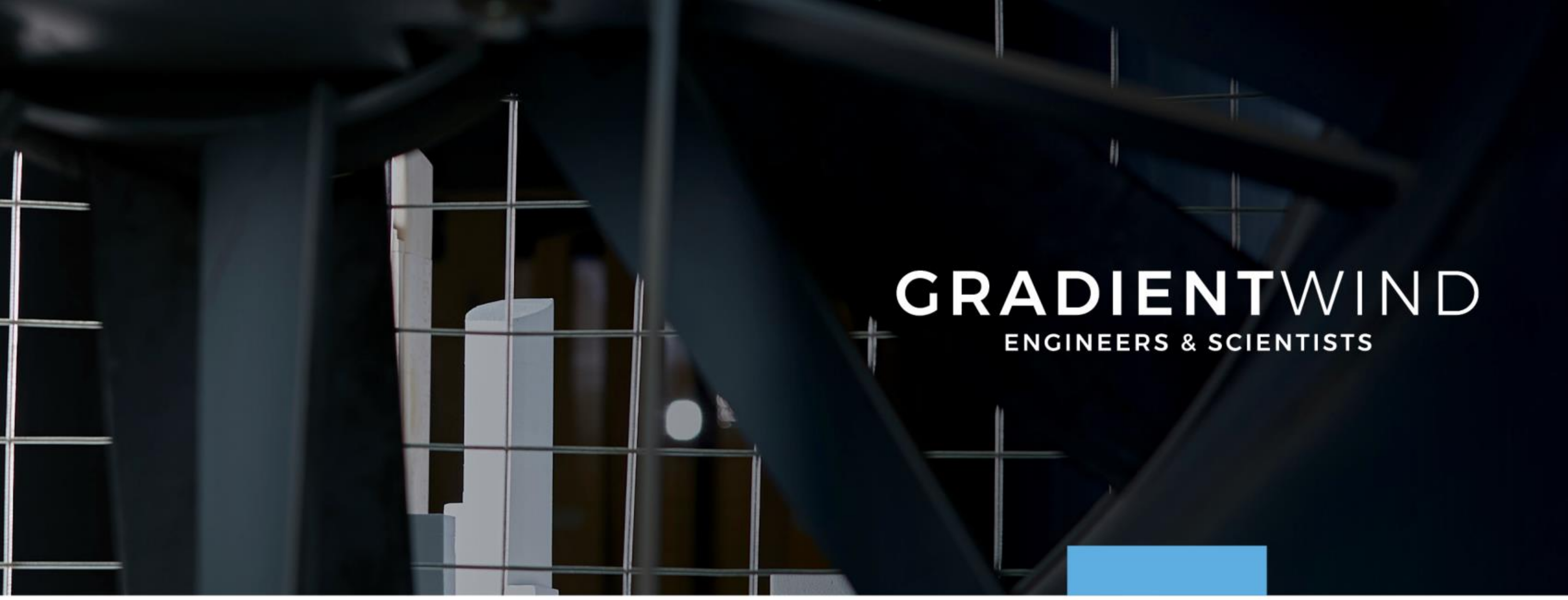
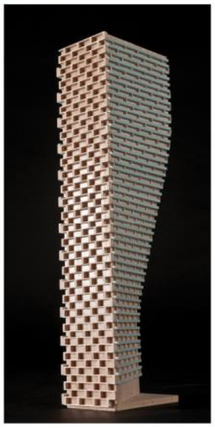
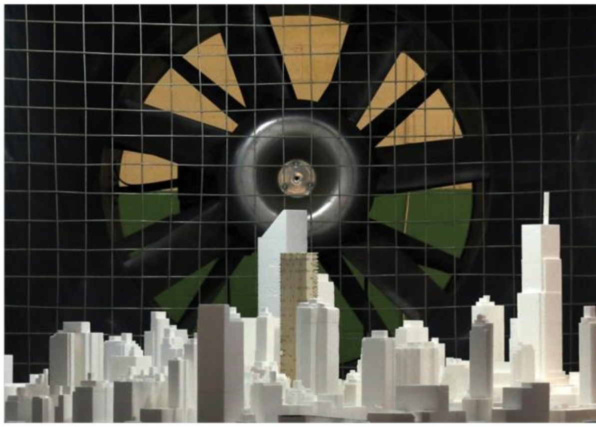


ENVIROMENTAL NOISE & VIBRATION ASSESSMENT

930 Carling Avenue and
520 Preston Street
Ottawa, Ontario

Report: 20-049-Noise & Vibration





May 7, 2021

PREPARED FOR
The Ottawa Hospital
1053 Carling Avenue
Ottawa, ON K1Y 4E9

PREPARED BY
Michael Lafortune, C.E.T., Environmental Scientist
Joshua Foster, P.Eng., Principal

EXECUTIVE SUMMARY

This report describes an environmental noise & vibration assessment to satisfy the requirements for a Site Plan Control (SPC) application submission for a Master Site Plan for the proposed New Civic Development serving The Ottawa Hospital (TOH) located at a portion of 930 Carling Avenue and 520 Preston Street in Ottawa, Ontario (hereinafter referred to as "subject site"). The current plan comprises the hospital building with two towers connected by a common podium on the west side of the site, an above ground parking garage on the east side of the site, and future research building and future office/mixed-use towers along Carling Avenue on the north side of the site. The major sources of transportation noise in the area are Carling Avenue, Prince of Wales Drive and the Trillium Line LRT. The Trillium Line LRT is also a source of minor ground vibrations and ground-borne noise, mainly due to steel wheels over rail. The study area is limited to the parcels illustrated in Figure 1 with the current site plan and surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the Ministry of the Environment, Conservation and Parks (MECP) and City of Ottawa requirements; (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 Gradient Wind's past experience with the Trillium Line LRT; and (iv) site plan drawings prepared by HDR in March 2021.

The results of the current analysis indicate that noise levels will range between 57 and 69 dBA during the daytime period (07:00-23:00) and between 49 and 62 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs along the north façades of the future buildings along Carling Avenue, which is nearest and most exposed to Carling Avenue. Figures 5 and 6 illustrate noise contours throughout the site at 20 m above grade for daytime and nighttime conditions, respectively.

The noise levels predicted due to roadway and LRT traffic exceed the criteria listed in the ENCG for upgraded building components for the future buildings along Carling Avenue. A detailed review of the window and wall assemblies should be performed by a qualified engineer with expertise in acoustics during the detailed design stage of the buildings.

