September 24, 2015

NOISE ASSESSMENT

Georgia and Dunsmuir Viaduct Area, City of Vancouver, BC

Submitted to:
Business Planning & Services
City of Vancouver
300 - 515 West 10th Avenue
Vancouver, BC
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Attention: Devan Fitch

REPORT

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Table of Contents

TABLES

FIGURES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the City of Vancouver (CoV) to complete a noise assessment for the potential removal of the Georgia and Dunsmuir viaducts and replacement with a mostly at-grade street network within the Pacific Place Lands located in Vancouver, BC (the Project).

This noise assessment addresses the potential effects of the Project on the existing acoustic environment of the site and surrounding area. Consideration of effects associated with noise is made in the context of how the proposed construction and operation of the Project will affect the acoustic environment of the site and surroundings.

There are two local noise regulations that were considered during this assessment, the BC Ministry of Transportation and Infrastructure's (MoTI) *Policy for Assessing and Mitigating Noise Impacts from New and Upgraded Numbered Highways* (MoTI Noise Policy) (MoTI 2014) and the CoV's *Noise Control Bylaw 6555* (CoV Noise Bylaw) (CoV 2014). Additional guidance regarding mitigation measures during construction was obtained from the United States (US) Federal Transit Administration's (FTA) *Transit Noise and Vibration Impact Assessment* (FTA Noise Criteria) (FTA 2006).

2.0 PROJECT DESCRIPTION

The proposed road network changes in the Project area are expected to include the removal of the Georgia and Dunsmuir Viaducts. They will be replaced with a new two-way Georgia Street extension to Pacific Boulevard that will be realigned and consolidated with Expo Boulevard north of the Sky Train guideway. A new two-way connection to Prior Street and Quebec Street will be constructed. A bike and pedestrian bridge may be constructed.

Project activities may include, but are not limited to:

- demolition of the existing roadways and viaducts;
- construction site preparation;
- realignment of roads and utilities; and
- construction of a bike and pedestrian bridge.

3.0 ASSESSMENT APPROACH

The purpose of the Project noise assessment was to assess potential changes in noise levels due to the Project and to determine if the Project meets relevant noise regulations. The approach for the Project noise assessment was to:

- predict Project construction noise level contributions to the acoustic environment in the Project study area;
- predict existing traffic noise level contributions to the acoustic environment in the Project study area;
- predict post-Project traffic noise level contributions to the acoustic environment in the Project study area;
- compare Project noise level predictions to existing noise levels and criteria in local noise regulations to characterize potential noise effects associated with the Project; and
- if required, recommend mitigation measures to bring predicted noise levels into compliance with local noise regulations.

3.1 Assessment Cases

This noise assessment considered three assessment cases:

- the Baseline Case consists of the existing road alignment and current traffic data;
- the Construction Case consists of the noise impacts during Project construction; and
- the Future Case consists of the post-Project road alignment and predicted future traffic data.

The construction noise and traffic noise contributions were predicted using a computer noise model developed in accordance with a widely-accepted calculation standard for the propagation of environmental noise (ISO 1996). More details on the computer models developed for this assessment are provided in Section 3.4 of this report.

3.2 Noise Criteria

There are two local noise regulations that were considered during this assessment, the BC MoTI Noise Policy (MoTI 2014) and the CoV Noise Bylaw (CoV 2014). As the MoTI Noise Policy is specifically for highways, it is not strictly relevant to city roads but is still considered here. Further guidance was obtained from the US FTA Noise Criteria (FTA 2006).

3.2.1 City of Vancouver Noise Bylaw

The CoV Noise Bylaw specifies that the Project area is comprised of an ‘event zone’ (the area surrounding BC Place and Rogers Arena) and an ‘intermediate zone’. When in an event or intermediate zone, no person can make or cause continuous noise which exceeds 70 dBA during the daytime and 65 dBA during the nighttime which is received in an event or an intermediate zone. The daytime period in the intermediate zone is defined as 7 AM to 10 PM on a weekday or Saturday and from 10 AM to 10 PM on a Sunday or holiday. In the ‘event zone’, the daytime period extends until 11 PM. The nighttime period is defined as any time not included within the definition of the daytime period.

The above limits are not applicable to construction noise. A limit of 85 dBA is provided for construction that does not occur on a street and therefore is not applicable in this assessment. The CoV Noise Bylaw states that for construction on a street, no person can cause or allow construction noise that disturbs the quiet, peace, rest or enjoyment of the public except between the hours of 7 AM and 8 PM on a weekday or Saturday and between 10 AM and 8 PM on a Sunday or holiday. When required to complete a project, permission may be granted to perform construction activities outside of these hours.

3.2.2 Ministry of Transportation and Infrastructure Traffic Noise Policy

The BC MoTI Noise Policy is specifically for highways, however was still considered for this assessment. The MoTI Noise Policy considers a day-night noise level (L_{dn}), which penalizes nighttime (between 10 PM and 7 AM) noise levels by an additional 10 dBA, accounting for the increased sensitivity of people to noise during the nighttime period.

The impact criteria are based on two curves, above which 'moderate' and 'severe' impacts are incurred. The change in noise level allowed before a moderate or severe impact rating is assigned decreases as existing noise increases (Figure 1). For example, when the existing noise exposure is 40 dBA, the allowable increase before a moderate effect is incurred is 10 dBA and before a severe impact is incurred is 15 dBA. When the existing noise exposure is 70 dBA, an increase greater than 0 dBA is considered to be a moderate impact and greater than 3.6 dBA is considered to be a severe impact. The Policy discusses that mitigation consideration shall be warranted for 'moderate' and 'severe' noise impacts. The Policy also states that mitigation measures must be able to achieve a minimum reduction in L_{dn} of 5 dBA for it to be considered effective and worth the cost of installation.

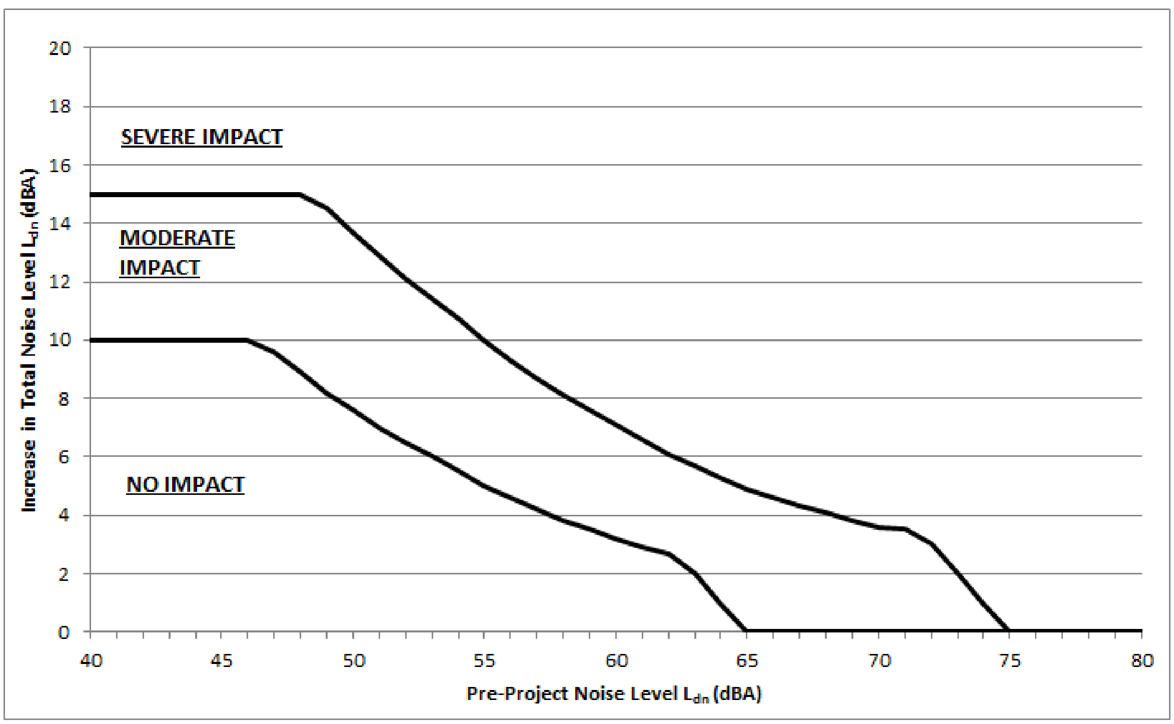


Figure 1: MoTI Noise Criteria (Figure 2 in MoTI 2014)

3.2.3 Federal Transit Administration Transit Noise and Vibration Assessment

As neither of the local criteria provides construction noise limits, the FTA Noise Criteria was considered for construction noise. The FTA daytime and nighttime 8-hour L_{eq} limits for construction in a residential area are 80 dBA and 70 dBA, respectively.

