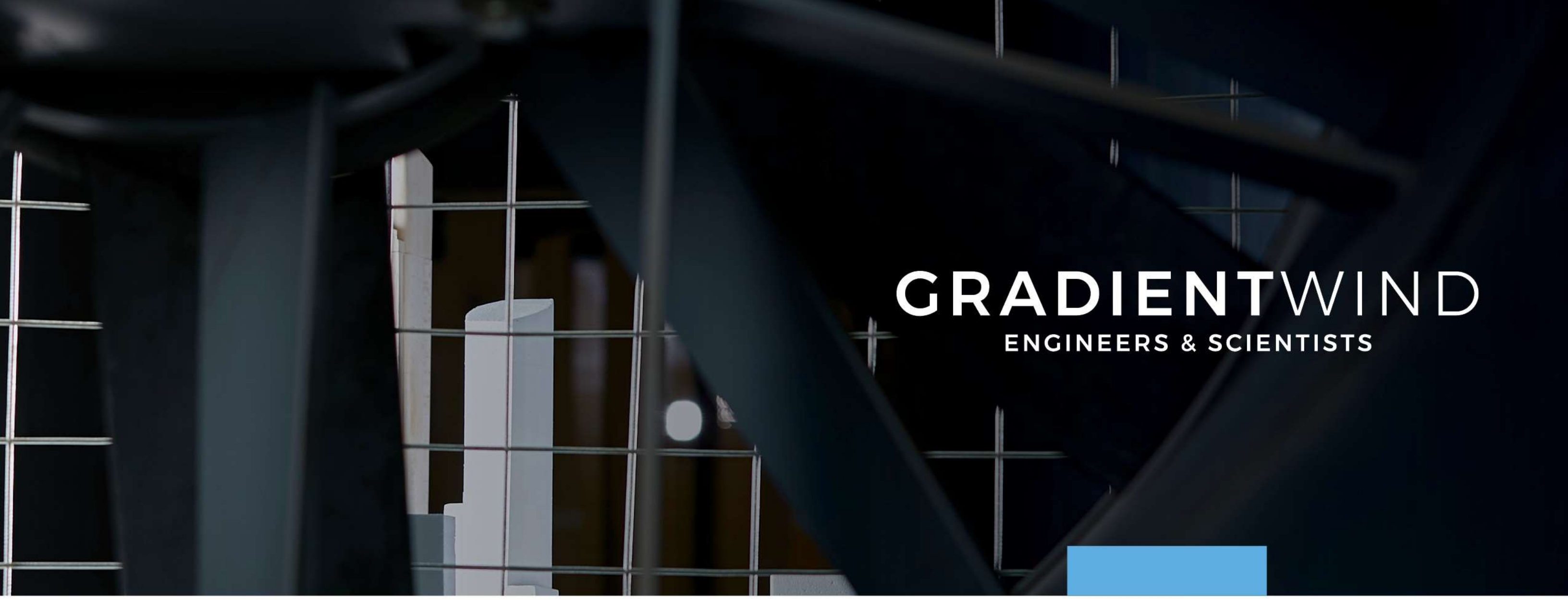
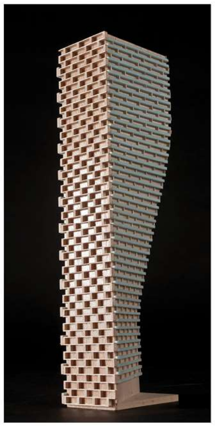
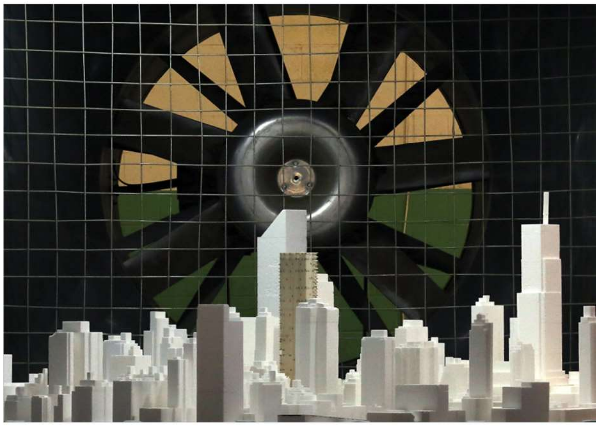


