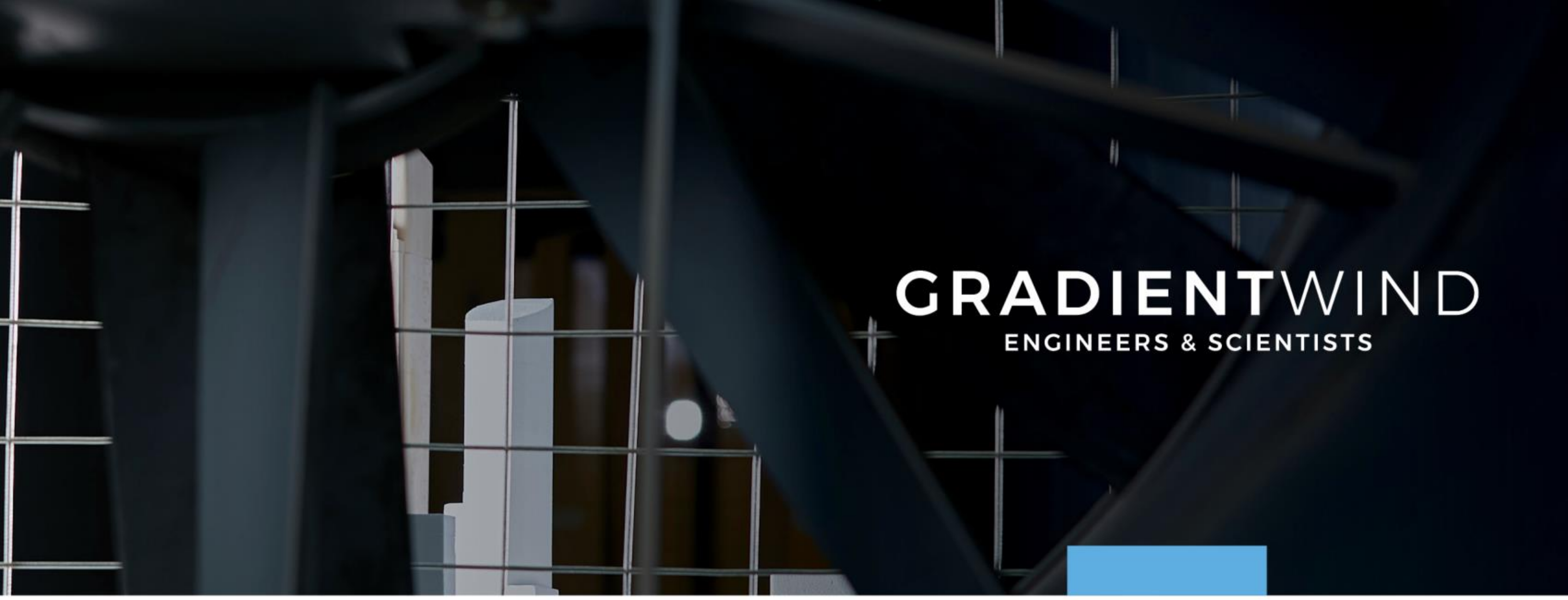
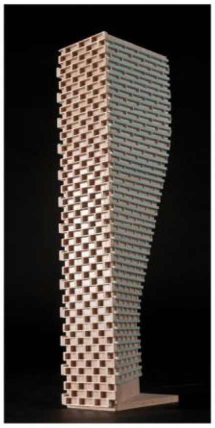
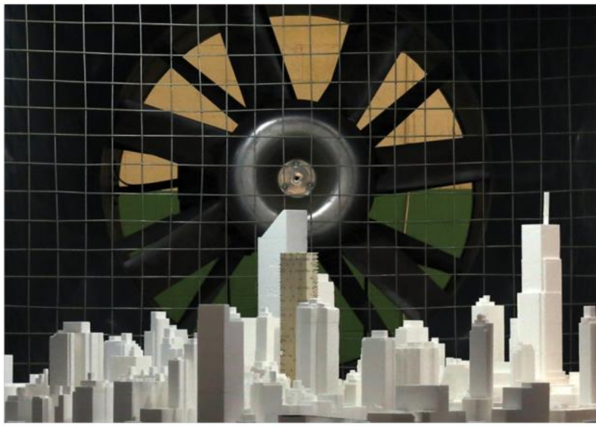


TRANSPORTATION NOISE AND VIBRATION STUDY

LeBreton Library Parcel
665 Albert Street
Ottawa, Ontario

Report: 22-064-Transportation Noise and Vibration





April 21, 2022

PREPARED FOR
Dream
30 Adelaide Street East, Suite 301
Toronto, Ontario M5C 3H1

PREPARED BY
Caleb Alexander, B.Eng., Junior Environmental Scientist
Joshua Foster, P.Eng., Lead Engineer

EXECUTIVE SUMMARY

This report describes a transportation noise and vibration assessment performed for a proposed mixed-use development located at 665 Albert Street in Ottawa, Ontario. The proposed development comprises two nominally rectangular buildings rising 31 and 36 storeys to the east and west, respectively, above a five-storey podium. The major sources of roadway noise are Albert Street, Slater Street, and Booth Street. The light rail transit (LRT) noise source is the O-Train Confederation Line that is north of the proposed development. Figure 1 illustrates a complete site plan with surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the Ministry of the Environment, Conservation and Parks (MECP); (ii) noise level criteria as specified by the City of Ottawa's Environmental Noise Control Guidelines (ENCG); (iii) future vehicular traffic volumes based on the City of Ottawa's Official Plan roadway classifications and Pimisi Station arrival/departure information; and (iv) architectural drawings prepared by KPMB and Perkins & Will, in March 2022.

The results of the current analysis indicate that noise levels will range between 57 and 68 dBA during the daytime period (07:00-23:00) and between 51 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e., 68 dBA) occurs along the south façade of the west podium, which is nearest and most exposed to Albert Street.

The noise levels predicted due to roadway and LRT traffic exceed the criteria listed in Section 4.2 for building components, therefore, building components which achieve the minimum STC rating as outlined in Section 5.2 will be required to control indoor sound levels. Noise levels at the outdoor living areas (OLA) exceed 60 dBA in some cases, therefore, mitigation is required in the form of an acoustic barrier as specified in Section 5.2.1. Warning Clauses will also be required depending on the barrier combination selected. The acoustic barrier should be built with solid elements having a minimum surface mass of 20 kg/m² and contain no gaps. The following information will be required by the City for review prior to installation of the barrier:

1. Shop drawings, signed and sealed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing the details of the acoustic barrier systems components, including material specifications.

2. Structural drawing(s), signed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing foundation details and specifying design criteria, climatic design loads, as well as applicable geotechnical data used in the design.
3. Layout plan, and wall elevations, showing proposed colours and patterns.

Results of the calculations also indicate that the east and west tower will require central air conditioning, or a similar ventilation system, which will allow occupants to keep windows closed and maintain a comfortable living environment at the occupant's discretion. Warning Clauses will also be required to be placed on all Lease, Purchase and Sale Agreements.

Vibrations generated by the O-Train Confederation Line LRT (See Appendix B Figure B1) were calculated between the building foundation and the track, shown in Figure 1. Vibration levels due to the nearest track were found to be 0.04 mm/s RMS (64 dBV) based on the FTA protocol and a conservative offset distance of 19 m to track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.14 mm/s RMS at building foundation, vibration mitigation will not be required.

Off-site stationary noise impacts can generally be minimized by judicious selection and placement of the equipment. Where necessary, noise screens and silencers can be placed into the design. It is recommended a stationary noise study be conducted once mechanical plans for the proposed building become available. This study would assess impacts of stationary noise from rooftop mechanical units serving the proposed building on surrounding noise-sensitive areas. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels fall below NPC-300 limits.

The surroundings comprise residential buildings which coincides with insignificant stationary noise emissions.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Dream to undertake a transportation noise and vibration study to satisfy concurrent Official Plan Amendment, Zoning By-law Amendment, and Site Plan Control application requirements for the proposed mixed-use residential development located at 665 Albert Street in Ottawa, Ontario (hereinafter referred to as "subject site" or "proposed development"). This report summarizes the methodology, results, and recommendations related to the assessment of exterior noise levels generated by local transportation.

The assessment was performed on the basis of theoretical noise calculation methods conforming to the City of Ottawa[1] and Ministry of the Environment, Conservation and Parks (MECP)[2] guidelines. Noise calculations were based on site plan drawings prepared by KPMB and Perkins & Will, in March 2022.

2. TERMS OF REFERENCE

The subject site is located at 665 Albert Street in Ottawa; situated at the northeast intersection of Albert Street and Booth Street. The proposed development comprises two nominally rectangular buildings rising 31 and 36 storeys to the east and west, respectively, above a five-storey podium. Throughout this report the buildings are referred to as the "East Tower" and the "West Tower". Each building includes a mechanical penthouse (MPH) level and a high-roof parapet sloping downwards to the west. Landscaped gathering spaces and walkways surround the buildings with the parkette (referred to as "Central Parkette"), between the East Tower and West Tower, and a park (referred to as "Wedge Park") to the north of the West Tower.

East Tower

Above two shared below-grade parking levels, the ground floor of the East Tower includes a residential main entrance and an office at the southeast corner, retail space to the south, a community bike shop and public long term and residential bike storage spaces at the northwest corner, childcare entrance to the east, and central loading space and elevator core. Access to below-grade parking is provided by a ramp

[1] City of Ottawa Environmental Noise Control Guidelines, January 2016

[2] Ontario Ministry of the Environment and Climate Change – Environmental Noise Guidelines, Publication NPC-300, Queens Printer for Ontario, Toronto, 2013

at the northeast corner of the East Tower via Empress Avenue Lane from Albert Street. The mezzanine is reserved for lockers and residential bike storage. Level 2 of the east building includes three residential units at the southeast corner, a central shared laundry room, and childcare spaces throughout the remainder of the level. This level is also served by a green roof to the north and a childcare outdoor play area to the southwest. Level 3 includes central lockers and a kids lounge, garden support and indoor amenity at the northwest corner, and residential units throughout the remainder of the level. Level 4 houses a central fitness room, lockers, garden support and indoor amenity, and residential units throughout the remainder of the level. Levels 3 and 4 are served by a community garden to the northwest and a green roof to the southwest. Level 5 includes a lounge, party room, and community kitchen. This level is also served by a community garden to the west, and an outdoor dining and lounge area to the east and southeast. Levels 5-36 comprise a nominally rectangular planform and Levels 6-36 are reserved for residential use.