Results of the calculations also indicate that the future research building and office/mixed-use towers are expected to require central air conditioning, or a similar ventilation system, which will allow occupants to keep windows closed and maintain a comfortable living environment. The hospital building is sufficiently setback from the roadways and is expected to require forced air heating, with provision for air conditioning. However, due to the institutional use of the proposed building, central air condition is expected to be provided. A detailed roadway traffic noise study will be required at the time of SPA for the future buildings/extensions to determine specific noise control measures.

Noise levels at the spiritual care garden associated with the hospital building were found to approach 57 dBA during the daytime period, which marginally exceeds the ENCG objective sound limit though is below 60 dBA were mitigation becomes mandatory. It is recommended that Outdoor Living Areas (OLAa) be positioned away from the roadways and use building massing to provide blockage from the roadways to reduce noise levels. The park on top of the parking garage and the urban square are designed for more active recreation and engagement with the public realm, and are therefore are not considered to be OLAs.

Based on an offset distance of 19 metres between the Trillium Line LRT and the nearest building foundation (Tower B), the estimated vibration level at the nearest point of reception is expected to be 0.025 mm/s RMS (60 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required. The hospital building is beyond the minimum 75 m setback from the Trillium Line LRT. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dB. The future parking garage does not contain sensitive space, and therefore is not considered for noise and vibration impacts. The expected vibrations from the rail line would not impact the structure of the parking garage, which has much higher tolerances then human perception.

With regards to stationary noise impacts, a review of satellite imagery revealed no significant source of off-site stationary noise impacting the study site. The hospital building mechanical equipment is located below grade to the west of the main building, including an outdoor mechanical area for cooling towers and a generator airwell at grade. A detailed stationary noise study will be performed once mechanical plans for the proposed building become available to determine noise impacts from mechanical equipment on surrounding noise-sensitive areas including the hospital building itself. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels fall below ENCG limits. Noise control measures may include silencers installed to the equipment, selection of quieter equipment, and/or noise screens blocking line-of-sight with noise-sensitive areas.

To mitigate interior noise impacts from the proposed helicopter landing pad, upgraded building components are recommended for façades with exposure to landing/takeoff operations. Using an outdoor ambient sound level of 74 dBA from helicopter landing/takeoff operations along these façades, based on Gradient Wind's experience with other hospital projects, a minimum Sound Transmission Class (STC) 34 is recommended for patient room and office windows (see Figure 3). This will ensure the indoor sound level limit, as specified by the City of Ottawa Environmental Noise Control Guidelines, is achieved.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by The Ottawa Hospital, through a sub-consultant agreement with Parsons Inc., to undertake an environmental noise & vibration assessment to satisfy the requirements for a Site Plan Control (SPC) application submission for a Master Site Plan for the proposed New Civic Development serving The Ottawa Hospital (TOH) located at a portion of 930 Carling Avenue and 520 Preston Street in Ottawa, Ontario (hereinafter referred to as "subject site"). This report summarizes the methodology, results, and recommendations related to the assessment of exterior noise and vibration levels generated by local roadway and LRT traffic.

Our work is based on 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 HDR in March 2021, with future traffic volumes corresponding to the City of Ottawa's Official Plan (OP) roadway classifications and Gradient Wind's past experience with the Trillium Line LRT.

2. TERMS OF REFERENCE

TOH is undertaking a master plan process for establishing a new hospital campus by replacing the aging Civic Campus located at 1053 Carling Avenue with a New Civic Development. The new Ottawa Hospital site is a diverse area located at the southwest intersection of Carling Avenue and Preston Street, on lands partially located within the Central Experimental Farm property. The new site will have immediate access to future Trillium Line, Dows Lake, Prince of Wales Drive and Maple Drive. The development of the new hospital campus,the related educational research centre and other ancillary uses aims to demonstrate architectural and urban design excellence by respecting the historical, cultural and physical environment of the site. The current plan comprises the hospital building with two towers connected by a common podium on the west side of the site, an above ground parking garage on the east side of the site, and future research building and future hospital ancillary use towers along Carling Avenue on the north side of the site. There are also two areas defined as future extensions to the hospital building on the north side

[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

of the hospital and a future relocated Heart Institute on south side of the south hospital tower. The study area is limited to the parcels illustrated in Figure 1 with the current site plan and surrounding context.

The major sources of transportation noise in the area are Carling Avenue, Prince of Wales Drive and the Trillium Line LRT. The Trillium Line LRT is also a source of minor ground vibrations and ground-borne noise, mainly due to steel wheels over rail. The future parking garage does not contain sensitive space, and therefore is not considered for noise and vibration impacts. Vibrations from the LRT will not adversely impact the foundations or structure of the parking garage.

3. OBJECTIVES

The principal objectives of this study are to (i) calculate the future noise levels on the study buildings produced by local roadway and LRT traffic, and (ii) ensure that interior noise levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines 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 Roadway and LRT Traffic Noise

4.2.1 Criteria for Roadway and LRT Traffic Noise

For surface roadway traffic noise, 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 noise-sensitive buildings. The City of Ottawa's Environmental Noise Control Guidelines (ENCG) recommended indoor noise limit range (that is relevant to this study) is highlighted in Table 1 for various uses throughout the site.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD) [3]

Type of Space	Time Period	Leq (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

* - Including temporary resident stay and residential care facilities

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[4]. A closed window due to a ventilation requirement will bring noise levels down to achieve an acceptable indoor environment[5]. 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 triggers the need

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[5] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8

for forced air heating with provision for central air conditioning. Where noise levels exceed 65 dBA daytime and 60 dBA nighttime, air conditioning will be required and building components will require higher levels of sound attenuation[6].

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

4.2.2 Theoretical Roadway and LRT Noise Predictions

The impact of transportation noise sources on the development was determined by computer modelling. Transportation 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. 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 for comparisons to the current Ontario traffic noise prediction model STAMSON. The STAMSON model is however an older software 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-Lima*. A total of 11 receptor locations were identified around the site, as illustrated in Figure 2.

Roadway traffic noise calculations were performed by treating each roadway segment as separate line sources of noise. 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 or absorptive, based on the presence of hard (paved) ground or soft (landscaped) ground between source and receptor.