The FTA also recommends mitigation measures to reduce the impact of construction noise on nearby residents. The specific construction mitigation measures recommended are as follows:

- Construct noise barriers, such as temporary walls or piles of excavated material, between noisy activities and noise-sensitive receptors.
- Reroute truck traffic away from residential receptors, if possible.
- Place equipment on the construction site as far from noise-sensitive receptors as possible.
- Construct walled enclosures around especially noisy activities or clusters of noisy equipment.
- Combine noisy operations to occur in the same time period.
- Avoid nighttime activities if possible.
- Avoid the use of impact pile drivers where possible in noise-sensitive areas. Drilled piles or the use of sonic or vibratory pile drivers are quieter alternatives where the geological conditions permit their use.
- Use specially-quieted equipment, such as quieted and enclosed compressors and properly-working mufflers on all engines.
- Select quieter demolition methods, such as sawing bridge decks into sections that can be loaded onto trucks rather than demolition by pavement breakers.

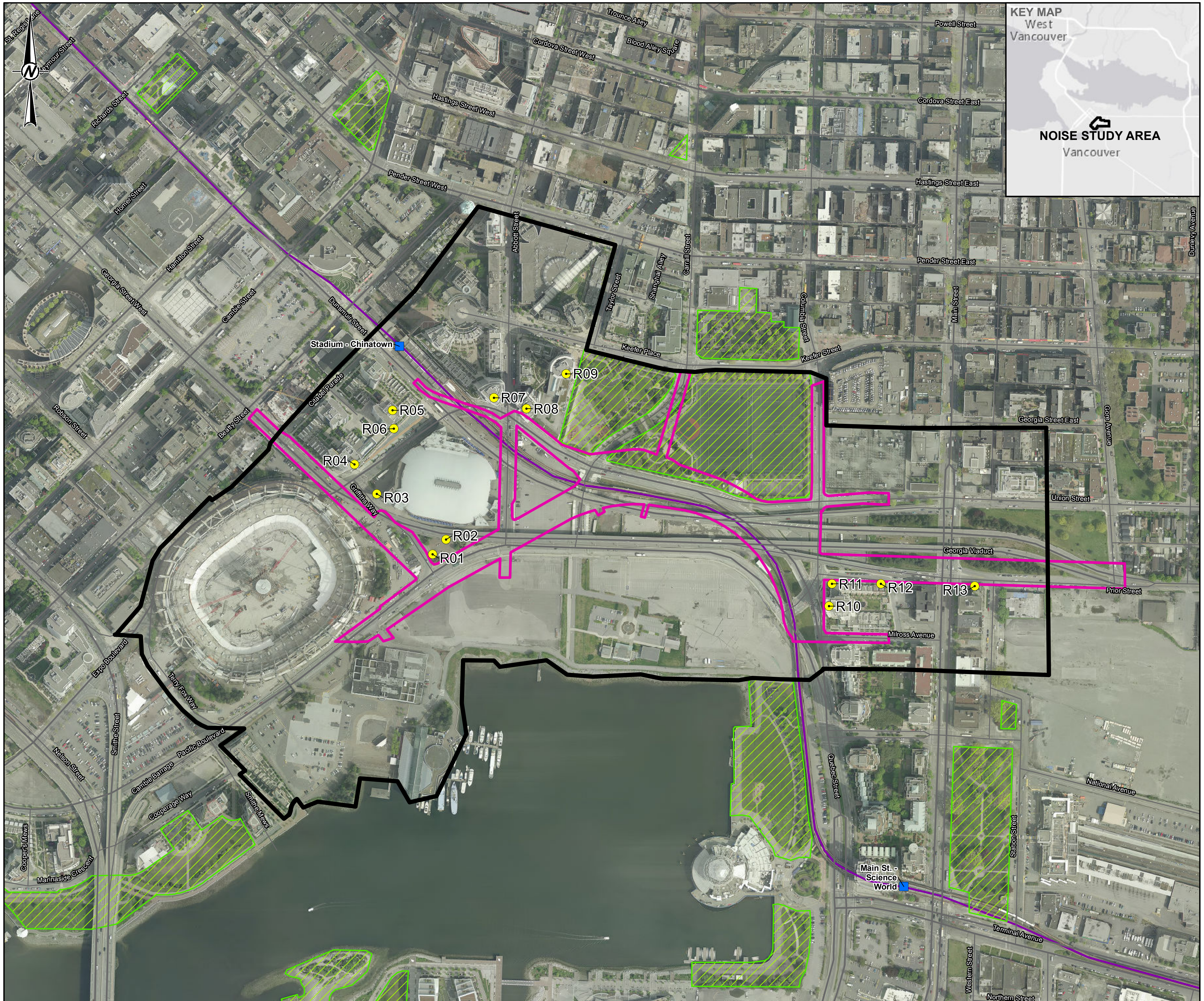
3.3 Noise Study Area and Receptors

The noise study area is defined as the area encompassing affected roads and the nearest affected receptors. Residential condo buildings anticipated to be affected by the Project were identified as noise sensitive receptors and are shown in Table 1. Multiple receptor heights are considered at each location. A receptor at a height of 1.5 m was placed at the façade of each building to represent the ground floor. Another receptor was placed at a height which approximately corresponded to the first residential floor of each building, as many of the condo buildings have lobbies, gym facilities, and other public areas on the first floor or two of the building.

The noise study area and the residential receptors are shown in Figure 2.

Table 1: Noise Receptors

Noise Receptor	Address	Universal Transverse Mercator Coordinates [NAD83, Zone 10]		Height (m)
		Easting [m]	Northing [m]	
R01	800 Griffiths Way – South Tower (South Side)	492074	5458258	1.5
				10.5
R02	800 Griffiths Way – South Tower (North Side)	492091	5458277	1.5
				10.5
R03	800 Griffiths Way – West Tower	492002	5458336	1.5
				7.5
R04	111 W Georgia St.	491973	5458374	1.5
				7.5
R05	131 Regiment Square (Facing Dunsmuir St.)	492022	5458444	1.5
				10.5
R06	131 Regiment Square (Facing Expo Blvd.)	492024	5458420	1.5
				7.5
R07	689 Abbott St.	492153	5458460	1.5
				7.5
R08	688 Abbott St.	492195	5458446	1.5
				7.5
R09	58 Keefer St.	492246	5458491	1.5
				7.5
R10	125 Milross Avenue	492585	5458191	1.5
				4.5
R11	108 Prior St.	492589	5458220	1.5
				4.5
R12	168 Prior St.	492652	5458220	1.5
				4.5
R13	200 Prior St.	492773	5458217	1.5
				4.5



LEGEND

PROJECT DATA

- NOISE RECEPTOR LOCATION
- NOISE STUDY AREA
- FUTURE ROADWORK

BASE DATA

- SKYTRAIN STATION
- SKYTRAIN LINE
- EXPRESSWAY
- MAJOR ROAD
- LOCAL ROAD
- PARK

0 100 200

1:5,000 METERS

REFERENCE(S)

1. ROADS OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. ORTHOPHOTO (2011), PARKS, AND SKYTRAIN FEATURES OBTAINED FROM THE CITY OF VANCOUVER.
3. INSET BASE ESRI, HERE, DELORME, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
4. DATUM: NAD83 PROJECTION: UTM ZONE 10

CLIENT

CITY OF VANCOUVER

PROJECT

VIADUCTS DATA CONSOLIDATION PROJECT
NORTH-EAST FALSE CREEK, VANCOUVER, B.C.