West Tower

Above two shared below-grade parking levels, the ground floor of the West Tower includes a residential main entrance at the southeast corner, a public long-term bike storage to the south, retail space to the west, a community hub at the northeast corner, and a central elevator core. The mezzanine is reserved for lockers. Level 2 includes a central games room, lockers at the northeast corner, and residential units throughout the remainder of the level. This level is also served by an outdoor amenity terrace at the northeast corner. Level 3 includes central lockers, a kids lounge to the north, and residential units throughout the remainder of the level. An outdoor amenity terrace is situated to the north and a green roof is at the southeast corner of this level. Level 4 includes central lockers, co-working space to the north, and a fitness room to the south. This level is also served by an outdoor amenity terrace to the south and a green roof to the north. Level 5 includes a lounge, party room, and community kitchen. An outdoor dining and lounge area is situated to the northwest and a community garden is to the southwest. Levels 5-31 comprise a nominally rectangular planform and Levels 6-31 are reserved for residential use.

Surrounding Context

The major sources of roadway noise are Albert Street, Slater Street, and Booth Street. The LRT noise source is the O-Train Confederation Line that is north of the proposed development. Collector and arterial roadways located more than 100 m from the site are considered to be insignificant sources of roadway traffic noise as per ENCG. The site is surrounded by low rise residential buildings to the south and high-rise residential buildings to the north beyond the LRT. Figure 1 illustrates the site location with surrounding context.

3. OBJECTIVES

The principal objectives of this study are to (i) calculate the future noise levels on the study building produced by local roadway traffic, and (ii) determine whether exterior noise levels exceed the allowable limits specified by the MECP Noise Control Guidelines – NPC-300 as outlined in Section 4.2 of this report.

4. METHODOLOGY

4.1 Background

Noise can be defined as any obtrusive sound. It is created at a source, transmitted through a medium, such as air, and intercepted by a receiver. Noise may be characterized in terms of the power of the source or the sound pressure at a specific distance. While the power of a source is characteristic of that particular source, the sound pressure depends on the location of the receiver and the path that the noise takes to reach the receiver. Measurement of noise is based on the decibel unit, dBA, which is a logarithmic ratio referenced to a standard noise level (2×10^{-5} Pascals). The 'A' suffix refers to a weighting scale, which better represents how the noise is perceived by the human ear. With this scale, a doubling of power results in a 3 dBA increase in measured noise levels and is just perceptible to most people. An increase of 10 dBA is often perceived to be twice as loud.

4.2 Transportation Noise

4.2.1 Criteria for Transportation Traffic Noise

For vehicular traffic, the equivalent sound energy level, L_{eq}, provides a measure of the time varying noise levels, which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a period of time. For roadways, the L_{eq} is commonly calculated on the basis of a 16-hour (L_{eq16}) daytime (07:00-23:00) / 8-hour (L_{eq8}) nighttime (23:00-07:00) split to assess its impact on residential buildings. The NPC-300 guidelines specify that the recommended indoor noise limit ranges (that are relevant to this study) are 50, 45 and 40 dBA for retail space, living rooms, and sleeping quarters, respectively, as listed in Table 1. However, to account for deficiencies in building construction and to control peak noise, these levels should be targeted toward 47, 42, and 37 dBA.

TABLE 1: INDOOR SOUND LEVEL CRITERIA

Type of Space	Time Period	L_{eq} (dBA)
General offices, reception areas, **retail** stores, etc.	07:00 – 23:00	50
Living/dining/den areas of **residences**, hospitals, schools, nursing/retirement homes, day-care centres, theatres, places of worship, libraries, individual or semi-private offices, conference rooms, etc.	07:00 – 23:00	45
Sleeping quarters of hotels/motels	23:00 – 07:00	45
Sleeping quarters of **residences**, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	40

Predicted noise levels at the plane of window (POW) dictate the action required to achieve the recommended sound levels. An open window is considered to provide a 10 dBA reduction in noise, while a standard closed window is capable of providing a minimum 20 dBA noise reduction[3]. A closed window due to a ventilation requirement will bring noise levels down to achieve an acceptable indoor environment[4]. Therefore, where noise levels exceed 55 dBA daytime and 50 dBA nighttime, the ventilation for the building should consider the need for having windows and doors closed, which normally triggers the need for central air conditioning. Where noise levels exceed 65 dBA daytime and 60 dBA nighttime, building components will require higher levels of sound attenuation[5].

The sound level criterion for outdoor living areas (OLA) is 55 dBA, which applies during the daytime (07:00 to 23:00). When noise levels exceed 55 dBA, mitigation should be provided to reduce noise levels where technically and administratively feasible to acceptable levels at or below the criterion. When noise levels at the OLA exceed 60 dBA, mitigation must be provided.

[3] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[4] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8
[5] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3

4.2.2 Theoretical Transportation Noise Predictions

The impact of roadway traffic noise sources on the development was determined by computer modelling. Traffic noise source modelling is based on the software program *Predictor-Lima* which utilizes the United States Federal Highway Administration's Traffic Noise Model (TNM) to represent the roadway line sources. The TNM analysis model as been recognised by the Ministry of Transportation Ontario (MTO) as the recommend noise model for transportation projects (ref. Environmental Guide for Noise, dated August 2021[6]). The Ministry of Environment, Conservation and Parks has also adopted the TMN model as per their "Draft Guideline Noise Pollution Control Publications 306 (NPC-306)[7] This computer program can represent three-dimensional surfaces and first reflections of sound waves over a suitable spectrum for human hearing. A set of comparative calculations were performed in the free field environment for comparisons to the current Ontario traffic noise prediction model STAMSON. The STAMSON model is however older and requires each receptor to be calculated separately. STAMSON also does not accurately account for building reflections and multiple screening elements, and curved road geometry. Noise levels were found to be within an imperceptible level of 0-3 dBA of those predicted in Predictor, as seen in Table 4.

Roadway traffic noise calculations were performed by treating each roadway segment as a separate line source of noise, and by using existing building locations as noise barriers. In addition to the traffic volumes summarized in Table 2, theoretical noise predictions were based on the following parameters:

- Truck traffic on all roadways was taken to comprise 5% heavy trucks and 7% medium trucks, as per ENCG requirements for noise level predictions.
- The day/night split for all streets was taken to be 92%/8%, respectively.
- Ground surfaces were taken to be reflective due to the presence of hard ground (pavement).
- Topography was assumed to be flat/gentle slope.
- Noise receptors were strategically placed at 26 locations around the study area (see Figure 1).

[6] Ministry of Transportation Ontario, "*Environmental Guide for Noise*", August 2021, pg. 16
[7] Ministry of Environment, Conservation and Parks, Ontario, "Methods to determine Sound Levels Due to Road and Rail Traffic", Draft February 12, 2020

4.2.3 Roadway and LRT Traffic Volumes

The ENCG dictates that noise calculations should consider future sound levels based on a roadway's classification at the mature state of development. Therefore, roadway traffic volumes are based on the roadway classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[8] which provide additional details on future roadway expansions. Average Annual Daily Traffic (AADT) volumes are then based on data in Table B1 of the ENCG for each roadway classification.

The LRT traffic volumes were obtained by analyzing the arrival/departure information for nearby Pimisi station and projection the traffic volumes into the future assuming a growth rate of 2.5% over 10 years. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment.

TABLE 2: ROADWAY AND LRT TRAFFIC DATA

Segment	Traffic Data	Speed Limit (km/h)	Traffic Volumes
Booth Street (North of Albert)	4-Lane Urban Arterial-Divided (4-UAD)	50	**35,000**
Booth Street (South of Albert)	2-Lane Major Collector (2-UMCU)	40	**12,000**
Slater Street	2-Lane Urban Arterial (2-UAU)	50	**15,000**
Albert Street	4-Lane Urban Arterial-Undivided (4-UAU)	50	**30,000**
Albert Street (East of Slater/Albert split)	3-Lane Urban Arterial-Undivided (3-UAU)	50	**22,500**
O-Train Confederation Line	LRT	70	**485/76***

*Daytime/Nighttime traffic volumes

4.3 Indoor Noise Calculations

The difference between outdoor and indoor noise levels is the noise attenuation provided by the building envelope. According to common industry practice, complete walls and individual wall elements are rated according to the Sound Transmission Class (STC). The STC ratings of common residential walls built in conformance with the Ontario Building Code (2012) typically exceed STC 35, depending on exterior

[8] City of Ottawa Transportation Master Plan, November 2013

cladding, thickness and interior finish details. For example, brick veneer walls can achieve STC 50 or more. Standard commercially sided exterior metal stud walls have around STC 45. Standard good quality double-glazed non-operable windows can have STC ratings ranging from 25 to 40, depending on the window manufacturer, pane thickness and inter-pane spacing. As previously mentioned, the windows are the known weak point in a partition.

As per Section 4.2, when daytime noise levels (from road and rail sources) at the plane of the window exceed 65 dBA, calculations must be performed to evaluate the sound transmission quality of the building components to ensure acceptable indoor noise levels. The calculation procedure[9] considers:

- Window type and total area as a percentage of total room floor area
- Exterior wall type and total area as a percentage of the total room floor area
- Acoustic absorption characteristics of the room
- Outdoor noise source type and approach geometry
- Indoor sound level criteria, which varies according to the intended use of a space

Based on published research[10], exterior walls possess specific sound attenuation characteristics that are used as a basis for calculating the required STC ratings of windows in the same partition. Due to the limited information available at the time of the study, which was prepared for site plan approval, detailed floor layouts and building elevations have not been finalized; therefore, detailed STC calculations could not be performed at this time. As a guideline, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels).