[6] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3

- Topography was accounted for in the Predictor and STAMSON models. The Trillium Line LRT is approximately 9 m below site grade and is located in a trench acting as a noise barrier. The proposed future parking garage will be built over the tracks, thus further containing noise.
- Receptor height was taken to be 20 metres above grade for plane of window receptors, and 1.5 m above grade for outdoor living area receptors.
- Receptor distances and exposure angles are illustrated in Figure 4 for comparative STAMSON calculations, and Appendix A contains the STAMSON input/output data.

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, traffic volumes are based on the roadway classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[7] 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. Future Trillium Line LRT traffic volumes are based on Gradient Wind's experience with the Trillium Line extension project. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment. Due to their low volume, local streets are not considered significant sources. Due to the emergency nature of ambulance, fire, and police cars, these are not considered sources of noise under the ENCG.

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway Traffic Data	Speed Limit (km/h)	Traffic Volumes
Carling Avenue	6-Lane Urban Arterial (6-UAD)	60	**50,000**
Prince of Wales Drive	2-Lane Urban Arterial (2-UAU)	60	**15,000**
Preston Street	2-Lane Urban Arterial (2-UAU)	50	**15,000**
Sherwood Drive	2-Lane Urban Collector (2-UCU)	50	**8,000**
Trillium Line LRT	LRT	70	**192/24***

* - Daytime/nighttime volumes

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

4.3 Ground Vibration and Ground-borne Noise

Transit 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 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. 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.

4.3.1 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 a partnership between the MECP and the Toronto Transit Commission[8]. These standards indicate that the appropriate criteria for residential buildings is 0.10 mm/s RMS for vibrations. For main line railways, a document titled Guidelines for New Development in Proximity to Railway Operations[9], 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. As the main vibration source is due to the LRT lines, which will have frequent events, the 0.10 mm/s RMS (72 dBV) vibration criteria and 35 dBA ground borne noise criteria were adopted for this study.

4.3.2 Theoretical Ground Vibration Prediction Procedure

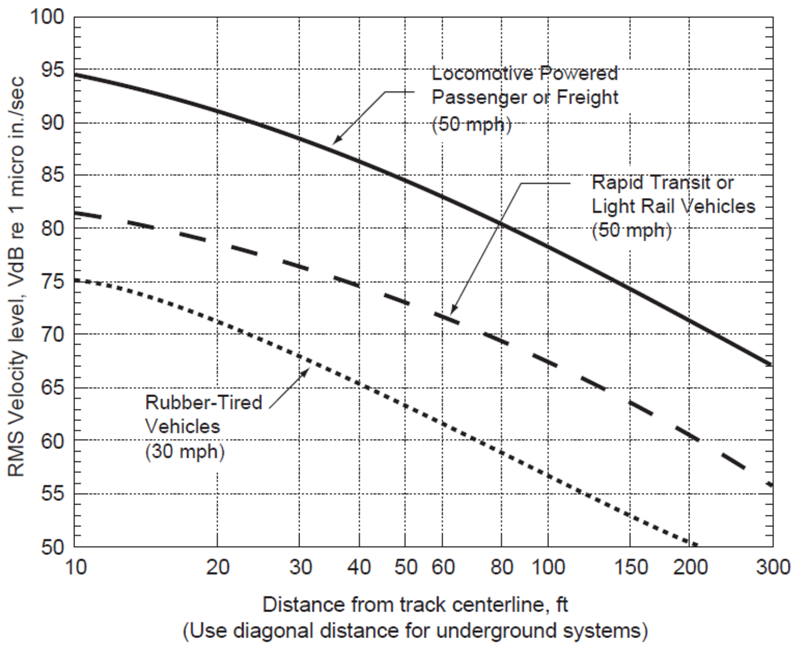
Potential vibration impacts of the future Trillium Line LRT were predicted using the FTA's Transit Noise and Vibration Impact Assessment[10] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure below, 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. Based on the setback distance of the closest building, initial vibration levels were deduced from a curve for light rail trains at 50 miles per hour (mph) and applying an adjustment factor of -1.3 dBV to account for an operational speed of 43.4 mph (70 km/h). The track was assumed to be jointed with no welds. Details of the vibration calculations are presented in Appendix B.

---

[8] MECP/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop, June 16, 1993

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

[10] 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. RESULTS

5.1 Roadway and LRT Traffic Noise Levels

The results of the roadway and LRT traffic noise calculations are summarized in Table 3 below. Table 4 summarized the comparative calculations performed in STAMSON for select receptors. Figures 5 and 6 illustrate noise contours throughout the site at 20 m above grade for daytime and nighttime conditions, respectively.

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROADWAY AND LRT TRAFFIC

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	Noise Level (dBA)	
			Day	Night
1	20	POW – Hospital Building – Northeast Façade	62	54
2	20	POW – Hospital Building – Northwest Façade	62	54
3	20	POW – Hospital Building – Northeast Façade	57	50
4	20	POW – Hospital Building – Southeast Façade	59	51
5	1.5	POW – Hospital Building – Spiritual Care Garden	57	49
6	20	POW – Research Building – West Façade	69	62
7	20	POW – Research Building – North Façade	66	58
8	20	POW – Tower A – North Façade	69	61
9	20	POW – Tower B – North Façade	69	61
10	20	POW – Tower C – East Façade	67	59
11	20	POW – Tower C – South Façade	61	53

TABLE 4: COMPARITIVE CALCULATION SUMMARY

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	Predictor Noise Level (dBA)		STAMSON Noise Level (dBA)	
			Day	Night	Day	Night
2	20	POW – Hospital Building – Northwest Façade	62	54	64	57
4	20	POW – Hospital Building – Southeast Façade	59	51	60	52
8	20	POW – Tower A – North Façade	69	61	72	64

6. DISCUSSION AND CONCLUSIONS

The results of the current analysis indicate that noise levels will range between 57 and 69 dBA during the daytime period (07:00-23:00) and between 49 and 62 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs along the north façades of the future buildings along Carling Avenue, which is nearest and most exposed to Carling Avenue. Figures 5 and 6 illustrate noise contours throughout the site at 20 m above grade for daytime and nighttime conditions, respectively.

The noise levels predicted due to roadway and LRT traffic exceed the criteria listed in the ENCG for upgraded building components for the future buildings along Carling Avenue. A detailed review of the window and wall assemblies should be performed by a qualified engineer with expertise in acoustics during the detailed design stage of the buildings.

