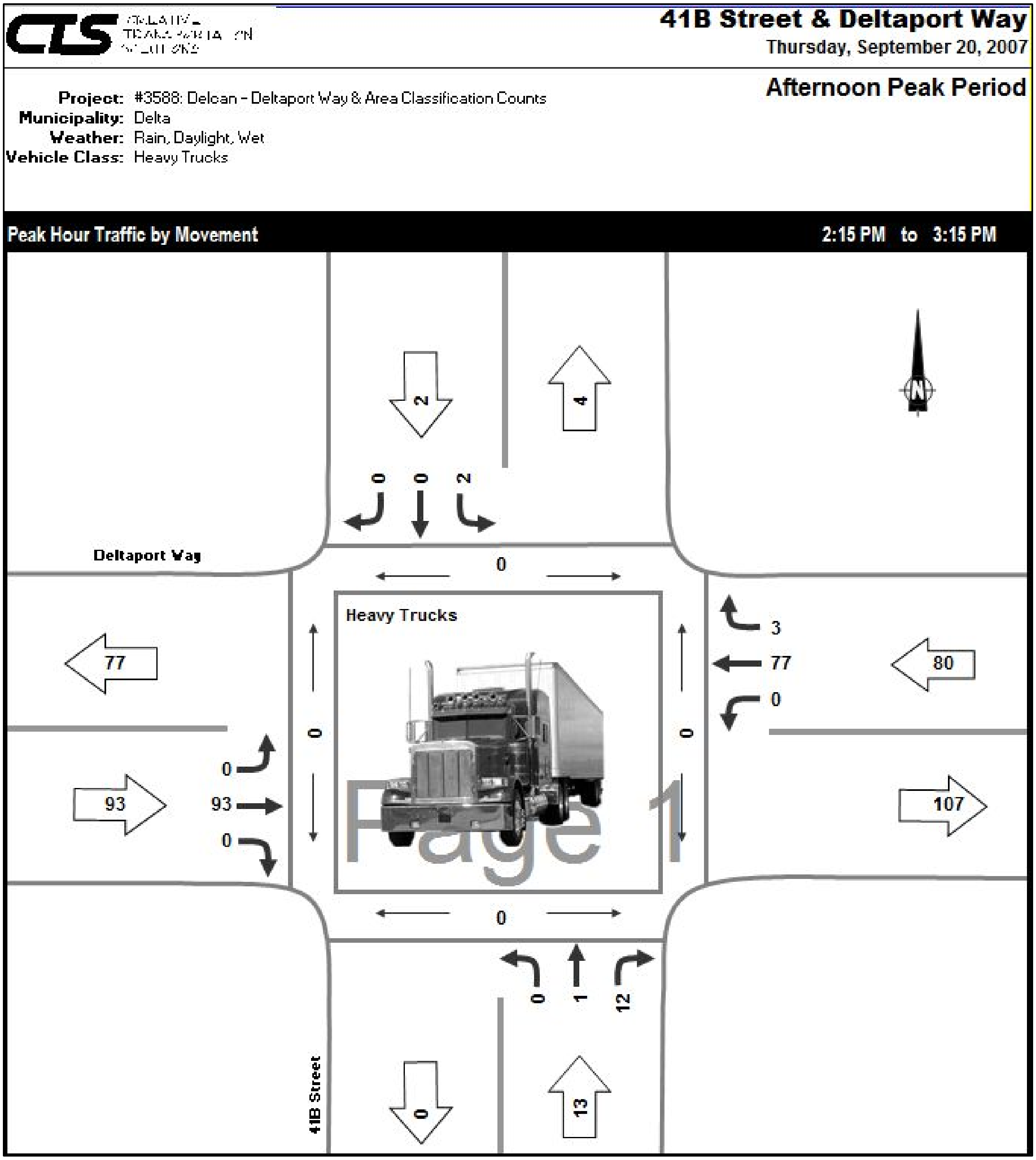


Figure I-7 41B St. Traffic Volumes – Heavy Trucks, Peak Hour, PM (CTS 2007)