4.4 Ground Vibration & Ground-borne Noise

Rail systems and heavy vehicles on roadways can produce perceptible levels of ground vibrations, especially when they are in close proximity to residential neighbourhoods or vibration-sensitive buildings. Similar to sound waves in air, vibrations in solids are generated at a source, propagated through a medium, and intercepted by a receiver. In the case of ground vibrations, the medium can be uniform, or more

[9] Building Practice Note: Controlling Sound Transmission into Buildings by J.D. Quirt, National Research Council of Canada, September 1985
[10] CMHC, Road & Rail Noise: Effects on Housing

often, a complex layering of soils and rock strata. Also, similar to sound waves in air, ground vibrations produce perceptible motions and regenerated noise known as 'ground-borne noise' when the vibrations encounter a hollow structure such as a building. Ground-borne noise and vibrations are generated when there is excitation of the ground, such as from a train or subway. Repetitive motion of the wheels on the track or rubber tires passing over an uneven surface causes vibration to propagate through the soil. When they encounter a building, vibrations pass along the structure of the building beginning at the foundation and propagating to all floors. Air inside the building excited by the vibrating walls and floors represents regenerated airborne noise. Characteristics of the soil and the building are imparted to the noise, thereby creating a unique noise signature.

Human response to ground vibrations is dependent on the magnitude of the vibrations, which is measured by the root mean square (RMS) of the movement of a particle on a surface. Typical units of ground vibration measures are millimeters per second (mm/s), or inch per second (in/s). Since vibrations can vary over a wide range, it is also convenient to represent them in decibel units, or dBV. In North America, it is common practice to use the reference value of one micro-inch per second (μin/s) to represent vibration levels for this purpose. The threshold level of human perception to vibrations is about 0.10 mm/s RMS or about 72 dBV. Although somewhat variable, the threshold of annoyance for continuous vibrations is 0.5 mm/s RMS (or 85 dBV), five times higher than the perception threshold, whereas the threshold for significant structural damage is 10 mm/s RMS (or 112 dBV), at least one hundred times higher than the perception threshold level.

4.4.1 Ground Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land uses next to transit corridors. Similar standards have been developed by the MECP. These standards indicate that the appropriate criteria for residences is 0.10 mm/s RMS for vibrations. For main line railways, a document titled *Guidelines for New Development in Proximity to Railway Operations*[11], indicates that vibration conditions should not exceed 0.14 mm/s RMS averaged over a one second time-period at the first floor and above of the proposed building. The Federal Transportation Authority (FTA) criterion was adopted as the appropriate standard for this study. As the main vibration source is due to

[11] Dialog and J.E. Coulter Associates Limited, prepared for The Federation of Canadian Municipalities and The Railway Association of Canada, May 2013

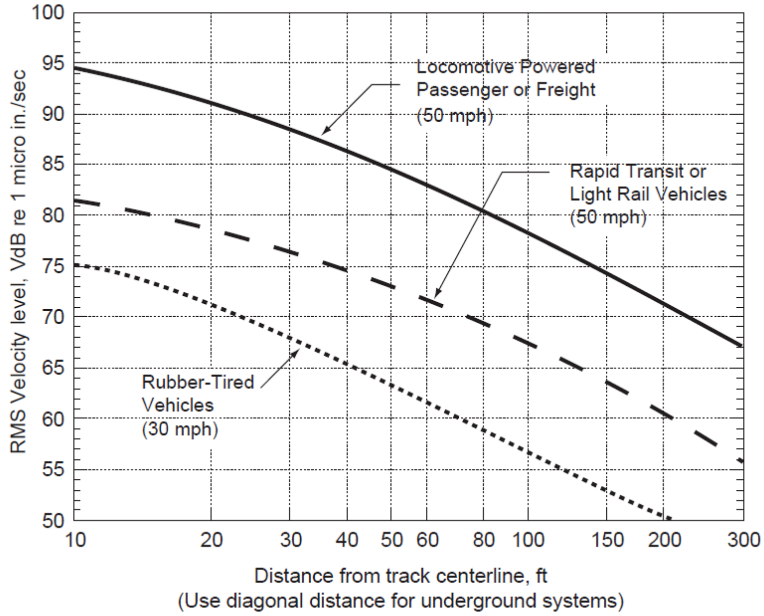
an LRT railway which has frequent events, the 0.14 mm/s RMS (75 dBV) vibration criteria and 40 dBA ground borne noise criteria were adopted for this study.

4.4.2 Theoretical Ground Vibration Prediction Procedure

Potential vibration impacts of the trains were predicted using the Federal Transit Authority's (FTA) Transit Noise and Vibration Impact Assessment[12] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure on the following page, are based on ground vibration measurements at various transit systems throughout North America. Vibration levels at points of reception are adjusted by various factors to incorporate known characteristics of the system being analyzed, such as operating speed of vehicle, conditions of the track, construction of the track and geology, as well as the structural type of the impacted building structures. The vibration impact on the building was determined using a set of curves for Locomotive Powered Passenger of Freight at a speed of 50 mph. Adjustment factors were considered based on the following information:

- The maximum operating speed of the trains is 70 km/h (44 mph)
- The distance between the development and the closest track is 19 m
- The vehicles are assumed to have soft primary suspensions
- Tracks are welded
- Soil conditions do not efficiently propagate vibrations
- The building's foundation is large masonry on piles

[12] C. E. Hanson; D. A. Towers; and L. D. Meister, Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006



FTA GENERALIZED CURVES OF VIBRATION LEVELS VERSUS DISTANCE (ADOPTED FROM FIGURE 10-1, FTA TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT)

5. TRANSPORTATION NOISE RESULTS

5.1 Transportation Noise Levels

The results of the roadway traffic noise calculations are summarized in Table 3 below.

TABLE 3: EXTERIOR NOISE LEVELS DUE TO TRANSPORTATION SOURCES

Receptor Number	Receptor Height Above Grade/ Roof (m)	Receptor Location	Transportation Noise Level (dBA)	
			Day	Night
R1	40	POW – West Tower – West Façade	65	58
R2	40	POW – West Tower – North Façade	61	54
R3	40	POW – West Tower – East Façade	62	54
R4	40	POW – West Tower – South Façade	66	59
R5	16.3	POW – West Podium – West Façade	68	60
R6	16.3	POW – West Podium – North Façade	66	58
R7	11.9	POW – West Podium – East Façade	64	56
R8	16.3	POW – West Podium – South Façade	68	61
R9	19.3	OLA – West Podium –5th Level	58	N/A*
R10	15.5	OLA – West Podium – 4th Level	59	N/A*
R11	11.9	OLA – West Podium – 3rd Level	62	N/A*
R12	8.2	OLA – West Podium – 2nd Level	61	N/A*
R13	40	POW – West Tower – East Façade	60	53
R14	40	POW – West Tower – South Façade	64	57
R15	40	POW – West Tower – West Façade	61	53
R16	40	POW – West Tower – North Façade	59	53
R17	16.3	POW – West Podium – East Façade	63	56
R18	16.3	POW – West Podium – Southeast Façade	67	59
R19	5.3	POW – West Podium – South Façade	65	58
R20	8.9	POW – West Podium –West Façade	61	54
R21	5.4	POW – West Podium – North Façade	62	57
R22	11.9	OLA – West Podium –3rd Level	59	N/A*
R23	15.5	OLA – West Podium – 4th Level	58	N/A*
R24	19.3	OLA – West Podium – 5th Level	57	N/A*
R25	8.2	OLA – West Podium – 2nd Level	59	N/A*
R26	19.3	OLA – West Podium – 5th Level	59	N/A*

The results of the current analysis indicate that noise levels will range between 57 and 68 dBA during the daytime period (07:00-23:00) and between 51 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e., 68 dBA) occurs along the south façade of the west podium, which is nearest and most exposed to Albert Street. A results comparison between the Predictor and Stamson calculations are shown in Table 4. The difference between calculation methods was within 0-3 dBA which is imperceptible to the human ear.

TABLE 4: RESULT CORRELATION WITH STAMSON

Receptor Number	Receptor Location	Receptor Height (m)	STAMSON 5.04 Noise Level (dBA)		PREDICTOR-LIMA Noise Level (dBA)	
			Day	Night	Day	Night
R8	POW – West Podium – South Façade	16.3	71	64	68	61
R18	POW – West Podium – Southeast Façade	16.3	70	63	67	59
R21	POW – West Podium – North Façade	5.4	62	57	62	57

5.2 Noise Control Measures

The noise levels predicted due to roadway traffic exceed the criteria listed in Section 4.2 for building components. As discussed in Section 4.3, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels). Detailed STC calculations will be required to be completed prior to building permit application for each unit type. The STC requirements for the windows are summarized below for various units within the development (see Figure 3), façades not listed do not require upgraded building components:

Bedroom Windows

(i) Bedroom windows on the east and south façades of the west podium, south façade of the west tower, and the south and north façades of the east podium will require a minimum STC of 31.

(ii) All other bedroom windows are to satisfy Ontario Building Code (OBC 2020) requirements.

Living Room Windows

(i) Living room windows on the east and south façades of the west podium, south façade of the west tower, and the south and north façades of the east podium will require a minimum STC of 26.

(ii) All other Living room windows are to satisfy Ontario Building Code (OBC 2020) requirements.

Retail Windows

(i) Retail windows on the east and south façades of the west podium, south façade of the west tower, and the south and north façades of the east podium will require a minimum STC of 21.

(ii) All other retail windows are to satisfy Ontario Building Code (OBC 2020) requirements.

Exterior Walls

(i) Exterior wall components on the north, south, and west façades will require a minimum STC of 45, which will be achieved with brick or precast cladding or an acoustical equivalent according to NRC test data[13].

The window STC requirements apply to windows, doors, spandrel panels, curtainwall, and window wall elements. If exterior wall components, such as stud walls, on these façades are used, it is recommended they have a minimum STC of 45, where a punch window and wall system is used. A review of window supplier literature indicates that the specified STC ratings can be achieved by a variety of window systems having a combination of glass thickness and inter-pane spacing. Several manufacturers and various combinations of window components, such as those proposed, will offer the necessary sound attenuation rating. It is the responsibility of the manufacturer to ensure that the specified window achieves the required STC. This can only be assured by using window configurations that have been certified by laboratory testing. The requirements for STC ratings assume that the remaining components of the building are constructed and installed according to the minimum standards of the Ontario Building Code. The specified STC requirements also apply to swinging and/or sliding patio doors.