Results of the calculations also indicate that the future research building and office/mixed-use towers are expected to require central air conditioning, or a similar ventilation system, which will allow occupants to keep windows closed and maintain a comfortable living environment. The hospital building is sufficiently setback from the roadways and is expected to require forced air heating, with provision for air conditioning. However, due to the institutional use of the proposed building, central air condition is expected to be provided. A detailed roadway traffic noise study will be required at the time of SPA for the future buildings/extensions to determine specific noise control measures.

Noise levels at the spiritual care garden associated with the hospital building were found to approach 57 dBA during the daytime period, which marginally exceeds the ENCG objective sound limit though is below 60 dBA were mitigation becomes mandatory. It is recommended that Outdoor Living Areas (OLAa) be positioned away from the roadways and use building massing to provide blockage from the roadways to reduce noise levels. The park on top of the parking garage and the urban square are designed for more active recreation and engagement with the public realm, and are therefore are not considered to be OLAs.

Based on an offset distance of 19 metres between the Trillium Line LRT and the nearest building foundation (Tower B), the estimated vibration level at the nearest point of reception is expected to be 0.025 mm/s RMS (60 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix

B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required. The hospital building is beyond the minimum 75 m setback from the Trillium Line LRT.

According to the United States Federal Transit Authority's vibration assessment protocol, ground borne noise can be estimated by subtracting 35 dB from the velocity vibration level in dBV. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dB. The future parking garage does not contain sensitive space, and therefore is not considered for noise and vibration impacts. The expected vibrations from the rail line would not impact the structure of the parking garage, which has much higher tolerances then human perception.

With regards to stationary noise impacts, a review of satellite imagery revealed no significant source of off-site stationary noise impacting the study site. The hospital building mechanical equipment is located below grade to the west of the building, including an outdoor mechanical area for cooling towers and a generator airwell at grade. A detailed stationary noise study will be performed once mechanical plans for the proposed building become available to determine noise impacts from mechanical equipment on surrounding noise-sensitive areas including the hospital building itself. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels fall below ENCG limits. Noise control measures may include silencers installed to the equipment, selection of quieter equipment, and/or noise screens blocking line-of-sight with noise-sensitive areas.

To mitigate interior noise impacts from the proposed helicopter landing pad, upgraded building components are recommended for façades with exposure to landing/takeoff operations. Using an outdoor ambient sound level of 74 dBA from helicopter landing/takeoff operations along these façades, based on Gradient Wind's experience with other hospital projects, a minimum Sound Transmission Class (STC) 34 is recommended for patient room and office windows (see Figure 3). This will ensure the indoor sound level limit, as specified by the City of Ottawa Environmental Noise Control Guidelines, is achieved.

This concludes our traffic 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.

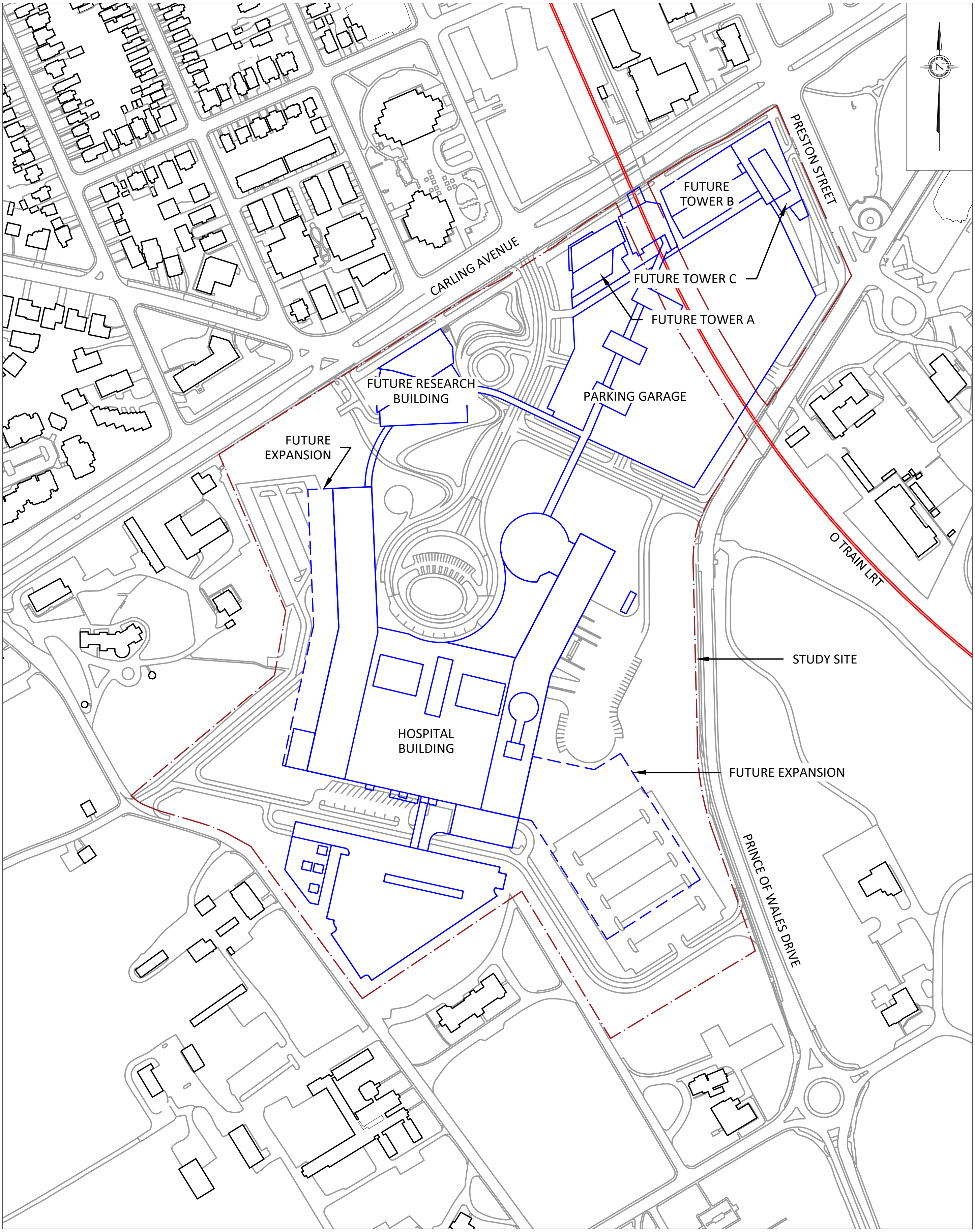
Sincerely,

Gradient Wind Engineering Inc.