TRANSPOTATION NOISE AND VIBRATION ASSESSMENT

2740 Queensview Drive
Ottawa, Ontario

REPORT: GW21-159-Noise & Vibration





August 18, 2021

PREPARED FOR
Granite Curling Club of West Ottawa

Attn: Greg Mathieu

Chair Redevelopment Sub- Committee

PREPARED BY

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EXECUTIVE SUMMARY

This report describes a transportation noise and vibration assessment prepared to satisfy a Site Plan Control Application (SPA) submission for the proposed Granite Curling Club Redevelopment located at 2740 Queensview Drive in Ottawa. The proposed development comprises a two-storey building (1715 m^2 in area), on a nearly-trapezoidal parcel of land overlooking Queensview Drive to the north and Highway 417 to the south. Throughout this report, the Queensview Drive elevation is referred to as the north elevation. Figure 1 illustrates a complete site plan with the surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the City of Ottawa Environmental Noise Control Guidelines (ENCG); (ii) noise level criteria as specified by the ENCG guidelines; (iii) future vehicular traffic volumes corresponding to roadway classification, roadway traffic volumes obtained from the City of Ottawa, and LRT information from the Rail Implementation Office; and (iv) site and floor plan drawings prepared by N45 Architecture Inc., dated February 3, 2021.

The major sources of transportation noise and their approximate distances from the study site are Pinecrest Road 100 meters to the west, the Queensway highway 130 meters south, and the Light Rail Transit (LRT) Confederation Line under development which will run parallel to the Queensway, 75 meters to the south. Potential ground vibration impacts caused by the LRT were also analyzed in this study.

The results of the current analysis indicate that noise levels will range between 60 and 75 dBA at the Plane of Window (POW) receptors during the daytime period (07:00-23:00) and between 52 and 68 dBA during the nighttime period (23:00-07:00). The highest noise level (75 dBA) occurs along the south façade of the building, which is nearest and most exposed to the Queensway. Building components with a higher Sound Transmission Class (STC) rating will be required where noise levels exceed 65 dBA, indicated in Figure 4. The components summarized in section 5.3 will provide the necessary attenuation.

In addition to upgraded windows, the installation of central air conditioning (or similar mechanical system) will be required for the development, which will allow occupants to keep windows closed and maintain a

comfortable environment. A Warning Clause[1] will be required in all Agreements of Lease, Purchase and Sale of the building, as summarized in section 6.

A preliminary stationary noise assessment was conducted for noise impacts of the proposed HVAC equipment on surrounding buildings. Modelling results indicate that the proposed equipment is not expected to have significant impacts on the surroundings, as noise levels at all points of reception for noise-sensitive areas are within the exclusionary limits for a Class 1 area. The most impacted buildings are residences to the north. The adjacent commercial buildings and place of worship to the west are on industrially zoned lands and therefore not considered noise-sensitive. The final placement and location of the equipment should be reviewed by a qualifed acoustic consultant prior to installation of the equipment.

The estimated vibration level due to Light Rail Transit in the area is expected to be 0.036 mm/s RMS (63 dBV) at the nearest point of reception based on the FTA protocol. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

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

GRADIENTWIND
ENGINEERS & SCIENTISTS

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Morley Hoppner Ltd. to undertake a transportation noise and vibration assessment to satisfy a Site Plan Control Application (SPA) submission for the proposed Granite Curling Club Redevelopment located at 2740 Queensview Drive in Ottawa (hereinafter referred to as "study building" or "proposed development"). This report summarizes the methodology, results, and recommendations related to a transportation noise and ground vibration assessment.

The present scope of work involves assessing exterior and interior noise levels generated by local transportation sources, as well as vibration levels generated by local light rail transit (LRT) activity. The assessment is based on (i) theoretical noise prediction methods that conform to the City of Ottawa Environmental Noise Control Guidelines[2] (ENCG); (ii) noise level criteria as specified by the ENCG guidelines; (iii) future vehicular traffic volumes corresponding to roadway classification, roadway traffic volumes obtained from the City of Ottawa, and LRT information from the Rail Implementation Office; and (iv) site and floor plan drawings prepared by N45 Architecture Inc., dated February 3, 2021.