TITLE

NOISE STUDY AREA AND RECEPTOR COMPONENTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-09-16
DESIGNED	SD
PREPARED	JP
REVIEWED	SD
APPROVED	AF

PROJECT NO.	PHASE	REV.	FIGURE
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3.4 Noise Prediction Methodology

3.4.1 Noise Model

The Computer Aided Noise Attenuation (CadnaA) prediction model (version 4.3.143), developed by DataKustik GmbH was identified as the appropriate software to develop predictive noise models for this Project. The algorithms used by CadnaA are consistent with international standards, including *ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 1996) and *RLS-90 Guidelines for Noise Protection on Roads (*Richtlinien für den Lärmschutz an Straßen*)* (RLS-90 1990). CadnaA has the capability to simulate a series of point, line and area emission sources as well as road sources. The road sources can be characterized by entering mean daily traffic data and speed limit. The CadnaA model also accounts for noise attenuation related to meteorological conditions (such as temperature and humidity), ground cover and physical barriers, either natural (terrain based) or man-made.

3.4.2 Model Input Parameters

The configuration of the calculation parameters used to complete the noise modelling for the noise assessment is listed in Table 2.

Table 2: Noise Model Input Parameters

Parameter	Model Setting	Description/Notes
Software	CadnaA Version 4.5.151	CadnaA is a widely-used environmental noise monitoring software package developed by DataKustik GmbH.
Standards	ISO 9613-2 RLS-90	All sources and attenuation effects were treated as required by these standards.
Ground Absorption	0.0 – water; 0.1 – rest of noise study area	These values represent the acoustic properties of the ground in accordance with ISO 9613-2: 0.0 represents hard ground and 1.0 represents porous ground.
Reflections	second-order	Second order reflections are included in the modelling in a manner consistent with ISO 9613-2.
Temperature/Humidity	10°C / 70% relative humidity	Consistent with representative summer conditions in the area.
Wind Conditions	1 to 5 m/s; all receivers downwind from all sources	Consistent with standard ISO 9613-2.
Terrain	contour lines and height points	Contour lines and height points provided by the CoV were used to represent ground elevation.

3.4.3 Prediction Confidence and Uncertainty

The uncertainty of traffic noise modelling is generally accepted to be 5 dB (Probst 2009). Model accuracy will also depend on the accuracy of the noise emission inputs, which is often +/- 2 dB for measured sources and potentially larger for empirical formulae and manufacturer noise ratings. Accounting for both these sources of uncertainty, the overall accuracy of noise level predictions presented here is expected to be +/- 5.4 dB.

Conservative assumptions regarding the Project have been made to account for the level of uncertainty inherent in the noise level predictions. In particular, all receptors are assumed to be downwind from all sources 100% of the time; because downwind conditions tend to enhance noise propagation, this assumption will tend to overestimate the noise effect of the Project.

4.0 NOISE EMISSIONS

4.1 Construction Case

Noise emissions for Project construction equipment were primarily established using manufacturer's specifications, published literature (FWHA 2011, Parsons 2009) and previous Golder measurements of similar equipment. Three construction activities were considered in the assessment:

- road construction;
- demolition; and
- bridge launching.

Preliminary phases of construction were provided by the CoV. This assessment considers the phase anticipated to utilize the most equipment, which would produce the greatest overall noise levels. Noise levels at individual receptors may increase during other phases when the areas under construction are in closer proximity to those receptors. The phase under consideration here includes the following activities:

- construction of the intersection at Georgia St. and Pacific Blvd. and the south portion of the Georgia Ramp;
- completion of all necessary works at Abbott St. and Pacific Blvd.; and
- removal of the Main St. off-ramp and construction of Quebec St. between Prior St. and Main St.

Octave-band sound power levels for each piece of Project construction equipment are presented in Table 3.

Table 3: Project Equipment Noise Emissions

Source Name	Quantity	Usage Factor	Octave-Band Sound Power Level [dBZ]									Sound Power Level [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Road Construction												
Bomag BW211D3 Roller	3	50%	111.0	105.1	104.7	99.9	104.8	93.6	88.2	81.2	29.1	103.0
CAT 320C Excavator	1	40%	114.8	101.6	102.6	98.6	98.6	98.6	95.6	90.6	92.7	103.0
Deere 650J Bulldozer	3	40%	104.6	110.4	106.1	107.1	104.9	103.7	99.8	94.2	32.8	108.0
Western Star HiHab Truck	2	40%	96.4	107.8	127.0	114.3	112.4	110.6	106.2	98.7	91.5	116.3
Deere 650D Excavator	2	40%	119.8	106.6	107.6	103.6	103.6	103.6	100.6	95.6	97.7	108.0
Deere 750D Excavator	1	40%	119.8	106.6	107.6	103.6	103.6	103.6	100.6	95.6	97.7	108.0
Deere 310SJ Backhoe	4	40%	118.4	105.2	106.2	102.2	102.2	102.2	99.2	94.2	96.3	106.6
S300 Bobcat	2	40%	116.8	103.6	103.6	100.6	100.6	100.6	97.6	92.6	94.7	105.0
Deere 544J Front Loader	1	40%	116.8	103.6	103.6	100.6	100.6	100.6	97.6	92.6	94.7	105.0
Deere 450C LC Excavator	2	40%	116.8	103.6	104.6	100.6	100.6	100.6	97.6	92.6	94.7	105.0
Case 590 Backhoe	2	40%	114.8	101.6	102.6	98.6	98.6	98.6	95.6	90.6	92.7	103.0
CAT 328D Excavator	3	40%	116.8	103.6	104.6	100.6	100.6	100.6	97.6	92.6	94.7	105.0
CAT 950H Front Loader	1	40%	122.8	109.6	109.6	106.6	106.6	106.6	103.6	98.6	100.7	111.0
CAT 420E Backhoe	1	40%	118.4	105.2	106.2	102.2	102.2	102.2	99.2	94.2	96.3	106.6
GOMACO Curb and Gutter Casting Machine	1	50%	128.5	115.3	115.3	112.3	112.3	112.3	109.3	104.3	106.4	116.7
Deere 225DLC Excavator	3	40%	114.8	101.6	102.6	98.6	98.6	98.6	95.6	90.6	92.7	103.0
CAT Grader	1	40%	123.3	118.4	120.5	110.0	109.2	107.0	102.7	91.4	76.8	112.0
Hyundai HL740-7 Front Loader	1	40%	115.8	102.6	102.6	99.6	99.6	99.6	96.6	91.6	93.7	104.0
CASE 580 Backhoe	1	40%	114.8	101.6	102.6	98.6	98.6	98.6	95.6	90.6	92.7	103.0
JLG Manlift	1	50%	108.7	108.7	102.7	95.7	94.7	107.7	95.7	83.7	76.7	108.3

Source Name	Quantity	Usage Factor	Octave-Band Sound Power Level [dBZ]									Sound Power Level [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Demolition												
Komatsu 450 Excavator	1	40%	123.8	110.6	111.6	107.6	107.6	107.6	104.6	99.6	101.7	112.0
CAT 345 Excavator	1	40%	118.8	105.6	106.6	102.6	102.6	102.6	99.6	94.6	96.7	107.0
Volvo 480 Excavator	1	40%	117.8	104.6	105.6	101.6	101.6	101.6	98.6	93.6	95.7	106.0
Volvo 460 Excavator	1	40%	117.8	104.6	105.6	101.6	101.6	101.6	98.6	93.6	95.7	106.0
Komatsu 290 Excavator	1	40%	116.8	103.6	104.6	100.6	100.6	100.6	97.6	92.6	94.7	105.0
Case 580 Backhoe	1	20%	116.7	116.7	115.7	112.7	115.7	117.7	115.7	110.7	100.7	121.7
CAT 235 Excavator	1	40%	114.8	101.6	102.6	98.6	98.6	98.6	95.6	90.6	92.7	103.0
Dump Trucks	1	40%	115.8	102.6	103.6	99.6	99.6	99.6	96.6	91.6	93.7	104.0
Cranes	2	40%	95.8	107.2	126.4	113.7	111.8	110.0	105.6	98.1	90.9	115.7
Bridge Launching												
Segment Lifters	4	60%	104.3	114.1	112.9	113.8	114.0	110.0	103.5	95.8	36.8	114.6
Delta Frame Lifters	2	30%	104.3	114.1	112.9	113.8	114.0	110.0	103.5	95.8	36.8	114.6
Segment Delivery Truck	2	30%	96.8	108.2	127.4	114.7	112.8	111.0	106.6	99.1	91.9	116.6
Service Crane	1	15%	104.3	114.1	112.9	113.8	114.0	110.0	103.5	95.8	36.8	114.6
Flat Bed Truck	1	15%	91.8	103.2	122.4	109.7	107.8	106.0	101.6	94.1	86.9	111.6