The results of the calculations also indicate that the development will require central air conditioning, which will allow occupants to keep windows closed and maintain a comfortable living environment. In addition to ventilation requirements, Warning Clauses will also be required in all Lease, Purchase and Sale Agreements, as summarized in Section 6.

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[13] J.S. Bradley and J.A. Birta. Laboratory Measurements of the Sound Insulation of Building Façade Elements, National Research Council October 2000.

5.2.1 Barrier Investigation

Noise levels at certain OLA's exceed 60 dBA during the daytime period. This exceeds ENCG criteria and noise mitigation measures will be required to bring noise levels to equal to or below 55 dBA. It was found that an acoustic barrier will be required at the perimeter of the OLA's represented by receptors 11 and 12. A barrier with a minimum height of 1.8 m will result in noise levels that meet the criteria. A 1.1 m barrier can also be provided to these OLA's in which case noise levels will not be reduced to equal to or below 55 dBA, triggering the need for a Type B Warning Clause on all Lease, Purchase, and Sale Agreements. Where noise levels exceed 55 dBA mitigation is required where it is economically, administratively, and technically feasible. An acoustic barrier with a minimum height of 1.8 m is recommended at OLA's represented by receptor 22, and an acoustic barrier with a minimum height of 1.1 m at the perimeter of the OLA's represented by receptor 9, 10, 23, 24, 25, 26 will result in noise levels that meet the criteria. Should mitigation not be provided for these areas, a Type A Warning Clause will be required on all Lease, Purchase, and Sale Agreements. Details of the barrier investigation are shown in Figure 4 and presented in Table 5.

TABLE 5: RESULTS OF NOISE BARRIER INVESTIGATION

Receptor Reference	Height (m)	Location	Daytime Leq Noise Levels (dBA)		
			Without Barrier	1.1 m Barrier	1.8 m Barrier
R9	19.3	OLA – West Podium –5th Level	58	**55**	N/A
R10	15.5	OLA – West Podium – 4th Level	59	**54**	N/A
R11	11.9	OLA – West Podium – 3rd Level	62	58	**55**
R12	8.2	OLA – West Podium – 2nd Level	61	58	**54**
R22	11.9	OLA – East Podium –3rd Level	59	56	**54**
R23	15.5	OLA – East Podium – 4th Level	58	**55**	N/A
R24	19.3	OLA – East Podium – 5th Level	57	**53**	N/A
R25	8.2	OLA – East Podium – 2nd Level	59	**52**	N/A
R26	19.3	OLA – East Podium – 5th Level	59	**55**	N/A

The barrier should be of solid construction, contain no gaps and have a minimum surface density of 20kg/m^2. This surface density is commonly achieved with a concrete wall or glass panels with a minimum thickness of 8 mm. Noise levels at the OLA's can also be reduced by increasing the setback distance of the useable area from the building façade.

5.3 Ground Vibrations & Ground-Borne Noise Levels

Vibration caused by the O-Train Confederation Line LRT (See Appendix B Figure B1) were calculated between the building foundation and the track, shown in Figure 1. Vibration levels due to the nearest track were found to be 0.04 mm/s RMS (64 dBV) based on the FTA protocol and a conservative offset distance of 19 m to track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.14 mm/s RMS at building foundation, vibration mitigation will not be required.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 57 and 68 dBA during the daytime period (07:00-23:00) and between 51 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e., 68 dBA) occurs along the south façade of the west podium, which is nearest and most exposed to Albert Street. The noise levels predicted due to roadway and LRT traffic exceed the criteria listed in Section 4.2 for building components, therefore, building components which achieve a minimum of the STC ratings outlined in Section 5.2 will be required to control indoor sound levels, as seen in Figure 3. Due to the net-zero target for the development, it is expected that wall and window elements will achieve sufficient STC ratings.

Noise levels at certain OLA's exceed 60 dBA during the daytime period. This exceeds ENCG criteria and noise mitigation measures will be required to bring noise levels to equal to or below 55 dBA. It was found that an acoustic barrier will be required at the perimeter of the OLA's represented by receptors 11 and 12. A barrier with a minimum height of 1.8 m will result in noise levels that meet the criteria. A 1.1 m barrier can also be provided to these OLA's in which case noise levels will not be reduced to equal to or below 55 dBA, triggering the need for a Type B Warning Clause on all Lease, Purchase, and Sale Agreements. Where noise levels exceed 55 dBA mitigation is required where it is economically, administratively, and technically feasible. An acoustic barrier with a minimum height of 1.8 m is recommended at OLA's represented by receptor 22, and an acoustic barrier with a minimum height of 1.1 m at the perimeter of the OLA's represented by receptor 9, 10, 23, 24, 25, 26 will result in noise levels that meet the criteria. Should mitigation not be provided for these areas, a Type A Warning Clause will be required on all Lease, Purchase, and Sale Agreements. The barrier should be of solid construction, contain no gaps and have a minimum surface density of 20kg/m^2. The following information will be required by the City for review prior to installation of the barrier:

1. Shop drawings, signed and sealed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing the details of the acoustic barrier systems components, including material specifications.
2. Structural drawing(s), signed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing foundation details and specifying design criteria, climatic design loads, as well as applicable geotechnical data used in the design.
3. Layout plan, and wall elevations, showing proposed colours and patterns.

The following Warning Clauses may be required depending on the barrier combination selected:

Type A

> *"Purchasers/tenants are advised that sound levels due to increasing road traffic may occasionally interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the Municipality and the Ministry of the Environment."*

Type B

> *"Purchasers/tenants are advised that despite the inclusion of noise control features in the development and within the building units, sound levels due to increasing road traffic may on occasions interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the Municipality and the Ministry of the Environment."*

Results of the calculations also indicate that the east and west tower will require central air conditioning, or a similar ventilation system, which will allow occupants to keep windows closed and maintain a comfortable living environment at the occupant's discretion. The following Warning Clauses will also be required to be placed on all Lease, Purchase and Sale Agreements, as summarized below:

Type D

> *"This dwelling unit has been supplied with a central air conditioning system which will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."*

In addition, the Rail Construction Program Office recommends that the warning clause identified below to be included in all agreements of Purchase and Sale and Lease Agreements for the proposed development including those prepared prior to the registration of the Site Plan Agreement:

"The Owner hereby acknowledges and agrees:

i) *The proximity of the proposed development of the lands described in Schedule "A" hereto (the "Lands") to the City's existing and future transit operations, may result in noise, vibration, electromagnetic interferences, stray current transmissions, smoke and particulate matter (collectively referred to as "Interferences") to the development;*

ii) *It has been advised by the City to apply reasonable attenuation measures with respect to the level of the Interferences on and within the Lands and the proposed development; and*

iii) *The Owner acknowledges and agrees all agreements of purchase and sale and lease agreements, and all information on all plans and documents used for marketing purposes, for the whole or any part of the subject lands, shall contain the following clauses which shall also be incorporated in all transfer/deeds and leases from the Owner so that the clauses shall be covenants running with the lands for the benefit of the owner of the adjacent road:*

    'The Transferee/Lessee for himself, his heirs, executors, administrators, successors and assigns acknowledges being advised that a public transit light-rail rapid transit system (LRT) is proposed to be located in proximity to the subject lands, and the construction, operation and maintenance of the LRT may result in environmental impacts including,

but not limited to noise, vibration, electromagnetic interferences, stray current transmissions, smoke and particulate matter (collectively referred to as the Interferences) to the subject lands. The Transferee/Lessee acknowledges and agrees that despite the inclusion of noise control features within the subject lands, Interferences may continue to be of concern, occasionally interfering with some activities of the occupants on the subject lands.

The Transferee covenants with the Transferor and the Lessee covenants with the Lessor that the above clauses verbatim shall be included in all subsequent lease agreements, agreements of purchase and sale and deeds conveying the lands described herein, which covenants shall run with the lands and are for the benefit of the owner of the adjacent road.'"

Vibration caused by the O-Train Confederation Line LRT (See Appendix B Figure B1) were calculated between the building foundation and the track, shown in Figure 1. Vibration levels due to the nearest track were found to be 0.04 mm/s RMS (64 dBV) based on the FTA protocol and a conservative offset distance of 19 m to track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.14 mm/s RMS at building foundation, vibration mitigation will not be required.

Off-site stationary noise impacts can generally be minimized by judicious selection and placement of the equipment. Where necessary, noise screens and silencers can be placed into the design. It is recommended a stationary noise study be conducted once mechanical plans for the proposed building become available. This study would assess impacts of stationary noise from rooftop mechanical units serving the proposed building on surrounding noise-sensitive areas. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels fall below NPC-300 limits.

The surroundings include a mix of residential and retail buildings which coincides with insignificant stationary noise emissions.

This concludes our transportation noise assessment and report. If you have any questions or wish to discuss our findings, please advise us. In the interim, we thank you for the opportunity to be of service.