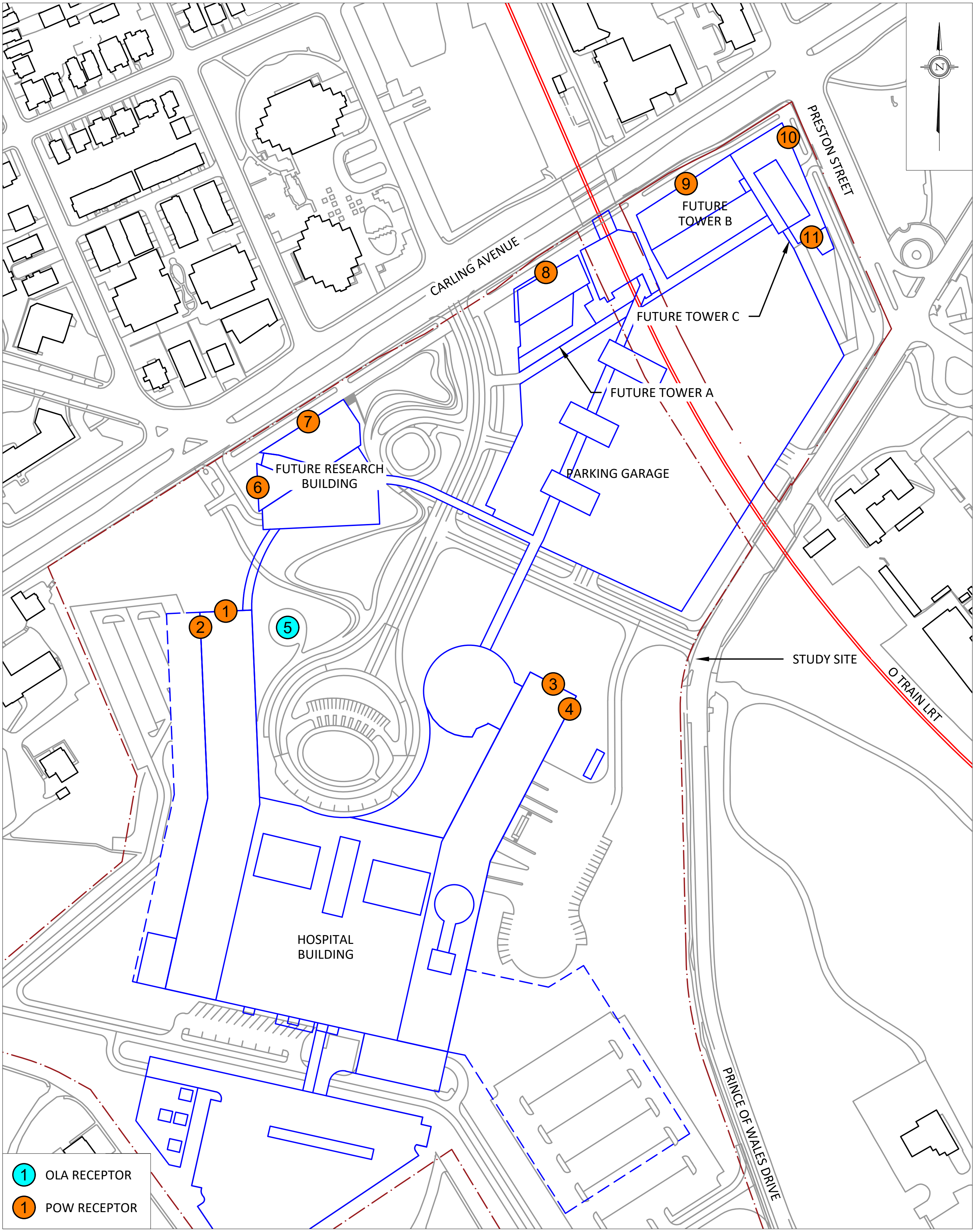
Michael Lafortune, C.E.T.
Environmental Scientist

Joshua Foster, P.Eng.
Principal

Gradient Wind File #20-049-Noise & Vibration



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 930 CARLING AVENUE AND 520 PRESTON STREET, OTTAWA ENVIRONMENTAL NOISE & VIBRATION ASSESSMENT		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
	SCALE: 1:4000 (APPROX.)	DRAWING NO.: GW20-049-1	
	DATE: APRIL 1, 2021	DRAWN BY: M.L.	