4.2 Baseline and Future Cases

The Baseline Case consists of traffic noise levels from the existing road network and traffic volumes provided by the CoV. The Future Case consists of traffic noise levels based on a design of the future road network and projected traffic volumes provided by the CoV. A summary of the traffic data incorporated into the prediction models is provided in Table 4. The traffic data for the peak hour, occurring during the evening rush hour, was also provided by the CoV and was considered in this assessment for comparison to the CoV Noise Bylaw. The posted speed limit is an input to the model as specified in RLS-90 (1990).

Table 4: Noise Model Input Parameters

Road	Speed Limit [km/hr]	Traffic Count (Baseline Case)		Traffic Count (Future Case)		% Heavy Vehicles	Day/Night Traffic Split [%]
		Per Day	Peak Daytime Hour	Per Day	Peak Daytime Hour		
Abbott	50	3876	323	3876	320	4.0	90/10
Dunsmuir	50	14568	1214	360	30	4.4	90/10
Expo	50	12864	1072	12864	1072	2.4	90/10
Georgia	50	23160	1930	37728	3144	4.4	90/10
Pacific (West of Georgia)	50	17544	1462	17544	1462	4.0	90/10
Pacific (Between Georgia and Abbot)	50	17544	1462	54324	4527	4.0	90/10
Pacific (Between Abbott and Quebec)	50	17544	1462	60552	5046	4.0	90/10
Pacific (Between Quebec and Main)[a]	50	—	—	37620	3135	4.0	90/10
Pacific (East of Main)[b]	50	—	—	21792	1816	4.0	90/10
Prior (East of Main)[b]	50	3500	248	—	—	4.0	90/10
Quebec	50	27204	2267	27204	2267	4.0	90/10

(a) In the Baseline Case, Pacific (Between Quebec and Main) is the 100 block of Prior Street, which has negligible vehicular traffic.

(b) In the Future Case, Prior (East of Main) becomes Pacific (East of Main).

5.0 ASSESSMENT RESULTS

5.1 Construction Case

As discussed in Section 3.1 of this report, the Construction Case consisted of noise emissions from equipment that is anticipated to be used in the Project area during one phase of construction. The noise contribution of the construction equipment was characterized using a computer noise model.

Construction Case noise levels are presented in Table 5 and are compared with the daytime FTA construction noise criteria. While construction activities may occur at night if permission is granted, noisy activities will be kept to a minimum and performed during the daytime whenever possible.

Table 5: Construction Case Noise Levels

Noise Receptor	Height [m]	Construction Noise Contribution (Daytime) [dBA]	FTA Construction Noise Criteria [dBA]	Margin of Compliance [dBA]
R01	1.5	77.5	80	2.5
	10.5	79.3	80	0.7
R02	1.5	67.4	80	12.6
	10.5	68.1	80	11.9
R03	1.5	75.4	80	4.6
	7.5	75.6	80	4.4
R04	1.5	67.1	80	12.9
	7.5	69.4	80	10.6
R05	1.5	52.4	80	27.6
	10.5	56.5	80	23.5
R06	1.5	54.4	80	25.6
	7.5	56.4	80	23.6
R07	1.5	62.8	80	17.2
	7.5	61.5	80	18.5
R08	1.5	64.7	80	15.3
	7.5	62.7	80	17.3
R09	1.5	61.2	80	18.8
	7.5	62.7	80	17.3
R10	1.5	62.7	80	17.3
	4.5	65.1	80	14.9
R11	1.5	75.7	80	4.3
	4.5	75.8	80	4.2
R12	1.5	77.9	80	2.1
	4.5	77.8	80	2.2
R13	1.5	69.9	80	10.1
	4.5	69.4	80	10.6

While Table 5 indicates that the predicted construction noise levels were below the daytime FTA construction noise criteria, the mitigation measures presented in Section 3.2.3 are still recommended to reduce the impact on nearby noise-sensitive receptors. Noise levels may be greater at individual noise receptor locations during other phases of construction due to the placement of equipment within the study area.

5.2 Baseline Case

As discussed in Section 3.1 of this report, the Baseline Case consisted of the existing road alignment and current traffic data. The noise contribution of the current traffic was characterized using a computer noise model.

Baseline Case noise levels are presented in Table 6. A comparison of the Baseline Case noise levels and the CoV Noise Bylaw criteria is presented in Table 7. The Baseline Case maximum hour noise level contours at a height of 1.5 m are presented in Figure 3.

Table 6: Baseline Case Noise Levels

Noise Receptor	Height [m]	Baseline Case Noise Levels [dBA]			
		$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$	L_{dn}
R01	1.5	61.6	60.2	52.8	64.7
	10.5	64.3	62.8	55.5	67.4
R02	1.5	56.0	54.6	47.2	59.1
	10.5	67.5	66.0	58.7	70.6
R03	1.5	69.8	68.4	61.0	72.9
	7.5	69.5	68.1	60.7	72.6
R04	1.5	67.4	66.0	58.6	70.5
	7.5	67.4	66.0	58.6	70.5
R05	1.5	62.1	60.7	53.3	65.2
	10.5	63.4	62.0	54.6	66.5
R06	1.5	65.4	64.0	56.6	68.5
	7.5	65.1	63.7	56.3	68.2
R07	1.5	67.1	65.7	58.3	70.2
	7.5	67.6	66.2	58.9	70.8
R08	1.5	65.7	64.2	56.9	68.8
	7.5	67.0	65.6	58.2	70.1
R09	1.5	57.2	55.8	48.5	60.4
	7.5	58.2	56.8	49.4	61.3
R10	1.5	66.7	65.3	57.9	69.8
	4.5	68.2	66.8	59.4	71.3
R11	1.5	67.5	66.0	58.7	70.6
	4.5	69.0	67.6	60.2	72.1
R12	1.5	66.3	64.9	57.5	69.4
	4.5	67.6	66.2	58.8	70.7
R13	1.5	66.8	65.1	57.7	69.6
	4.5	66.8	65.4	58.0	69.9