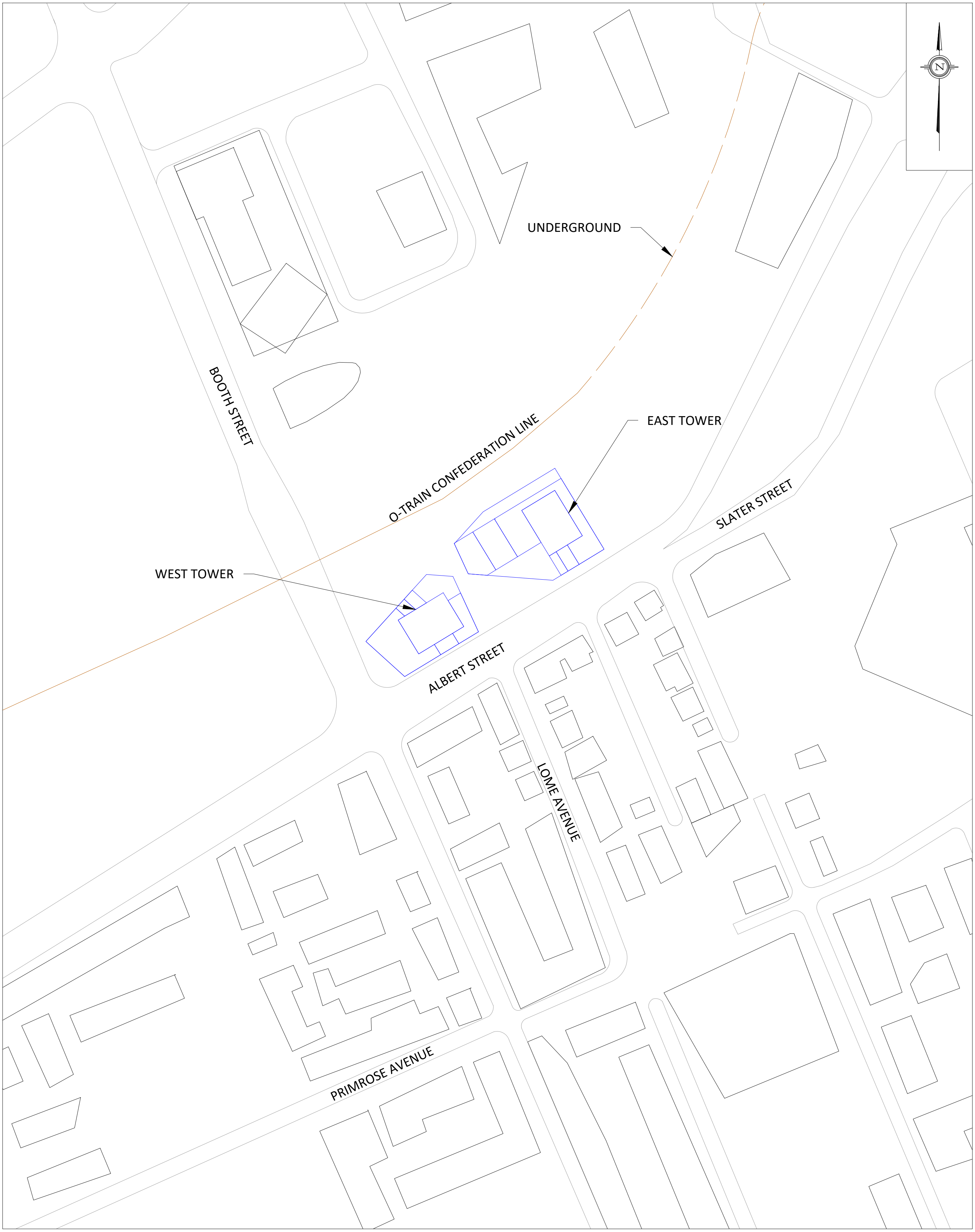
Sincerely,

Gradient Wind Engineering Inc.

Caleb Alexander, B.Eng.
Junior Environmental Scientist

Joshua Foster, P.Eng.
Lead Engineer

Gradient Wind File 22-064-Transportation Noise & Vibration



GRADIENTWIND
ENGINEERS & SCIENTISTS
127 WALGREEN ROAD , OTTAWA, ON
613 836 0934 • GRADIENTWIND.COM

PROJECT: 665 ALBERT STREET, OTTAWA
ROADWAY TRAFFIC NOISE ASSESSMENT

SCALE: 1:3000 (APPROX.)
DRAWING NO.: GW22-064-1
DATE: APRIL 5, 2022
DRAWN BY: C.A.

DESCRIPTION: FIGURE 1:
SITE PLAN AND SURROUNDING CONTEXT

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PROJECT	665 ALBERT STREET, OTTAWA ROADWAY TRAFFIC NOISE ASSESSMENT		
SCALE	1:3000 (APPROX.)	DRAWING NO.	GW22-064-2
DATE	APRIL 5, 2022	DRAWN BY	C.A.

DESCRIPTION

FIGURE 2:
RECEPTOR LOCATION

BEDROOM/LIVING ROOM/RETAIL WINDOWS: STC 31/26/21

GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 665 ALBERT STREET, OTTAWA ROADWAY TRAFFIC NOISE ASSESSMENT		DESCRIPTION: FIGURE 3: UPGRADED BUILDING COMPONENTS
	SCALE: 1:3000 (APPROX.)	DRAWING NO. GW22-064-3	
	DATE: APRIL 5, 2022	DRAWN BY: C.A.	

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PROJECT		DESCRIPTION
665 ALBERT STREET, OTTAWA ROADWAY TRAFFIC NOISE ASSESSMENT		FIGURE 4: NOISE BARRIERS
SCALE 1:3000 (APPROX.)	DRAWING NO. GW22-064-4	
DATE APRIL 5, 2022	DRAWN BY C.A.	

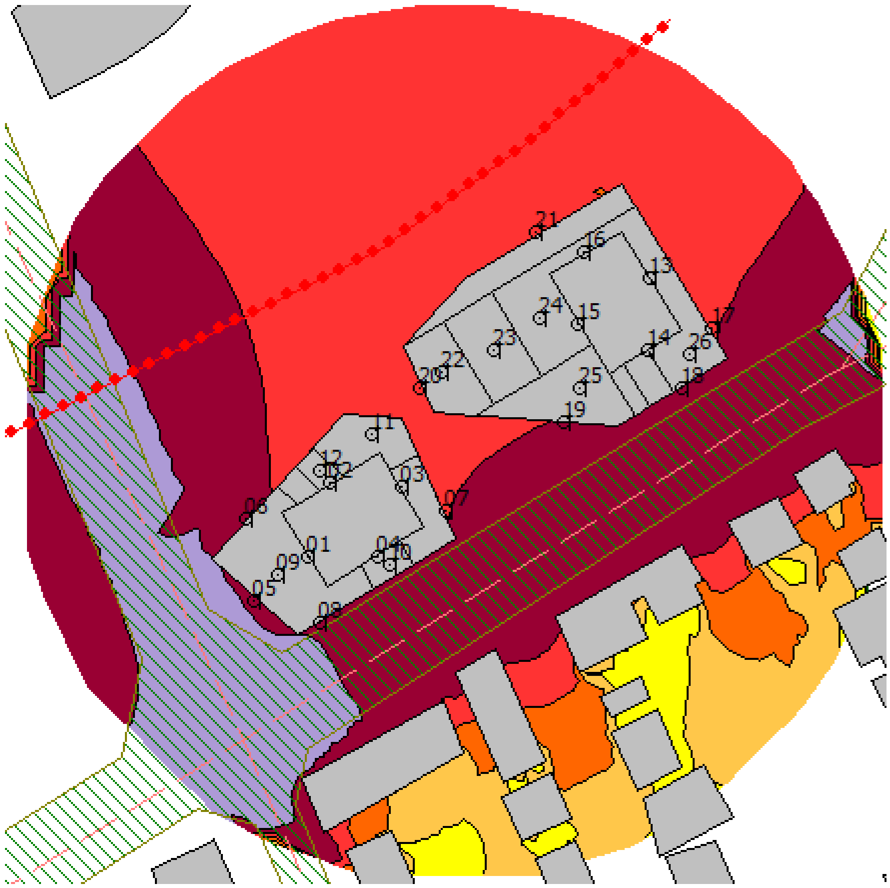
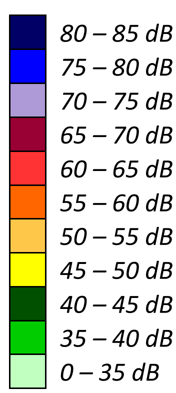


FIGURE 5: DAYTIME ROADWAY TRAFFIC NOISE LEVELS (30 METERS ABOVE GRADE)