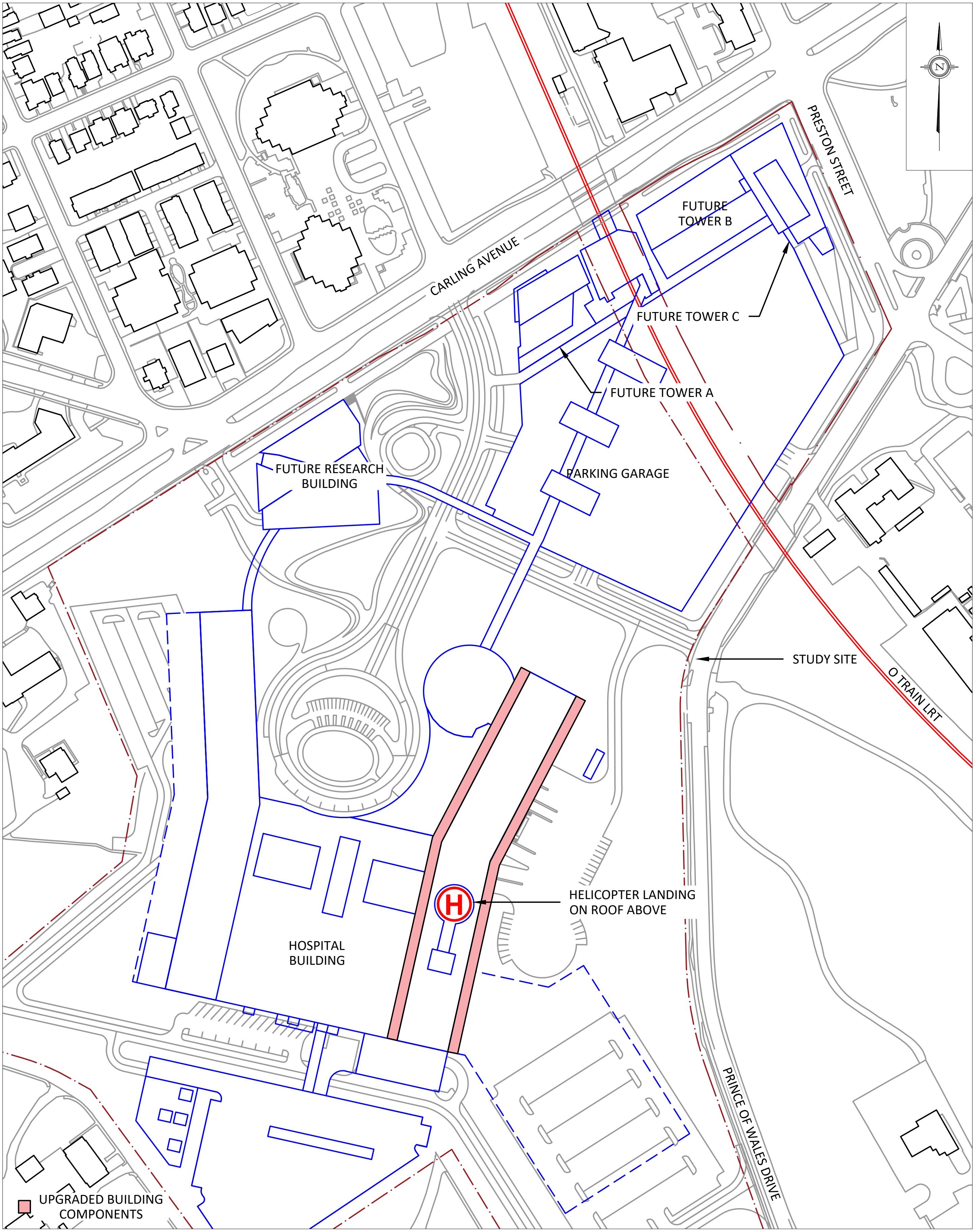
GRADIENTWIND
ENGINEERS & SCIENTISTS

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

PROJECT 930 CARLING AVENUE AND 520 PRESTON STREET, OTTAWA ENVIRONMENTAL NOISE & VIBRATION ASSESSMENT	
SCALE 1:3000 (APPROX.)	DRAWING NO. GW20-049-2
DATE APRIL 1, 2021	DRAWN BY M.L.

DESCRIPTION

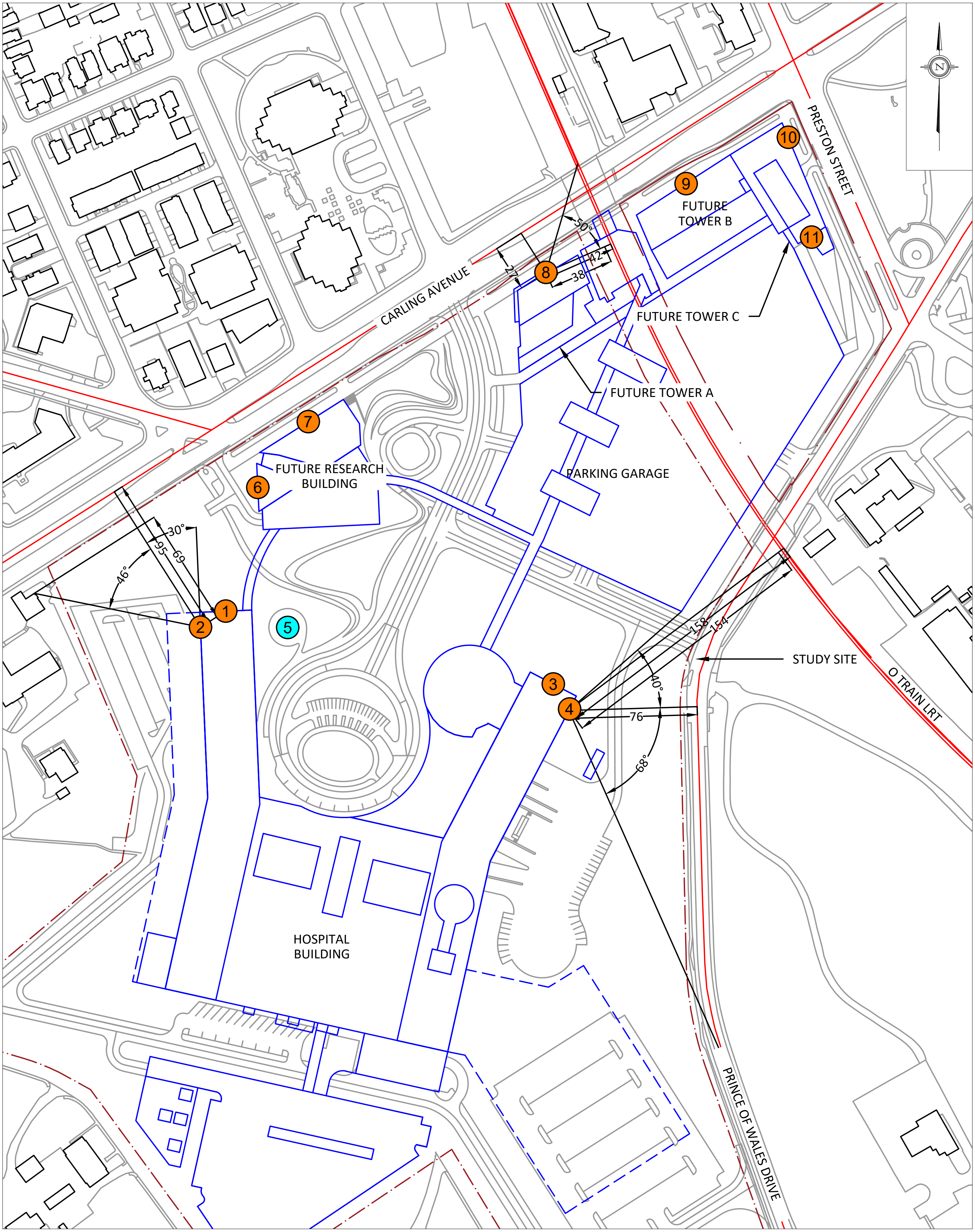
FIGURE 2:
RECEPTOR LOCATIONS



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

PROJECT	930 CARLING AVENUE AND 520 PRESTON STREET, OTTAWA ENVIRONMENTAL NOISE & VIBRATION ASSESSMENT		
SCALE	1:3000 (APPROX.)	DRAWING NO.	GW20-049-3
DATE	APRIL 1, 2021	DRAWN BY	M.L.