Table 7: Comparison of Baseline Case Noise Levels and the CoV Noise Bylaw Limits

Noise Receptor	Height [m]	Baseline Case Noise Levels [dBA]			CoV Noise Bylaw Limits [dBA]		Margin of Compliance [dBA]		
		$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$	Daytime	Nighttime	$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$
R01	1.5	61.6	60.2	52.8	70	65	8.4	9.8	12.2
	10.5	64.3	62.8	55.5	70	65	5.7	7.2	9.5
R02	1.5	56.0	54.6	47.2	70	65	14.0	15.4	17.8
	10.5	67.5	66.0	58.7	70	65	2.5	4.0	6.3
R03	1.5	69.8	68.4	61.0	70	65	0.2	1.6	4.0
	7.5	69.6	68.1	60.7	70	65	0.4	1.9	4.3
R04	1.5	67.4	66.0	58.6	70	65	2.6	4.0	6.4
	7.5	67.4	66.0	58.6	70	65	2.6	4.0	6.4
R05	1.5	62.1	60.7	53.3	70	65	7.9	9.3	11.7
	10.5	63.4	62.0	54.6	70	65	6.6	8.0	10.4
R06	1.5	65.4	64.0	56.6	70	65	4.6	6.0	8.4
	7.5	65.1	63.7	56.3	70	65	4.9	6.3	8.7
R07	1.5	67.1	65.7	58.3	70	65	2.9	4.3	6.7
	7.5	67.6	66.2	58.9	70	65	2.4	3.8	6.1
R08	1.5	65.7	64.2	56.9	70	65	4.3	5.8	8.1
	7.5	67.0	65.6	58.2	70	65	3.0	4.4	6.8
R09	1.5	57.2	55.8	48.5	70	65	12.8	14.2	16.5
	7.5	58.2	56.8	49.4	70	65	11.8	13.2	15.6
R10	1.5	66.7	65.3	57.9	70	65	3.3	4.7	7.1
	4.5	68.2	66.8	59.4	70	65	1.8	3.2	5.6
R11	1.5	67.5	66.0	58.7	70	65	2.5	4.0	6.3
	4.5	69.0	67.6	60.2	70	65	1.0	2.4	4.8
R12	1.5	66.3	64.9	57.5	70	65	3.7	5.1	7.5
	4.5	67.6	66.2	58.8	70	65	2.4	3.8	6.2
R13	1.5	66.8	65.1	57.7	70	65	3.2	4.9	7.3
	4.5	66.8	65.4	58.0	70	65	3.2	4.6	7.0

5.3 Future Case

As discussed in Section 3.1 of this report, Future Case consists of the Project road alignment and predicted future traffic data. The noise contribution from the Project traffic was characterized using a computer noise model.

Future Case noise levels are presented in Table 8, and Table 9 and Table 10 compare the results to the relevant criteria. The MoTI impact ratings in Table 10 are based on Figure 1 presented in Section 3.2.2. The Future Case maximum hour noise level contours at a height of 1.5 m are presented in Figure 4.

Table 8: Future Case Noise Levels

Noise Receptor	Height [m]	Future Case Noise Levels [dBA]			
		$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$	L_{dn}
R01	1.5	68.7	67.3	59.9	71.8
	10.5	69.8	68.4	61.0	72.9
R02	1.5	59.7	58.3	50.9	62.8
	10.5	62.2	60.7	53.4	65.3
R03	1.5	67.7	66.3	58.9	70.8
	7.5	67.9	66.5	59.1	71.0
R04	1.5	67.5	66.1	58.7	70.6
	7.5	67.7	66.2	58.9	70.8
R05	1.5	52.9	51.5	44.2	56.1
	10.5	57.1	55.7	48.3	60.2
R06	1.5	64.7	63.3	55.9	67.8
	7.5	64.4	63.0	55.6	67.5
R07	1.5	66.3	64.9	57.5	69.4
	7.5	66.8	65.4	58.0	69.9
R08	1.5	65.0	63.6	56.2	68.1
	7.5	66.4	65.0	57.6	69.5
R09	1.5	58.2	56.8	49.4	61.3
	7.5	58.9	57.5	50.1	62.0
R10	1.5	68.3	66.9	59.5	71.4
	4.5	69.7	68.3	60.9	72.8
R11	1.5	69.6	67.9	60.5	72.4
	4.5	70.9	69.4	62.0	73.9
R12	1.5	68.8	67.2	59.8	71.7
	4.5	69.9	68.4	61.0	72.9
R13	1.5	69.4	68.0	60.6	72.5
	4.5	69.9	68.4	61.1	73.0

Table 9: Comparison of Future Case Noise Levels and the CoV Noise Bylaw Limits

Noise Receptor	Height [m]	Future Case Noise Levels [dBA]			CoV Noise Bylaw Limits [dBA]		Margin of Compliance [dBA]		
		$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$	Daytime	Nighttime	$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$
R01	1.5	68.7	67.3	59.9	70	65	1.3	2.7	5.1
	10.5	69.8	68.4	61.0	70	65	0.2	1.6	4.0
R02	1.5	59.7	58.3	50.9	70	65	10.3	11.7	14.1
	10.5	62.2	60.7	53.4	70	65	7.8	9.3	11.6
R03	1.5	67.7	66.3	58.9	70	65	2.3	3.7	6.1
	7.5	67.9	66.5	59.1	70	65	2.1	3.5	5.9
R04	1.5	67.5	66.1	58.7	70	65	2.5	3.9	6.3
	7.5	67.7	66.2	58.9	70	65	2.3	3.8	6.1
R05	1.5	52.9	51.5	44.2	70	65	17.1	18.5	20.8
	10.5	57.1	55.7	48.3	70	65	12.9	14.3	16.7
R06	1.5	64.7	63.3	55.9	70	65	5.3	6.7	9.1
	7.5	64.4	63.0	55.6	70	65	5.6	7.0	9.4
R07	1.5	66.3	64.9	57.5	70	65	3.7	5.1	7.5
	7.5	66.8	65.4	58.0	70	65	3.2	4.6	7.0
R08	1.5	65.0	63.6	56.2	70	65	5.0	6.4	8.8
	7.5	66.4	65.0	57.6	70	65	3.6	5.0	7.4
R09	1.5	58.2	56.8	49.4	70	65	11.8	13.2	15.6
	7.5	58.9	57.5	50.1	70	65	11.1	12.5	14.9
R10	1.5	68.3	66.9	59.5	70	65	1.7	3.1	5.5
	4.5	69.7	68.3	60.9	70	65	0.3	1.7	4.1
R11	1.5	69.6	67.9	60.5	70	65	0.4	2.1	4.5
	4.5	70.9	69.4	62.0	70	65	**-0.9**	0.6	3.0
R12	1.5	68.8	67.2	59.8	70	65	1.2	2.8	5.2
	4.5	69.9	68.4	61.0	70	65	0.1	1.6	4.0
R13	1.5	69.4	68.0	60.6	70	65	0.6	2.0	4.4
	4.5	69.9	68.4	61.1	70	65	0.1	1.6	3.9