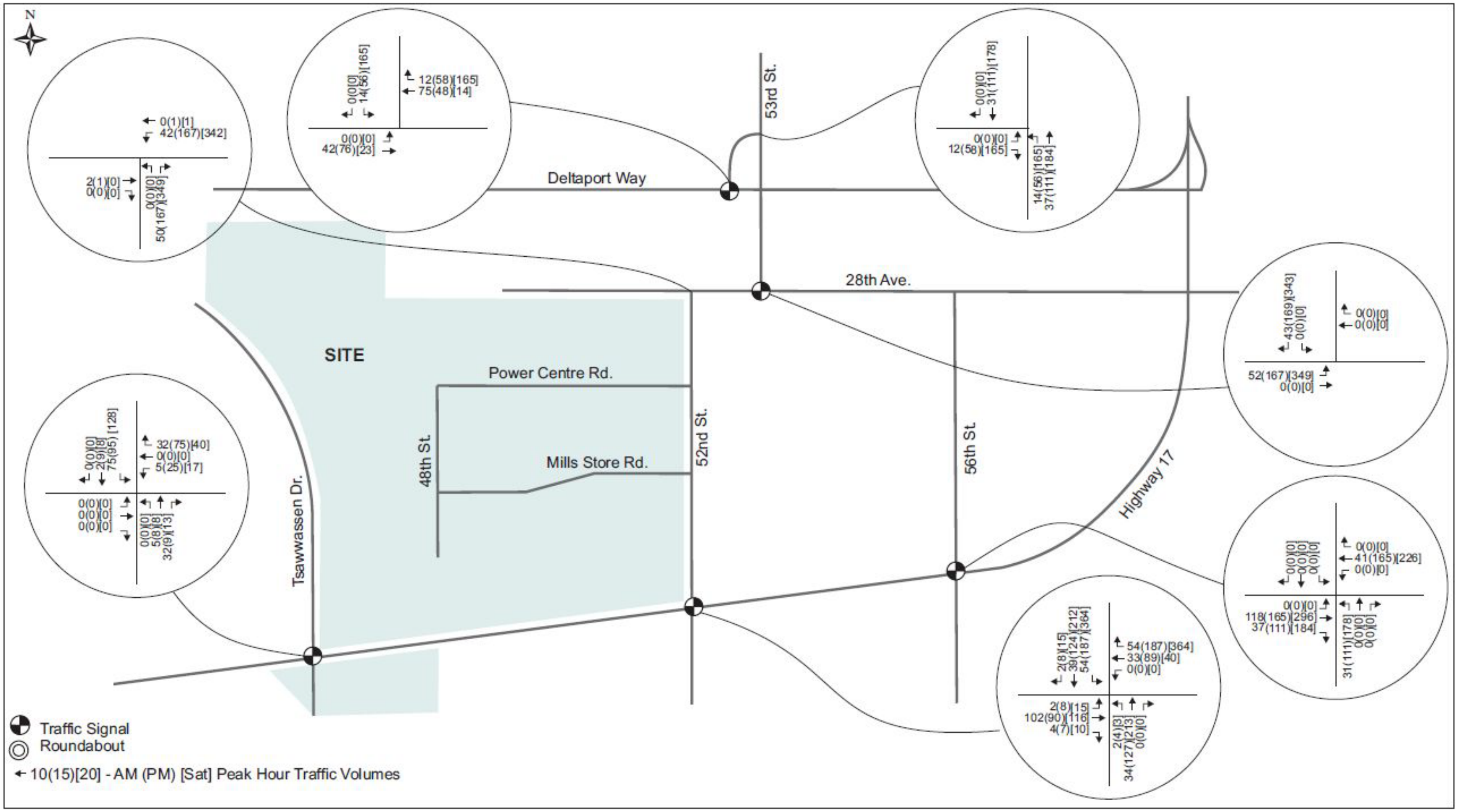


Exhibit 5.1
Estimated Site Generated Traffic 2013

Tsawwassen First Nations Community Development Traffic Assessment
4531.14 August 2011 Scale NTS

bunt & associates

Figure I-8 Tsawwassen Drive North Traffic Volumes (Bunt & Associates 2011)