DESCRIPTION
FIGURE 3:
UPGRADED BUILDING COMPONENTS



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

PROJECT	930 CARLING AVENUE AND 520 PRESTON STREET, OTTAWA ENVIRONMENTAL NOISE & VIBRATION ASSESSMENT		DESCRIPTION: FIGURE 4: STAMSON INPUT PARAMETERS - RECEPTOR 2,4,8
SCALE	1:3000 (APPROX.)	DRAWING NO.	GW20-049-4
DATE	APRIL 1, 2021	DRAWN BY	M.L.

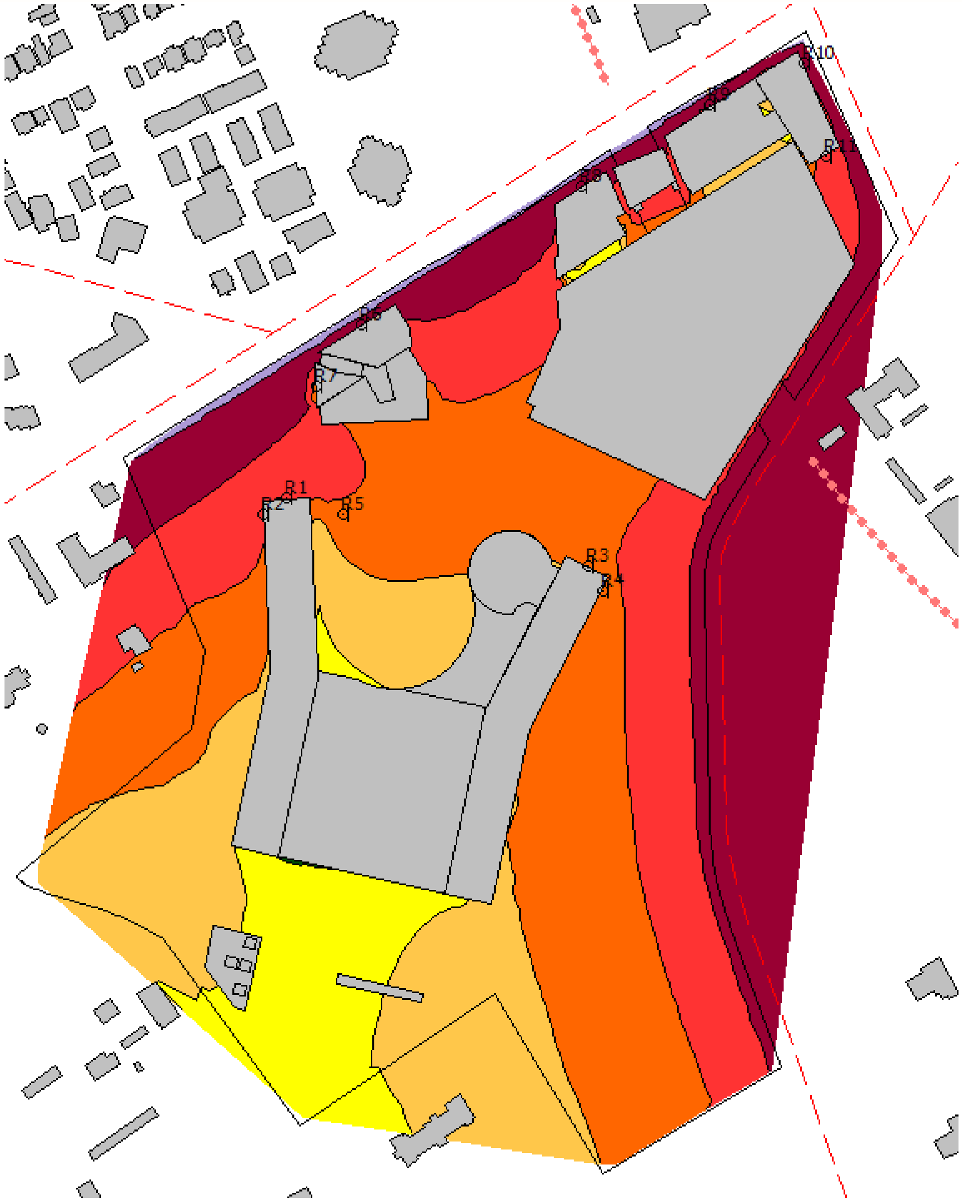


FIGURE 5: DAYTIME NOISE CONTOURS (20 M ABOVE GRADE)

- *80 – 85 dB*
- *75 – 80 dB*
- *70 – 75 dB*
- *68 – 70 dB*
- *66 – 68 dB*
- *64 – 66 dB*
- *62 – 64 dB*
- *60 – 62 dB*
- *55 – 60 dB*
- *50 – 55 dB*
- *0 – 50 dB*

FIGURE 6: NIGHTTIME NOISE CONTOURS (20 M ABOVE GRADE)

	80 – 85 dB
	75 – 80 dB
	70 – 75 dB
	68 – 70 dB
	66 – 68 dB
	64 – 66 dB
	62 – 64 dB
	60 – 62 dB
	55 – 60 dB
	50 – 55 dB
	0 – 50 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: 01-04-2021 11:42:40
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r2.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Carling (day/night)
-------------------------------------------
Car traffic volume  : 40480/3520  veh/TimePeriod  *
Medium truck volume :  3220/280   veh/TimePeriod  *
Heavy truck volume  :  2300/200   veh/TimePeriod  *
Posted speed limit  :    60 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):  50000
    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: Carling (day/night)
-----------------------------------------
Angle1   Angle2            : -90.00 deg   30.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   :  95.00 / 95.00  m
Receiver height            :  20.00 / 20.00  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -90.00 deg   Angle2 : -46.00 deg
Barrier height             :   6.00 m
Barrier receiver distance  :  69.00 / 69.00  m
Source elevation           :   0.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00
```

```
Results segment # 1: Carling (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 !       20.00 !        6.56 !          6.56

ROAD (0.00 + 59.68 + 62.58) = 64.38 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -90    -46   0.00  75.22   0.00  -8.02  -6.12   0.00   0.00  -4.84
56.25*
   -90    -46   0.11  75.22   0.00  -8.86  -6.69   0.00   0.00   0.00
59.68
---------------------------------------------------------------------------
--
   -46     30   0.11  75.22   0.00  -8.86  -3.78   0.00   0.00   0.00
62.58
---------------------------------------------------------------------------
--

 * Bright Zone !