(a) **Bold** indicates exceedances

Table 10: Comparison of Change in Day-Night Noise Levels and MoTI Noise Criteria

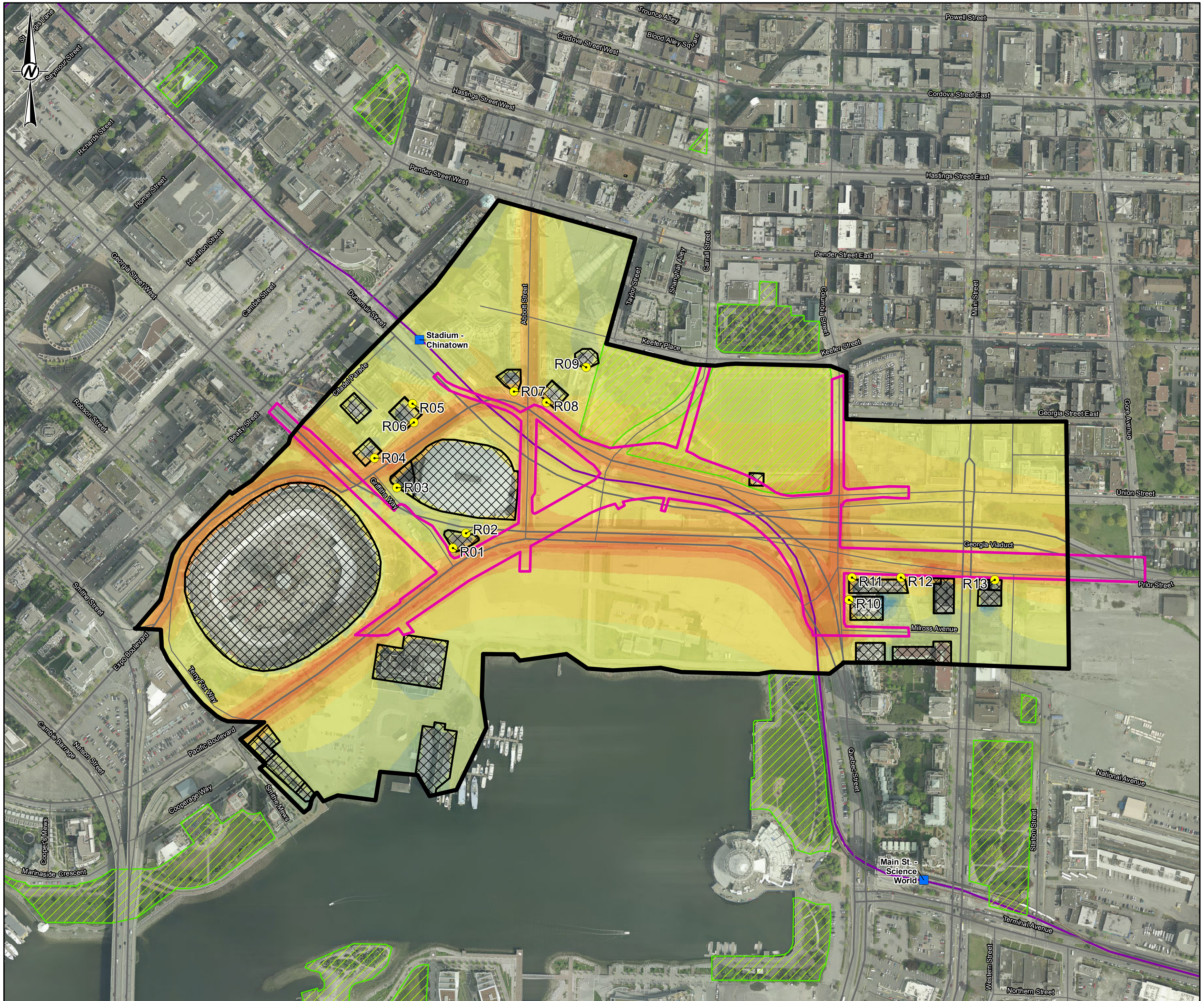
Noise Receptor	Height [m]	Baseline Case L_{dn} [dBA]	Future Case L_{dn} [dBA]	Difference [dBA]	MoTI Impact Rating[(a)] [dBA]
R01	1.5	64.7	71.8	7.1	Severe
	10.5	67.4	72.9	5.5	Severe
R02	1.5	59.1	62.8	3.7	No Impact
	10.5	70.6	65.3	-5.3	Positive Impact
R03	1.5	72.9	70.8	-2.1	Positive Impact
	7.5	72.6	71.0	-1.6	Positive Impact
R04	1.5	70.5	70.6	0.1	No Impact[(b)]
	7.5	70.5	70.8	0.3	No Impact[(b)]
R05	1.5	65.2	56.1	-9.1	Positive Impact
	10.5	66.5	60.2	-6.3	Positive Impact
R06	1.5	68.5	67.8	-0.7	Positive Impact
	7.5	68.2	67.5	-0.7	Positive Impact
R07	1.5	70.2	69.4	-0.8	Positive Impact
	7.5	70.8	69.9	-0.9	Positive Impact
R08	1.5	68.8	68.1	-0.7	Positive Impact
	7.5	70.1	69.5	-0.6	Positive Impact
R09	1.5	60.4	61.3	0.9	No Impact
	7.5	61.3	62.0	0.7	No Impact
R10	1.5	69.8	71.4	1.6	Moderate
	4.5	71.3	72.8	1.5	Moderate
R11	1.5	70.6	72.4	1.8	Moderate
	4.5	72.1	73.9	1.8	Moderate
R12	1.5	69.4	71.7	2.3	Moderate
	4.5	70.7	72.9	2.2	Moderate
R13	1.5	69.6	72.5	2.9	Moderate
	4.5	69.9	73.0	3.1	Moderate

(a) See Figure 2 in MoTI 2014.

(b) Although there is a small increase in noise level, this is considered to be No Impact as the change would be imperceptible.

An exceedance in the CoV criteria was predicted during the maximum hour at the ground floor of one receptor location (R11). This receptor also had a ‘moderate’ impact rating according to the MoTI Noise Policy, along with several other receptors located in the same area (R10, R12 and R13). These receptors are located near the intersection of Pacific Blvd. and Quebec St. just south of the existing viaducts. The new road alignment moves the majority of the traffic from both viaducts to the new Pacific Blvd., which is aligned close to these residences.

The noise levels at receptor R01 did not exceed the CoV criteria, but a ‘severe’ MoTI impact rating was predicted due to the change in L_{dn}. This receptor is located on the south side of the south tower at 800 Griffiths Way (Rogers Arena). Receptor R02 is located on the north side of the same building. While the noise levels on the south side increased (+5.5 dBA at the first residential floor), noise levels at the first residential floor on the north side decreased (-5.3 dBA). This was due to the traffic flow moving from the Georgia Viaduct, located north of the building, to the new Georgia St. and Pacific Blvd. located on the east and south sides of the building. Note that while noise levels increased on the north side on the ground floor, the MoTI impact rating is ‘no impact’ due to the low baseline noise level, as it was located beneath the existing viaduct.



LEGEND

PROJECT DATA

- NOISE RECEPTOR LOCATION
- NOISE STUDY AREA
- FUTURE ROADWORK
- BUILDING FOOTPRINT

BASELINE CASE MAX HOUR NOISE LEVELS (dBA)

- 0-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65-70
- 70-75
- 75-80
- 80-85
- 85+

BASE DATA

- SKYTRAIN STATION
- SKYTRAIN LINE
- MAJOR ROAD
- LOCAL ROAD
- PARK

0 100 200

1:5,000 METERS

REFERENCE(S)

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2. ORTHOPHOTO (2011), PARKS, AND SKYTRAIN FEATURES OBTAINED FROM THE CITY OF VANCOUVER.
3. DATUM: NAD83 PROJECTION: UTM ZONE 10

CLIENT

CITY OF VANCOUVER

PROJECT

VIADUCTS DATA CONSOLIDATION PROJECT
NORTH-EAST FALSE CREEK, VANCOUVER, B.C.

TITLE

BASELINE CASE MAXIMUM HOUR NOISE LEVELS AT 1.5 METRES

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-09-16
DESIGNED	SD
PREPARED	JP
REVIEWED	SD
APPROVED	AF

PROJECT NO.	PHASE	REV.	FIGURE
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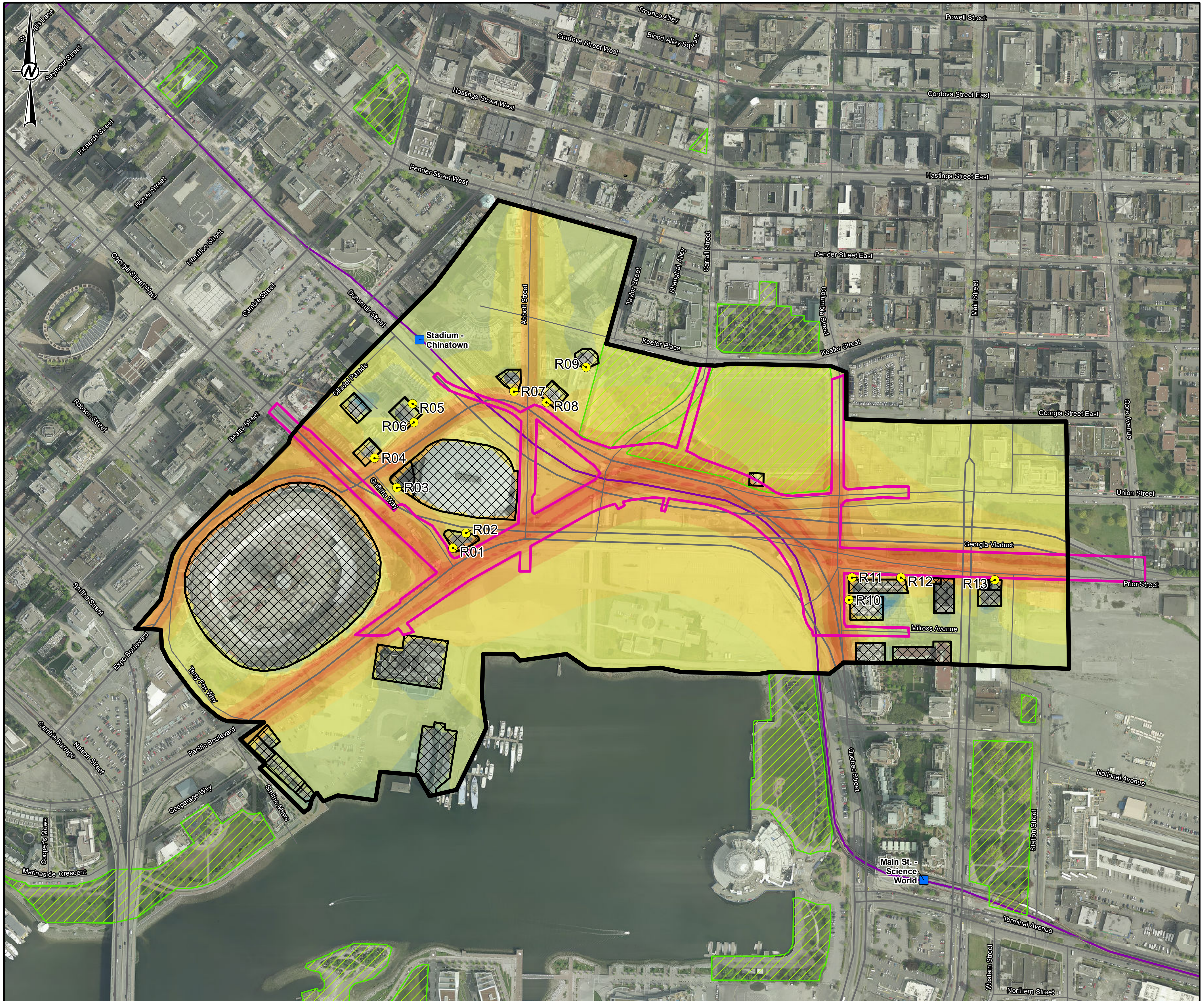