2. TERMS OF REFERENCE

The study building is located at 2740 Queensview Drive on the south elevation of Queensview Drive, approximately 100 meters (m) to the east of the intersection of Queensview Drive and Pinecrest Road. Throughout this report, the Queensview Drive elevation is referred to as the north elevation.

The proposed development comprises a two-storey building (1715 m^2 in area), on a nearly-trapezoidal parcel of land overlooking Queensview Drive to the north and Highway 417 to the south. The ground floor comprises an east-central ice arena (975 m^2), arena support facilities, lounge/dining (320 m^2) and kitchen areas (north), gallery space, storage areas, and other functions. Floor 2 comprises an opening to the ice arena below, games room, and locker/washroom facilities primarily, on a reduced floorplate. 78 surface parking spaces are also featured at grade, with vehicular and one-way access off of Queensview Drive to the north. Building access points are on the west façade. Green frontage surrounds the building/parking.

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

The study site is surrounded by low-rise commercial buildings to the east and north, a place of worship to the west, residential dwellings on Moncton Road to the north, and the Queensway highway to the south. The major sources of transportation noise and their approximate distances from the study site are Pinecrest Road 100 meters to the west, the Queensway highway 130 meters south, and the Light Rail Transit (LRT) Confederation Line under development which will run parallel to the Queensway, 75 meters to the south. Pinecrest Station will be located approximately 200 meters to the southwest of the study site, on the opposite side of Pinecrest Road. The section of the LRT Confederation Line running along the study site will travel above-ground, and was included in the transportation noise analysis. Potential ground vibration impacts caused by the LRT are also analyzed in this study. Figure 1 illustrates a complete site plan and surrounding context.

3. OBJECTIVES

The main goals of this work are to (i) calculate the future noise levels on the study building produced by local transportation noise sources, (ii) calculate the future vibration levels on the study building produced by local LRT traffic, and (iii) ensure that interior noise levels and vibration levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines as outlined in Section 4 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 Noise

For vehicle 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 that 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 City of Ottawa's Environmental Noise Control Guidelines (ENCG) specifies that the recommended indoor noise limit range (that is relevant to this study) is 50 dBA for office/retail space, as listed in Table 1. However, to account for deficiencies in building construction and control peak noise, this levels should be targeted toward 47 dBA.

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

Type of Space	Time Period	Leq (dBA)	
		Road	Rail
General **offices**, reception areas, **retail** stores, etc.	07:00 – 23:00	50	45
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	40
Sleeping quarters of hotels/motels	23:00 – 07:00	45	40
Sleeping quarters of residences, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	40	35

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]. 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

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125

conditioning (or similar systems). 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 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 Roadway 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[6] 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. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment.

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway Traffic Data	Speed Limit (km/h)	Traffic Volumes
Pincrest Road	4-UAD	50	**35,000**
Queensway	8 Lane Highway	100	**146,664**
Confederation Line	LRT	70	**540/60***

*Daytime/nighttime volumes

4.2.3 Theoretical Transportation Noise Predictions

Noise predictions were performed with the aid of the MECP computerized noise assessment program, STAMSON 5.04, for road and rail analysis. Appendix A includes the STAMSON 5.04 input and output data.

[5] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3
[6] City of Ottawa Transportation Master Plan, November 2013

Roadway noise calculations were performed by treating each road 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 4, 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 was taken to be 92%/8% respectively for all streets.
- Ground surfaces were taken to be absorptive and reflective based on specific source-receiver path ground characteristics.
- Site topography was assumed to elevated by 3 meters with respect to the LRT and the Queensway.
- Noise receptors were strategically placed at 5 locations around the study building (see Figure 2).
- Receptor height was taken to be 1.5 meters for the center of the window of the 1st floor (Receptor 1) , and 4.5 meters for the 2nd floor (Receptors 2-5).
- Receptor distances and exposure angles are illustrated in Appendix A Figures A1-A4.
- LRT was modelled using 4-car SRT vehicle type in STAMSON.