Segment Leq : 64.38 dBA

Total Leq All Segments: 64.38 dBA
```

```
Results segment # 1: Carling (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 !        20.00 !         6.56 !          6.56

ROAD (0.00 + 52.08 + 54.98) = 56.78 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -90    -46   0.00  67.63   0.00  -8.02  -6.12   0.00   0.00  -4.84
48.65*
   -90    -46   0.11  67.63   0.00  -8.86  -6.69   0.00   0.00   0.00
52.08
---------------------------------------------------------------------------
--
   -46     30   0.11  67.63   0.00  -8.86  -3.78   0.00   0.00   0.00
54.98
---------------------------------------------------------------------------
--

 * Bright Zone !

Segment Leq : 56.78 dBA

Total Leq All Segments: 56.78 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 64.38
                         (NIGHT): 56.78
```

```
STAMSON 5.0        NORMAL REPORT        Date: 01-04-2021 11:42:45
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r4.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: QED (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  :    60 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 # 1: QED (day/night)
-------------------------------------
Angle1   Angle2           : -40.00 deg   68.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  76.00 / 76.00  m
Receiver height           :  20.00 / 20.00  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

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

Source height = 1.50 m

ROAD (0.00 + 59.90 + 0.00) = 59.90 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -40     68   0.11  70.00   0.00  -7.79  -2.31   0.00   0.00   0.00
59.90
--------------------------------------------------------------------------
--

Segment Leq : 59.90 dBA

Total Leq All Segments: 59.90 dBA


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

Source height = 1.50 m

ROAD (0.00 + 52.30 + 0.00) = 52.30 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -40     68   0.11  62.40   0.00  -7.79  -2.31   0.00   0.00   0.00
52.30
--------------------------------------------------------------------------
--

Segment Leq : 52.30 dBA

Total Leq All Segments: 52.30 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   192/24    veh/TimePeriod
Speed             :    70  km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2           :   0.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 158.00 / 158.00 m
Receiver height           :  20.00 / 20.00  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :   0.00 deg   Angle2 : 90.00 deg
Barrier height            :   9.00 m
Barrier receiver distance : 154.00 / 154.00 m
Source elevation          :  -9.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :  -9.00 m
Reference angle           :   0.00
```

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

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       0.50 !       20.00 !        1.22 !        -7.78

RT/Custom (0.00 + 28.18 + 0.00) = 28.18 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.00  58.95 -10.23  -3.01   0.00   0.00 -17.53  28.18
----------------------------------------------------------------------

Segment Leq : 28.18 dBA

Total Leq All Segments: 28.18 dBA
```

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

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       20.00 !        1.22 !        -7.78

RT/Custom (0.00 + 22.16 + 0.00) = 22.16 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.00  52.93 -10.23  -3.01   0.00   0.00 -17.53  22.16
----------------------------------------------------------------------

Segment Leq : 22.16 dBA

Total Leq All Segments: 22.16 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 59.90
                         (NIGHT): 52.30
```

```
STAMSON 5.0        NORMAL REPORT        Date: 01-04-2021 11:52:39
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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


Road data, segment # 1: Carling (day/night)
-------------------------------------------
Car traffic volume  : 40480/3520  veh/TimePeriod  *
Medium truck volume :  3220/280   veh/TimePeriod  *
Heavy truck volume  :  2300/200   veh/TimePeriod  *
Posted speed limit  :    60 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):  50000
    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: Carling (day/night)
-----------------------------------------
Angle1   Angle2           : -70.00 deg   70.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  27.00 / 27.00  m
Receiver height           :  20.00 / 20.00  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

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

Source height = 1.50 m

ROAD (0.00 + 71.58 + 0.00) = 71.58 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -70     70   0.00  75.22   0.00  -2.55  -1.09   0.00   0.00   0.00
71.58
---------------------------------------------------------------------------
--

Segment Leq : 71.58 dBA

Total Leq All Segments: 71.58 dBA


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

Source height = 1.50 m

ROAD (0.00 + 63.98 + 0.00) = 63.98 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -70     70   0.00  67.63   0.00  -2.55  -1.09   0.00   0.00   0.00
63.98
---------------------------------------------------------------------------
--

Segment Leq : 63.98 dBA

Total Leq All Segments: 63.98 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   192/24    veh/TimePeriod
Speed             :    70  km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2           : -90.00 deg   -50.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  42.00 / 42.00  m
Receiver height           :  20.00 / 20.00  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : -50.00 deg
Barrier height            :   9.00 m
Barrier receiver distance :  38.00 / 38.00  m
Source elevation          :  -9.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :  -9.00 m
Reference angle           :   0.00
```

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

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       0.50 !       20.00 !        3.21 !        -5.79

RT/Custom (0.00 + 35.29 + 0.00) = 35.29 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90    -50   0.00  58.95  -4.47  -6.53   0.00   0.00 -12.66  35.29
----------------------------------------------------------------------

Segment Leq : 35.29 dBA

Total Leq All Segments: 35.29 dBA
```

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

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       0.50 !       20.00 !        3.21 !        -5.79

RT/Custom (0.00 + 29.27 + 0.00) = 29.27 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
-----------------------------------------------------------------------
   -90    -50   0.00  52.93  -4.47  -6.53   0.00   0.00 -12.66  29.27
-----------------------------------------------------------------------

Segment Leq : 29.27 dBA

Total Leq All Segments: 29.27 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 71.58
                         (NIGHT): 63.98
```

APPENDIX B

FTA VIBRATION CALCULATIONS

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

GW20-049 1-Apr-21

Possible Vibration Impacts on 89-109 Niagra
Perdicted using FTA General Assesment

Train Speed 70 km/h 43 mph

	Distance from C/L	
	(m)	(ft)
LRT	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 95 km/h (60 mph)	
Vehicle Parameters	0	Assume Soft primary suspension, Weels run true	
Track Condition	0	None	
Track Treatments	0	None	
Type of Transit Structure	-5	Station	
Efficient vibration Propagation	0	Propagation through rock	
Vibration Levels at Fdn	66		0.049
Coupling to Building Foundation	-10	Large Massonry on Piles	
Floor to Floor Attenuation	-2.0	Ground Floor Ocupied	
Amplification of Floor and Walls	6		
Total Vibration Level	59.7	dBV or	0.025 mm/s
Noise Level in dBA	24.7	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.