LEGEND

PROJECT DATA

- NOISE RECEPTOR LOCATION
- NOISE STUDY AREA
- FUTURE ROADWORK
- BUILDING FOOTPRINT

FUTURE CASE MAX HOUR NOISE LEVELS (dBA)

- 0-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65-70
- 70-75
- 75-80
- 80-85
- 85+

BASE DATA

- SKYTRAIN STATION
- SKYTRAIN LINE
- MAJOR ROAD
- LOCAL ROAD
- PARK

0 100 200

1:5,000 METERS

REFERENCE(S)

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2. ORTHOPHOTO (2011), PARKS, AND SKYTRAIN FEATURES OBTAINED FROM THE CITY OF VANCOUVER.
3. DATUM: NAD83 PROJECTION: UTM ZONE 10

CLIENT

CITY OF VANCOUVER

PROJECT

VIADUCTS DATA CONSOLIDATION PROJECT
NORTH-EAST FALSE CREEK, VANCOUVER, B.C.

TITLE

FUTURE CASE MAXIMUM HOUR NOISE LEVELS AT 1.5 METRES

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-09-16
DESIGNED	SD
PREPARED	JP
REVIEWED	SD
APPROVED	AF

PROJECT NO.	PHASE	REV.	FIGURE
1405994	2000	2	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

5.4 Mitigated Future Case

Due to the location of receptor location R01, physical berms or barriers are not feasible to reduce the noise levels. Mitigation may be achieved by considering low-noise pavement options or increasing the sound insulation of the receptor building facades. The MoTI (MoTI 2014) states that low-noise pavements can provide 4 to 7 dBA of attenuation to highway traffic noise levels and could change the impact rating of the moderately affected receptors to a No Impact or Positive Impact rating. Depending on the current acoustical performance of the building façade, especially windows and doors, sound insulation treatments can improve the noise reduction of traffic noise by 5 to 20 dBA (FTA 2006). Note that the buildings in close proximity to the stadia, including R01, have building envelopes that were designed to a higher than standard acoustical performance to reduce transmission of stadium noise (BKL 2015). Therefore, the future impact on indoor noise may be lower than predicted for outdoor noise.

The effects of three 3 m high earth berms were modelled to decrease the traffic noise impact at receptor locations R10, R11, R12 and R13. Two berms were located between R11, R12 and R13 and the new Pacific Blvd. while the other was located between R10 and Quebec St.

The Mitigated Future Case noise levels are presented in Table 11 and a comparison to the Baseline Case noise levels is shown in Table 12. The change in future noise levels due to the berm are presented in Table 13. As discussed in Section 3.2.2, the MoTI Noise Policy states that mitigation must be able to achieve a minimum reduction of 5 dBA in L_{dn} for it to be considered a viable mitigation option. The Mitigated Future Case maximum hour noise contours at a height of 1.5 m are shown in Figure 5.

Table 11: Mitigated Future Case Noise Levels

Noise Receptor	Height [m]	Mitigated Future Case Noise Levels [dBA]			
		$L_{eq,1hour}$ (max)	$L_{eq,day}$	$L_{eq,night}$	L_{dn}
R10	1.5	61.7	60.6	53.2	65.1
	4.5	67.4	65.9	58.6	70.5
R11	1.5	66.6	64.8	57.4	69.3
	4.5	69.2	67.7	60.3	72.2
R12	1.5	61.6	60.2	52.8	64.7
	4.5	66.3	64.9	57.6	69.5
R13	1.5	61.0	59.8	52.4	64.3
	4.5	66.8	65.1	57.7	69.6

Table 12: Comparison of Change in Mitigated Day-Night Noise Levels and MoTI Noise Criteria

Noise Receptor	Height [m]	Baseline Case L_{dn} [dBA]	Mitigated Future Case L_{dn} [dBA]	Difference [dBA]	MoTI Impact Rating[a] [dBA]
R10	1.5	69.8	65.1	-4.7	Positive Impact
	4.5	71.3	70.5	-0.8	Positive Impact
R11	1.5	70.6	69.3	-1.3	Positive Impact
	4.5	72.1	72.2	0.1	No Impact[b]
R12	1.5	69.4	64.7	-4.7	Positive Impact
	4.5	70.7	69.5	-1.2	Positive Impact
R13	1.5	69.6	64.3	-5.3	Positive Impact
	4.5	69.9	69.6	-0.3	Positive Impact

(a) See Figure 2 in MoTI 2014.

(b) Although there is a small increase in noise level, this is considered to be No Impact as the change would be imperceptible.