4.3 Stationary Noise

4.3.1 Criteria for Stationary Noise

For stationary sources, the L_{eq} is commonly calculated on an hourly interval, while for roadways, the L_{eq} is calculated on the basis of a 16-hour daytime/8-hour nighttime split as previously mentioned in Section 4.2.1

Stationary sources are defined in the ENCG as “all sources of sound and vibration, whether fixed or mobile, that exist or operate on a premises, property or facility, the combined sound and vibration levels of which are emitted beyond the property boundary of the premises, property or facility, unless the source(s) is (are) due to construction”.

Sound level limits apply at the plane of window and outdoor points of reception (OPOR) at surrounding noise-sensitive lands, such as residential dwellings. The closest noise-sensitive area to the development is the existing residential neighbourhood on Moncton Road, north of Queensview Drive on the opposite side to a row of commercial buildings. The immediate surrounding commercial buildings and place of worship are not considered to be noise-sensitive under ENCG and NPC-300 guidelines as they are on industrial zoned lands. The surrounding area of the development would be defined as a Class 1 (Urban) environment, as background noise levels are dominated by human activities such as the highway and transit sources. The sound level limits are the exclusionary sound level limits described in Table 3 below or background noise, whichever is higher. For this study the exclusionary sound level limits were adopted.

TABLE 3: EXCLUSIONARY LIMITS FOR CLASS 1 AREA

Time of Day	Class 1	
	Outdoor Points of Reception	Plane of Window
07:00 – 19:00	50	50
19:00 – 23:00	50	50
23:00 – 07:00	N/A	45

4.3.2 Assumptions

The following assumptions have been included in the analysis:

(ii) The quantity, location and sound power of rooftop equipment has been assumed based on Gradient Wind's experience on similar projects.

(iii) The rooftop air handling units are assumed to operate continuously over a 1-hour period during the daytime and nighttime periods, and at 50% operation during the nighttime. This is to account for the decreased occupancy loads in the building overnight.

(iv) Screening effects of adjacent buildings have been considered in the modelling.

4.3.3 Determination of Noise Source Power Levels

Sound power data for the rooftop equipment were assumed based on Gradient Wind's experience with similar types of equipment that are present on the surrounding commercial facilities. Table 4 summarizes the sound power assumed for each source used in the analysis.

TABLE 4: EQUIPMENT SOUND POWER LEVELS (dBA)

Source ID	Description	Height Above Grade(m)	Sound Power Level (dBA)
S1	Refrigeration unit	4.5	95
S2	Rooftop AC unit	7.5	90
S3	Rooftop AC unit	7.5	90

4.3.4 Stationary Source Noise Predictions

The impact of stationary noise sources from the proposed development on their surroundings was determined by computer modelling. Stationary noise source modelling is based on the software program *Predictor-Lima* developed from the International Standards Organization (ISO) standard 9613 Parts 1 and 2. This computer program is capable of representing three-dimensional surfaces and first reflections of sound waves over a suitable spectrum for human hearing. The methodology has been used on numerous assignments and has been accepted by the MECP as part of Environmental Compliance Approvals applications.

Ten individual noise sensor locations were selected in the *Predictor-Lima* model to measure the noise impact at points of reception (POR) during the daytime (07:00 – 23:00) and nighttime (23:00 – 07:00) periods (see Figure 3). POR locations included the the plane of windows (POW's) of nearby residential dwellings and adjacent commercial buildings, as well as outdoor living areas (OLA's) of nearby residential dwellings. All mechanical equipment was represented as point sources in the model. Air temperature, pressure and humidity were set to 10°C, 101.3 kPA and 70%, respectively. Ground absorption over the study area was determined based on topographical features (such as water, concrete, grassland, etc.). A coefficient of 0 was used for hard surfaces, such as concrete and paved areas, and 1 for soft surfaces, such as grass and vegetative areas. Existing and proposed buildings were added to the model to account for screening and reflection effects from building façades. Modelling files and outputs are available upon request.

4.4 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 cladding, thickness and interior finish details. For example, concrete and masonry walls can achieve STC 50 or more. Curtainwall systems typically provide around STC 35, depending on the glazing elements. 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.

According to the ENCG, when daytime noise levels 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[7] 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[8], 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, final detailed floor layouts and building elevations were unavailable and 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).

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[7] Building Practice Note: Controlling Sound Transmission into Buildings by J.D. Quirt, National Research Council of Canada, September 1985

[8] CMHC, Road & Rail Noise: Effects on Housing

4.5 Ground Vibration & 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 vibrations 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.