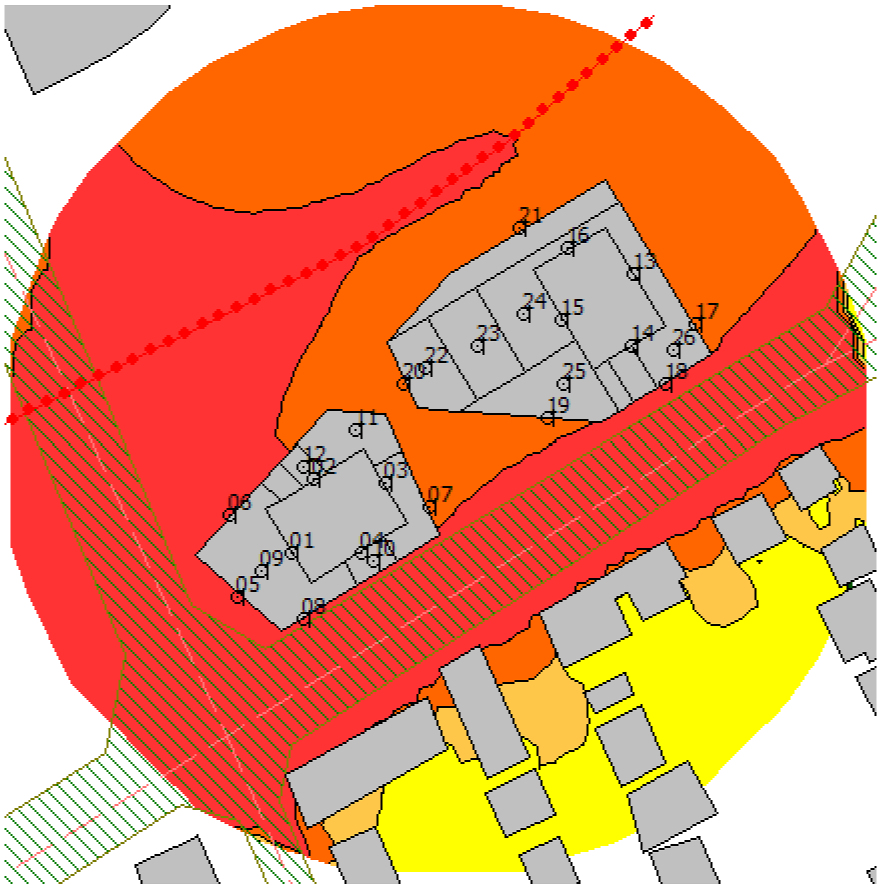
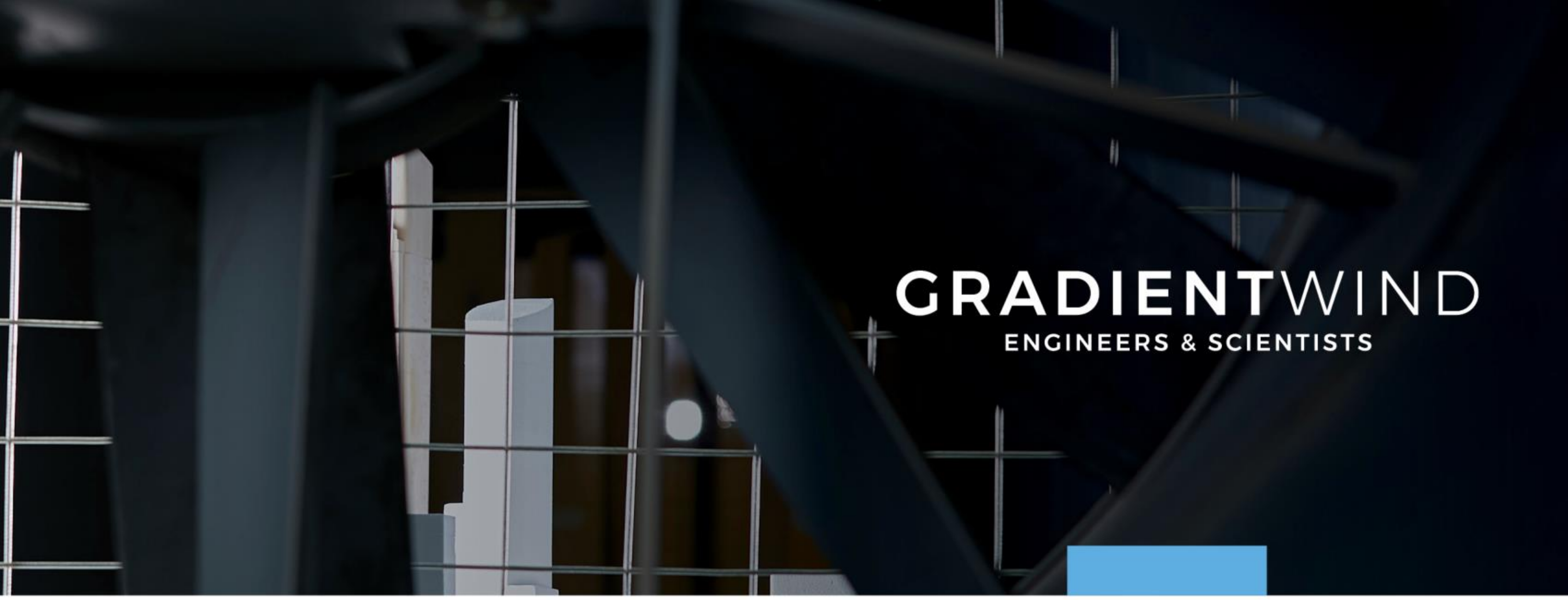


FIGURE 6: NIGHTTIME ROADWAY TRAFFIC NOISE LEVELS (30 METERS ABOVE GRADE)

- *80 – 85 dB*
- *75 – 80 dB*
- *70 – 75 dB*
- *65 – 70 dB*
- *60 – 65 dB*
- *55 – 60 dB*
- *50 – 55 dB*
- *45 – 50 dB*
- *40 – 45 dB*
- *35 – 40 dB*
- *0 – 35 dB*



APPENDIX A

STAMSON 5.04 – INPUT AND OUTPUT DATA

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

```
STAMSON 5.0        NORMAL REPORT        Date: 07-04-2022 17:38:55
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r8.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Albert (day/night)
------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Albert (day/night)
----------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  17.00 / 17.00  m
Receiver height           :  16.30 / 17.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Road data, segment # 2: Booth N (day/night)
-------------------------------------------
Car traffic volume  : 28336/2464  veh/TimePeriod  *
Medium truck volume :  2254/196   veh/TimePeriod  *
Heavy truck volume  :  1610/140   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  35000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 2: Booth N (day/night)
-----------------------------------------
Angle1   Angle2           :   7.00 deg   33.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  31.00 / 31.00  m
Receiver height           :  16.30 / 17.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Road data, segment # 3: Booth S (day/night)
-------------------------------------------
Car traffic volume  :  9715/845   veh/TimePeriod  *
Medium truck volume :   773/67    veh/TimePeriod  *
Heavy truck volume  :   552/48    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  12000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 3: Booth S (day/night)
-----------------------------------------
Angle1   Angle2           :  33.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  31.00 / 31.00  m
Receiver height           :  16.30 / 16.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  59.00 deg   Angle2 : 90.00 deg
Barrier height            :   9.00 m
Barrier receiver distance :  21.00 / 21.00  m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: Albert (day)
---------------------------------

Source height = 1.50 m

ROAD (0.00 + 70.95 + 0.00) = 70.95 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  71.49   0.00  -0.54   0.00   0.00   0.00   0.00  70.95
----------------------------------------------------------------------------

Segment Leq : 70.95 dBA


Results segment # 2: Booth N (day)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 60.60 + 0.00) = 60.60 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     7     33   0.00  72.16   0.00  -3.15  -8.40   0.00   0.00   0.00  60.60
----------------------------------------------------------------------------

Segment Leq : 60.60 dBA


Results segment # 3: Booth S (day)
----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
------------+--------------+--------------+---------------
       1.50 !        16.30 !         6.27 !          6.27

ROAD (55.96 + 48.49 + 0.00) = 56.67 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    33     59   0.00  67.51   0.00  -3.15  -8.40   0.00   0.00   0.00  55.96
----------------------------------------------------------------------------
    59     90   0.00  67.51   0.00  -3.15  -7.64   0.00   0.00  -8.23  48.49
----------------------------------------------------------------------------

Segment Leq : 56.67 dBA

Total Leq All Segments: 71.48 dBA
```

```
Results segment # 1: Albert (night)
-----------------------------------

Source height = 1.50 m

ROAD (0.00 + 63.35 + 0.00) = 63.35 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  63.89   0.00  -0.54   0.00   0.00   0.00   0.00  63.35
----------------------------------------------------------------------------

Segment Leq : 63.35 dBA


Results segment # 2: Booth N (night)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 53.01 + 0.00) = 53.01 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     7     33   0.00  64.56   0.00  -3.15  -8.40   0.00   0.00   0.00  53.01
----------------------------------------------------------------------------

Segment Leq : 53.01 dBA
```

```
Results segment # 3: Booth S (night)
------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
-------------+--------------+--------------+---------------