APPENDIX 9.3-B

Rationale for Inclusion / Exclusion of Other Certain and Reasonably Foreseeable Projects and Activities in the Noise and Vibration Assessment of Cumulative Change

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Appendix 9.3-B Rationale for Inclusion / Exclusion of Other Certain and Reasonably Foreseeable Projects and Activities in the Noise and Vibration Assessment of Cumulative Change

The assessment included consideration of the potential for an interaction between potential Project-related changes to noise and vibration, and the changes resulting from other certain and reasonably foreseeable projects and activities on noise and vibration. The rationale for inclusion or exclusion of each certain and reasonably foreseeable project and activity identified in **Section 8.1.9 Cumulative Effects Assessment**, **Table 8-8 Project and Activity Inclusion List**, from the assessment of cumulative change for noise and vibration is presented in **Table 9.3-B1**.

Table 9.3-B1 Rationale for Inclusion/Exclusion of Other Certain and Reasonably Foreseeable Projects in the Noise and Vibration Assessment of Cumulative Change

Other Certain and Reasonably Foreseeable Project /Activity	Included (I) /Excluded (E)	Rationale for Inclusion / Exclusion
Project		
BURNCO Aggregate Project, Gibsons, B.C.	E	Located too far away from the Project (approx. 60 km).
Centerm Container Terminal Expansion, Vancouver, B.C.	I	Project will result in additional ship calls. Potential for interaction between noise from ships-in-transit and Project noise.
Fraser Surrey Docks Direct Coal Transfer Facility, Surrey, B.C.	I	Project will include 580 ship calls. Potential for interaction between noise from ships-in-transit and Project noise.
Gateway Pacific Terminal at Cherry Point and associated BNSF Railway Company Rail Facilities Project, Blaine, Washington	I	Project will result in 25 additional ship calls. Potential for interaction between noise from ships-in-transit and Project noise.
Gateway Program - North Fraser Perimeter Road Project, Coquitlam, B.C.	N/A	Included in expected conditions (see **Table 9.3-14**).
George Massey Tunnel Replacement Project, Richmond and Delta, B.C.	I	Project will generate additional traffic which could potentially interact with Project noise.
Kinder Morgan Pipeline Expansion Project, Strathcona County, Alberta to Burnaby, B.C.	I	Project will result in 350 additional ship calls. Potential for interaction between noise from ships-in-transit and Project noise.
Lehigh Hanson Aggregate Facility, Richmond, B.C.	E	Located too far away from the Project (approx. 12 km).
Lions Gate Wastewater Treatment Plant Project, District of North Vancouver, B.C.	E	Located too far away from the Project (approx. 30 km).

Other Certain and Reasonably Foreseeable Project /Activity	Included (I) /Excluded (E)	Rationale for Inclusion / Exclusion
North Shore Trade Area Project - Western Lower Level Route Extension, West Vancouver, B.C.	E	Located too far away from the Project (approx. 30 km).
Pattullo Bridge Replacement Project, New Westminster and Surrey, B.C.	E	Located too far away from the Project (approx. 24 km).
Southlands Development, Delta, B.C.	I	Project may generate additional traffic, which could potentially interact with Project noise.
Vancouver Airport Fuel Delivery Project, Richmond, B.C.	I	Project will result in 60 additional ship calls. Potential for interaction between noise from ships-in-transit and Project noise.
Woodfibre LNG Project, Squamish, B.C.	E	Located too far away from the Project (approx. 69 km).
Activity		
Incremental Road Traffic Associated with RBT2	I	Increased road traffic on Deltaport Way will increase traffic noise emissions.
Incremental Train Traffic Associated with RBT2	I	Increased rail traffic on the section of the RBRC that is within the LSA will increase rail noise emissions.
Incremental Marine Vessel Traffic Associated with RBT2	I	Included due to potential for additional noise in marine areas as a result of increase in marine vessel traffic. No incremental cumulative changes expected; however, as noise from vessels in transit is not present for long enough to interact with Project operation or construction noise, and is not expected to measurably affect average daytime noise levels.