4.5.1 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[9]. 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[10], 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.

4.5.2 Theoretical Ground Vibration Prediction Procedure

Potential vibration impacts of the future Confederation LRT rail line, currently under construction, were predicted using the FTA's Transit Noise and Vibration Impact Assessment[11] 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 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.

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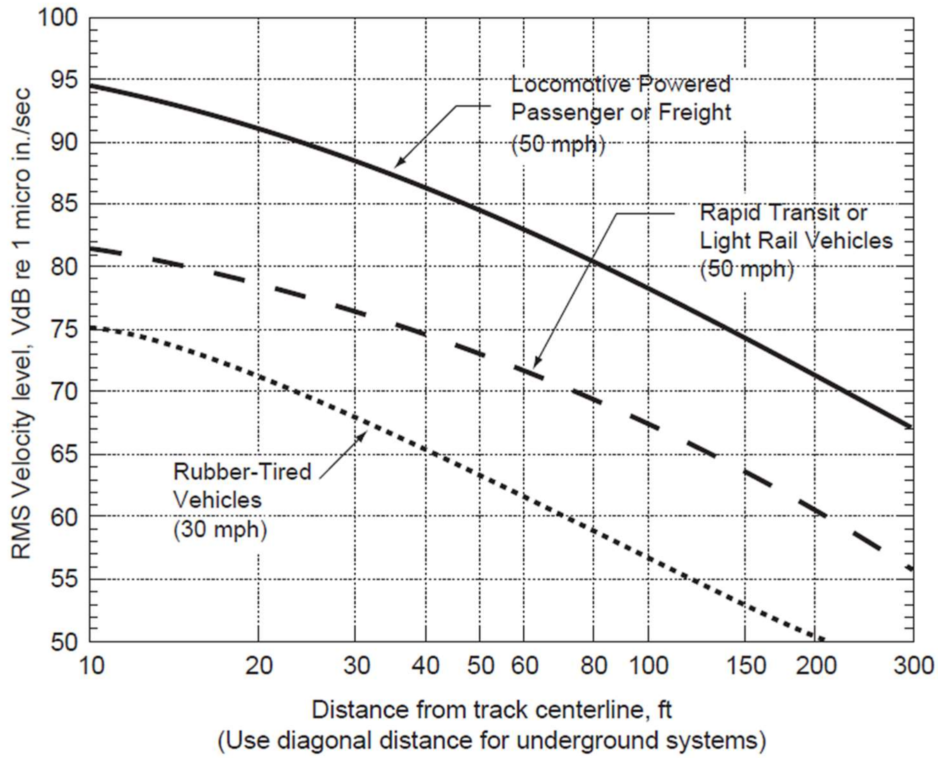
[9] MECP/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop, June 16, 1993

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

[11] 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 AND DISCUSSION

5.1 Roadway Traffic Noise Levels

The results of the roadway noise calculations are summarized in Table 5 below. A complete set of input and output data from all STAMSON 5.04 calculations are available in Appendix A.

TABLE 5: EXTERIOR NOISE LEVELS DUE TO TRANSPORTATION NOISE SOURCES

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	Transportation Noise Level (dBA)	
			Day	Night
1	1.5	POW / 1st Floor - South Façade	75	68
2	4.5	POW / 2nd Floor - West Façade	71	64
3	4.5	POW / 2nd Floor - West Façade	70	63
4	4.5	POW / 2nd Floor - North Façade	60	52
5	4.5	POW / 2nd Floor - East Façade	72	65

The results of the current analysis indicate that noise levels will range between 60 and 75 dBA at the Plane of Window (POW) receptors during the daytime period (07:00-23:00) and between 52 and 68 dBA during the nighttime period (23:00-07:00). The highest noise level (75 dBA) occurs along the south façade of the building, which is nearest and most exposed to the Queensway.

5.2 Stationary Noise Levels

The anticipated noise levels on the surroundings caused by the mechanical equipment of the study building are summarized in Table 6 below and are based on the assumptions outlined in Section 4.3.2. Noise contours along the building façades at a height of 1.5 meters can be seen in Figures 5 and 6 for daytime and nighttime conditions, respectively. The most impacted buildings are residences on Moncton Road to the north. The adjacent commercial buildings and place of worship to the west are on industrially zoned lands and therefore not considered noise-sensitive.