       1.50 !        16.30 !         6.27 !          6.27

ROAD (48.36 + 40.89 + 0.00) = 49.07 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
-----------------------------------------------------------------------------
    33     59   0.00  59.91   0.00  -3.15  -8.40   0.00   0.00   0.00  48.36
-----------------------------------------------------------------------------
    59     90   0.00  59.91   0.00  -3.15  -7.64   0.00   0.00  -8.23  40.89
-----------------------------------------------------------------------------

Segment Leq : 49.07 dBA

Total Leq All Segments: 63.88 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 71.48
                         (NIGHT): 63.88
```

```
STAMSON 5.0        NORMAL REPORT        Date: 07-04-2022 17:39:04
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r21.te               Time Period: Day/Night 16/8 hours
Description:


RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   485/76    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  20.00 / 20.00  m
Receiver height           :   7.40 / 5.40   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: LRT (day)
------------------------------

Source height = 0.50 m

RT/Custom (0.00 + 61.72 + 0.00) = 61.72 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  62.97  -1.25   0.00   0.00   0.00   0.00  61.72
----------------------------------------------------------------------

Segment Leq : 61.72 dBA

Total Leq All Segments: 61.72 dBA


Results segment # 1: LRT (night)
--------------------------------

Source height = 0.50 m

RT/Custom (0.00 + 56.68 + 0.00) = 56.68 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  57.93  -1.25   0.00   0.00   0.00   0.00  56.68
----------------------------------------------------------------------

Segment Leq : 56.68 dBA

Total Leq All Segments: 56.68 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 61.72
                         (NIGHT): 56.68
```

```
STAMSON 5.0        NORMAL REPORT        Date: 07-04-2022 17:39:17
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r18.te               Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Albert (day/night)
------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Albert (day/night)
----------------------------------------
Angle1   Angle2          : -88.00 deg   64.00 deg
Wood depth               :      0       (No woods.)
No of house rows         :      0 / 0
Surface                  :      2       (Reflective ground surface)
Receiver source distance :  17.00 / 17.00  m
Receiver height          :  16.30 / 17.30  m
Topography               :      1       (Flat/gentle slope; no barrier)
Reference angle          :   0.00
```

```
Road data, segment # 2: Albert 3 (day/night)
--------------------------------------------
Car traffic volume  : 18216/1584  veh/TimePeriod  *
Medium truck volume :  1449/126   veh/TimePeriod  *
Heavy truck volume  :  1035/90    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  22500
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 2: Albert 3 (day/night)
------------------------------------------
Angle1   Angle2           :  41.00 deg   65.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  32.00 / 32.00  m
Receiver height           :  17.30 / 17.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Road data, segment # 3: Slater (day/night)
------------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 3: Slater (day/night)
----------------------------------------
Angle1   Angle2           :  65.00 deg   78.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  43.00 / 43.00  m
Receiver height           :  17.30 / 17.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

Results segment # 1: Albert (day)

Source height = 1.50 m

ROAD (0.00 + 70.21 + 0.00) = 70.21 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-88	64	0.00	71.49	0.00	-0.54	-0.73	0.00	0.00	0.00	70.21

Segment Leq : 70.21 dBA

Results segment # 2: Albert 3 (day)

Source height = 1.50 m

ROAD (0.00 + 58.20 + 0.00) = 58.20 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
41	65	0.00	70.24	0.00	-3.29	-8.75	0.00	0.00	0.00	58.20

Segment Leq : 58.20 dBA

Results segment # 3: Slater (day)

Source height = 1.50 m

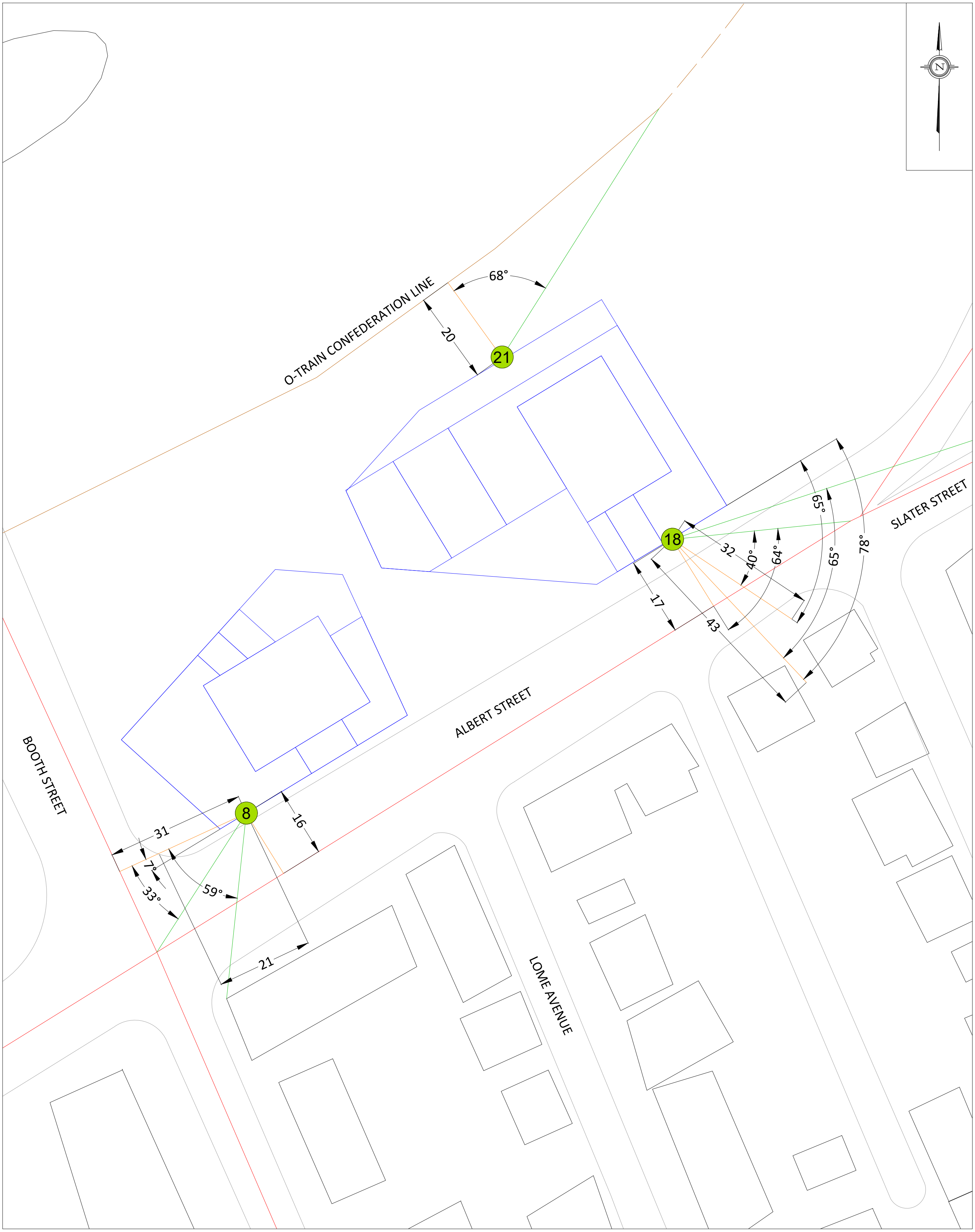
ROAD (0.00 + 52.49 + 0.00) = 52.49 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
65	78	0.00	68.48	0.00	-4.57	-11.41	0.00	0.00	0.00	52.49

Segment Leq : 52.49 dBA

Total Leq All Segments: 70.54 dBA