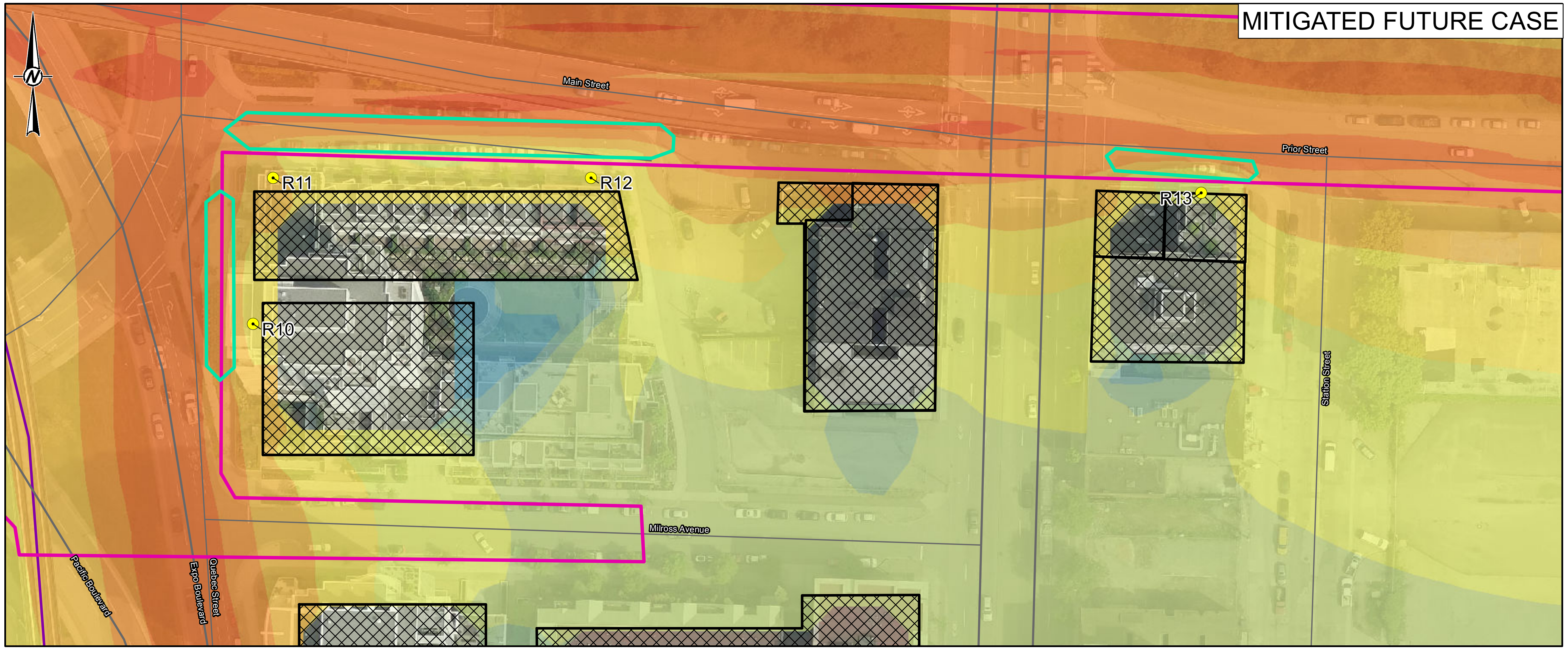
Table 13: Change in Noise Levels Due to Mitigation Measures

Noise Receptor	Height [m]	Unmitigated Future Case L_{dn} [dBA]	Mitigated Future Case L_{dn} [dBA]	Difference [dBA]	MoTI Difference Criteria[a] [dBA]	Margin of Compliance [dBA]
R10	1.5	71.4	65.1	6.1	5	1.1
	4.5	72.8	70.5	2.1	5	**-2.9**
R11	1.5	72.4	69.3	3.4	5	**-1.6**
	4.5	73.9	72.2	1.8	5	**-3.2**
R12	1.5	71.7	64.7	7.0	5	2.1
	4.5	72.9	69.5	3.5	5	**-1.5**
R13	1.5	72.5	64.3	8.2	5	3.2
	4.5	73.0	69.6	3.4	5	**-1.6**

(a) Mitigation must provide a minimum of 5 dBA reduction when compared with the unmitigated case.

(b) **Bold** indicates exceedances.

The barriers provided at least 5 dBA of reduction at the ground floor of R10, R12 and R13 when compared with the unmitigated case. While 5 dBA of reduction is not obtained at the other receptor locations, the 3 m berms decrease the impact of traffic noise at all receptors into the ‘no impact’ or ‘positive impact’ MoTI impact ratings. As previously discussed, further mitigation can be achieved at all impacted receptors by considering low-noise pavement options or increasing the sound insulation of the receptor building facades.



LEGEND

PROJECT DATA

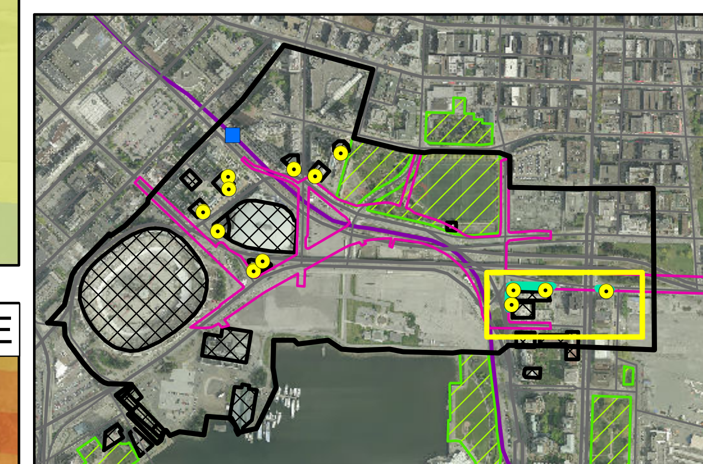
- NOISE RECEPTOR LOCATION
- BERM
- NOISE STUDY AREA
- FUTURE ROADWORK
- BUILDING FOOTPRINT

MAX HOUR NOISE LEVELS (dBA)

- 0-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- 65-70
- 70-75
- 75-80
- 80-85
- 85+

BASE DATA

- SKYTRAIN STATION
- SKYTRAIN LINE
- MAJOR ROAD
- LOCAL ROAD
- PARK



0 20 40

1:1,000 METERS

REFERENCE(S)

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2. ORTHOPHOTO (2011), PARKS, AND SKYTRAIN FEATURES OBTAINED FROM THE CITY OF VANCOUVER.
3. DATUM: NAD83 PROJECTION: UTM ZONE 10

CLIENT
CITY OF VANCOUVER

PROJECT
VIADUCTS DATA CONSOLIDATION PROJECT
NORTH-EAST FALSE CREEK, VANCOUVER, B.C.

TITLE
FUTURE CASE COMPARED TO MITIGATED FUTURE CASE MAXIMUM HOUR NOISE LEVELS AT 1.5 METRES

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-09-16
DESIGNED	SD
PREPARED	JP
REVIEWED	SD
APPROVED	AF

PROJECT NO.	PHASE	REV.	FIGURE
1405994	2000	2	5

PATH: Y:\burnaby\CAD-GIS\Client\City_of_Vancouver\Northeast_False_Creek\99_PROJECTS\1405994_Northeast_False_Creek\02_PRODUCTION\REPORT\NOISE\Rev2\1405994_Figure_05_Mitigated_vs_Future_Case_Max_Hour_Noise_Levels.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

6.0 CONCLUSIONS

Three cases were considered in this noise assessment of the realignment of roads in northeast False Creek in the CoV: the Baseline Case, the Construction Case, and the Future Case. The Construction Case was compared with daytime FTA Noise Criteria, as the majority of noisy activities will occur in the daytime hours, as per the CoV Noise Bylaw; if nighttime construction activities occur, permission must be granted and efforts must be made to keep noise generating activities to a minimum. The prediction results indicate that daytime noise levels during the construction phase considered in this assessment will be below the daytime FTA construction noise criteria of 80 dBA. However, mitigation measures during construction are recommended to reduce the impact to nearby receptors.

The predicted change in noise levels between the Baseline Case and the Future Case were compared to criteria from the CoV Noise Bylaw and the MoTI Noise Policy to identify potential noise issues due to the road realignment. The model predicted that the CoV Noise Bylaw was exceeded at one residential receptor within the study area. This receptor plus three others within the same vicinity had a ‘moderate’ MoTI impact rating. Three earth berms were considered for these receptors, which decreased the predicted impact to a ‘no impact’ or ‘positive impact’ rating. Further mitigation can be achieved by considering low-noise pavement options or increasing the sound insulation of the receptor building facades. Low-noise pavements can provide 4 to 7 dBA of attenuation to highway traffic noise levels and could change the impact rating of the moderately affected receptors to a No Impact or Positive Impact rating. Depending on the current acoustical performance of the building façade, especially windows and doors, sound insulation treatments can improve the noise reduction of traffic noise by 5 to 20 dBA.

A ‘severe’ MoTI impact rating was predicted at one receptor location. Note that two receptor locations on the same building were considered, and that noise levels on one side of the building increased while noise levels on the other side decreased by approximately equal levels. Due to the location of the receptor, berms or barriers were not a feasible mitigation measure. This building was designed with a building envelope with a higher than standard acoustical performance to reduce transmission of stadium noise (BKL 2015) and therefore the impact on indoor noise may be lower than predicted for outdoor noise. As discussed above, further mitigation can be achieved by considering low-noise pavement options.

7.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or requirements, please contact the undersigned. The reader is referred to the Study Limitations, which precedes the text and forms an integral part of this report.

GOLDER ASSOCIATES LTD.

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