```
Results segment # 1: Albert (night)
-----------------------------------

Source height = 1.50 m

ROAD (0.00 + 62.62 + 0.00) = 62.62 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -88     64   0.00  63.89   0.00  -0.54  -0.73   0.00   0.00   0.00  62.62
----------------------------------------------------------------------------

Segment Leq : 62.62 dBA


Results segment # 2: Albert 3 (night)
-------------------------------------

Source height = 1.50 m

ROAD (0.00 + 50.60 + 0.00) = 50.60 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    41     65   0.00  62.64   0.00  -3.29  -8.75   0.00   0.00   0.00  50.60
----------------------------------------------------------------------------

Segment Leq : 50.60 dBA


Results segment # 3: Slater (night)
-----------------------------------

Source height = 1.50 m

ROAD (0.00 + 44.90 + 0.00) = 44.90 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    65     78   0.00  60.88   0.00  -4.57 -11.41   0.00   0.00   0.00  44.90
----------------------------------------------------------------------------

Segment Leq : 44.90 dBA

Total Leq All Segments: 62.95 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 70.54
                         (NIGHT): 62.95
```



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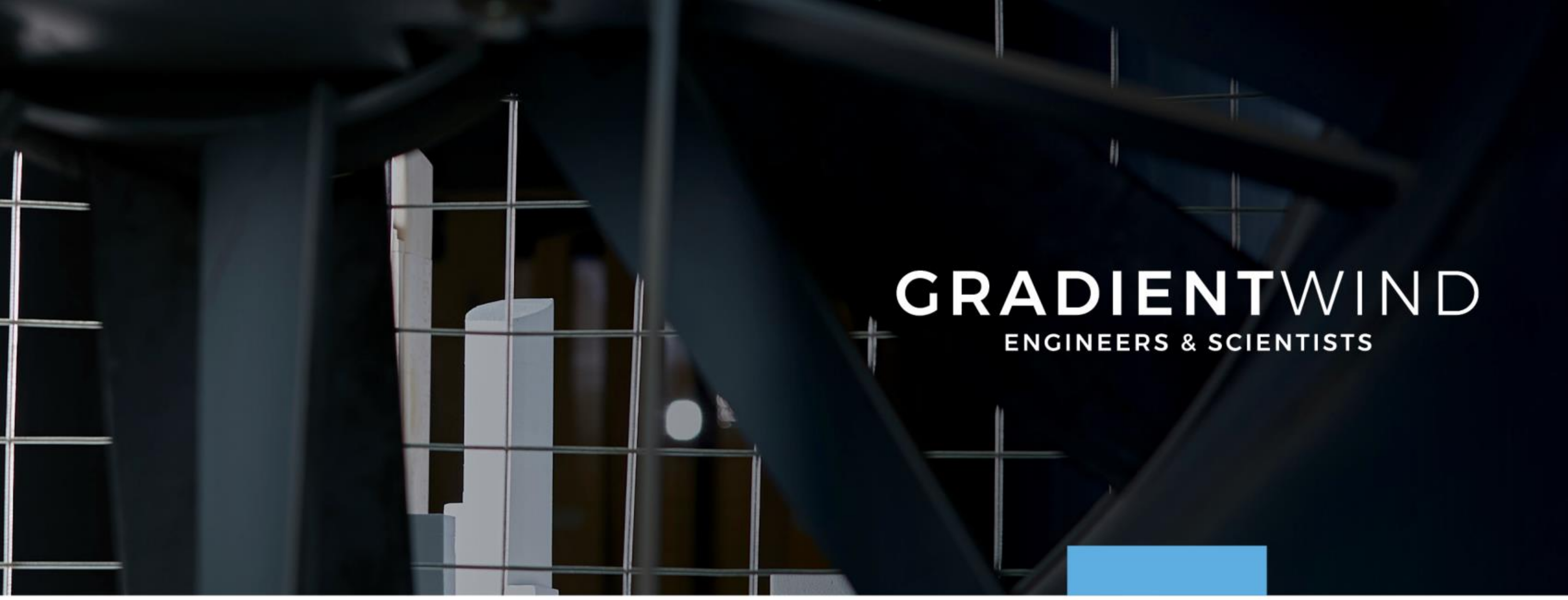
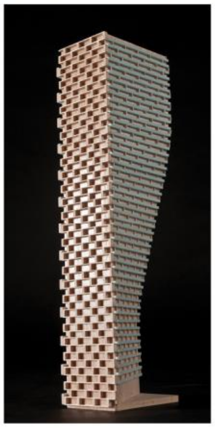
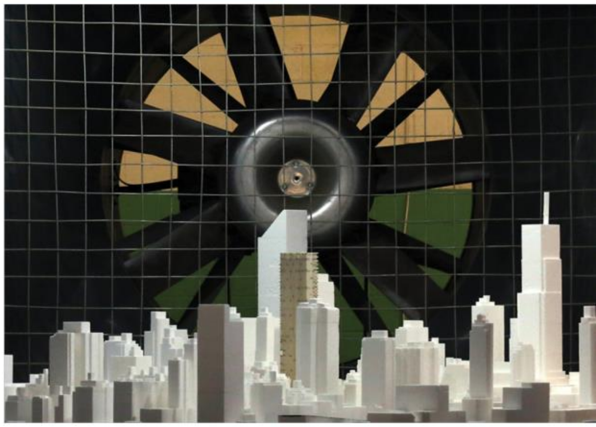
PROJECT: 665 ALBERT STREET, OTTAWA ROADWAY TRAFFIC NOISE ASSESSMENT		DESCRIPTION: FIGURE A1: STAMSON INPUT PARAMETERS
SCALE: 1:3000 (APPROX.)	DRAWING NO. GW22-064-A1	
DATE: APRIL 5, 2022	DRAWN BY: C.A.	







APPENDIX B

FTA VIBRATION CALCULATIONS

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GW22-064 08-Apr-22

Possible Vibration Impacts
Predicted using FTA General Assesment

Train Speed 70 km/h 44 mph

	Distance from C/L	
	(m)	(ft)
Subway	19.0	62.3

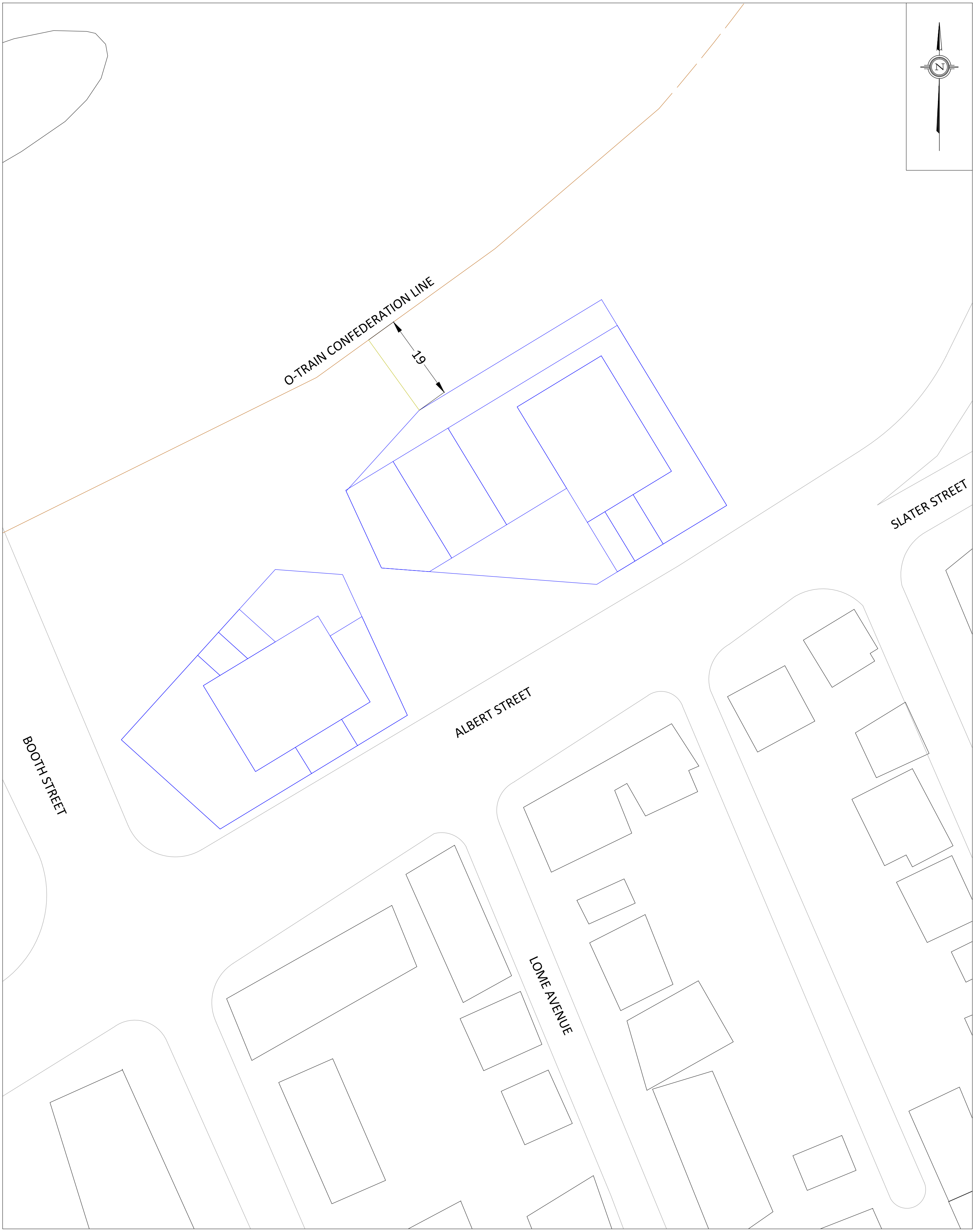
Vibration

From FTA Manual Fig 10-1		
Vibration Levels at distance from track	72	dBV re 1 micro in/sec
Adjustment Factors FTA Table 10-1		
Speed reference 50 mph	-1	Speed Limit of 70 km/h (44 mph)
Vehicle Parameters	0	Assume Soft primary suspension, Wheels run true
Track Condition	0	None
Track Treatments	0	None
Type of Transit Structure	-3	cut and cover
Efficient vibration Propagation	0	Propagation through rock
Vibration Levels at Fdn	68	
Coupling to Building Foundation	-10	Large masonry on piles
Floor to Floor Attenuation	0.0	Ground Floor Occupied
Amplification of Floor and Walls	6	
Total Vibration Level	64	dBV or 0.040 mm/s
Noise Level in dBA	29	dBA

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise

Factors Affecting Vibration Source				
Source Factor	**Adjustment to Propagation Curve**			**Comment**
		Reference Speed		
Speed	Vehicle Speed	50 mph	30 mph	Vibration level is approximately proportional to $20*\log(speed/speed_{ref})$. Sometimes the variation with speed has been observed to be as low as 10 to 15 $\log(speed/speed_{ref})$.
	60 mph	+1.6 dB	+6.0 dB	
	50 mph	0.0 dB	+4.4 dB	
	40 mph	-1.9 dB	+2.5 dB	
	30 mph	-4.4 dB	0.0 dB	
	20 mph	-8.0 dB	-3.5 dB	
Vehicle Parameters (not additive, apply greatest value only)				
Vehicle with stiff primary suspension	+8 dB			Transit vehicles with stiff primary suspensions have been shown to create high vibration levels. Include this adjustment when the primary suspension has a vertical resonance frequency greater than 15 Hz.
Resilient Wheels	0 dB			Resilient wheels do not generally affect ground-borne vibration except at frequencies greater than about 80 Hz.
Worn Wheels or Wheels with Flats	+10 dB			Wheel flats or wheels that are unevenly worn can cause high vibration levels. This can be prevented with wheel truing and slip-slide detectors to prevent the wheels from sliding on the track.
Track Conditions (not additive, apply greatest value only)				
Worn or Corrugated Track	+10 dB			If both the wheels and the track are worn, only one adjustment should be used. Corrugated track is a common problem. Mill scale on new rail can cause higher vibration levels until the rail has been in use for some time.
Special Trackwork	+10 dB			Wheel impacts at special trackwork will significantly increase vibration levels. The increase will be less at greater distances from the track.
Jointed Track or Uneven Road Surfaces	+5 dB			Jointed track can cause higher vibration levels than welded track. Rough roads or expansion joints are sources of increased vibration for rubber-tire transit.
Track Treatments (not additive, apply greatest value only)				
Floating Slab Trackbed	-15 dB			The reduction achieved with a floating slab trackbed is strongly dependent on the frequency characteristics of the vibration.
Ballast Mats	-10 dB			Actual reduction is strongly dependent on frequency of vibration.
High-Resilience Fasteners	-5 dB			Slab track with track fasteners that are very compliant in the vertical direction can reduce vibration at frequencies greater than 40 Hz.

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise (Continued)		
Factors Affecting Vibration Path		
Path Factor	**Adjustment to Propagation Curve**	**Comment**
Resiliently Supported Ties	-10 dB	Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.
Track Configuration (not additive, apply greatest value only)		
Type of Transit Structure	Relative to at-grade tie & ballast: Elevated structure -10 dB Open cut 0 dB	The general rule is the heavier the structure, the lower the vibration levels. Putting the track in cut may reduce the vibration levels slightly. Rock-based subways generate higher-frequency vibration.
	Relative to bored subway tunnel in soil: Station -5 dB Cut and cover -3 dB Rock-based - 15 dB	
Ground-borne Propagation Effects		
Geologic conditions that promote efficient vibration propagation	Efficient propagation in soil +10 dB	Refer to the text for guidance on identifying areas where efficient propagation is possible.
	Propagation in rock layer **Dist.** / **Adjust.** 50 ft +2 dB 100 ft +4 dB 150 ft +6 dB 200 ft +9 dB	The positive adjustment accounts for the lower attenuation of vibration in rock compared to soil. It is generally more difficult to excite vibrations in rock than in soil at the source.
Coupling to building foundation	Wood Frame Houses -5 dB 1-2 Story Masonry -7 dB 3-4 Story Masonry -10 dB Large Masonry on Piles -10 dB Large Masonry on Spread Footings -13 dB Foundation in Rock 0 dB	The general rule is the heavier the building construction, the greater the coupling loss.
Factors Affecting Vibration Receiver		
Receiver Factor	**Adjustment to Propagation Curve**	**Comment**
Floor-to-floor attenuation	1 to 5 floors above grade: -2 dB/floor 5 to 10 floors above grade: -1 dB/floor	This factor accounts for dispersion and attenuation of the vibration energy as it propagates through a building.
Amplification due to resonances of floors, walls, and ceilings	+6 dB	The actual amplification will vary greatly depending on the type of construction. The amplification is lower near the wall/floor and wall/ceiling intersections.
Conversion to Ground-borne Noise		
Noise Level in dBA	Peak frequency of ground vibration: Low frequency (<30 Hz): -50 dB Typical (peak 30 to 60 Hz): -35 dB High frequency (>60 Hz): -20 dB	Use these adjustments to estimate the A-weighted sound level given the average vibration velocity level of the room surfaces. See text for guidelines for selecting low, typical or high frequency characteristics. Use the high-frequency adjustment for subway tunnels in rock or if the dominant frequencies of the vibration spectrum are known to be 60 Hz or greater.



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PROJECT	665 ALBERT STREET, OTTAWA ROADWAY TRAFFIC NOISE ASSESSMENT		
SCALE	1:3000 (APPROX.)	DRAWING NO.	GW22-064-B1
DATE	APRIL 5, 2022	DRAWN BY	C.A.

DESCRIPTION

FIGURE B1:
FTA VIBRATION PARAMETERS