TABLE 6: NOISE LEVELS DUE TO STATIONARY SOURCES

Receptor Number	Receptor Location	Noise Level (dBA)		Exclusionary Limits		Meets ENCG Class 1 Criteria	
		Day	Night	Day	Night	Day	Night
R1	POW / 1st Floor – 2744 Moncton Rd – South Façade	46	43	50	45	YES	YES
R2	POW / 1st Floor – 2740 Moncton Rd – South Façade	45	42	50	45	YES	YES
R3	POW / 1st Floor – 2736 Moncton Rd – South Façade	37	34	50	45	YES	YES
R4	OLA / Back Yard – 2744 Moncton Rd	48	45	50	45	YES	YES
R5	OLA / Back Yard – 2740 Moncton Rd	48	45	50	45	YES	YES
R6	OLA / Back Yard – 2736 Moncton Rd	42	39	50	45	YES	YES

5.3 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). As per city of Ottawa requirements, detailed STC calculations will be required to be completed prior to building permit application for each unit type. The STC requirements for the windows of the development are summarized below (see Figure 4):

- **Windows**

(i) Windows facing south will require a minimum STC of 30

(ii) Windows facing east and west will require a minimum STC of 25

(iii) All other bedroom windows are to satisfy Ontario Building Code (OBC 2012) requirements

- **Exterior Walls**

(i) Exterior wall components on the south, east, and west façades will require a minimum STC of 45, which will be achieved with brick cladding or an acoustical equivalent according to NRC test data[12]

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

The STC requirements apply to windows, doors, spandrel panels and curtainwall elements. Exterior wall components on these façades are recommended to have a minimum STC of 45, where a punch window and wall system is used. This can often be achieved with commercial steel stud wall construction. 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. We have specified an example window configuration, however, 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.

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.

5.4 Ground Vibrations & Ground-borne Noise Levels

Based on an offset distance of 72 metres between the nearest railway track of the LRT Confederation Line and the building foundation, the estimated vibration level at the nearest point of reception is expected to be 0.036 mm/s RMS (63 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.

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. The result of our analysis indicates that the ground-bourne noise levels will be at 28 dB.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 60 and 75 dBA at the Plane of Window (POW) receptors during the daytime period (07:00-23:00) and between 52 and 68 dBA during the nighttime period (23:00-07:00). The highest noise level (75 dBA) occurs along the south façade of the building, which is nearest and most exposed to the Queensway. Building components with a higher Sound Transmission Class (STC) rating will be required where noise levels exceed 65 dBA, indicated in Figure 4. The components summarized in section 5.3 will provide the necessary attenuation.

In addition to upgraded windows, the installation of central air conditioning (or similar mechanical system) will be required for the development, which will allow occupants to keep windows closed and maintain a comfortable environment. The following Warning Clause[13] will be required in all Agreements of Lease, Purchase and Sale of the building:

> *"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 roadway traffic may, on occasion, interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the City and the Ministry of the Environment and Climate Change. To help address the need for sound attenuation, this development includes:*
>
> - *STC rated multi-pane glass glazing elements and spandrel panels*
> - *Upgraded exterior walls achieving STC 45 or greater*
>
> *This dwelling unit has also been designed with air conditioning (or similar mechanical system). Air conditioning will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the City and the Ministry of the Environment and Climate Change.*
>
> *To ensure that provincial sound level limits are not exceeded, it is important to maintain these sound attenuation features."*

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

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.'"

A preliminary stationary noise assessment was conducted for noise impacts of the proposed HVAC equipment on surrounding buildings. Modelling results indicate that the proposed equipment is not expected to have significant impacts on the surroundings, as noise levels at all points of reception for noise-sensitive areas are within the exclusionary limits for a Class 1 area. The most impacted buildings are residences to the north. The adjacent commercial buildings and place of worship to the west are on industrially zoned lands and therefore not considered noise-sensitive. The final placement and location of the equipment should be reviewed by a qualifed acoustic consultant prior to installation of the equipment.

The estimated vibration level due to Light Rail Transit in the area is expected to be 0.036 mm/s RMS (63 dBV) at the nearest point of reception based on the FTA protocol. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

This concludes our 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.

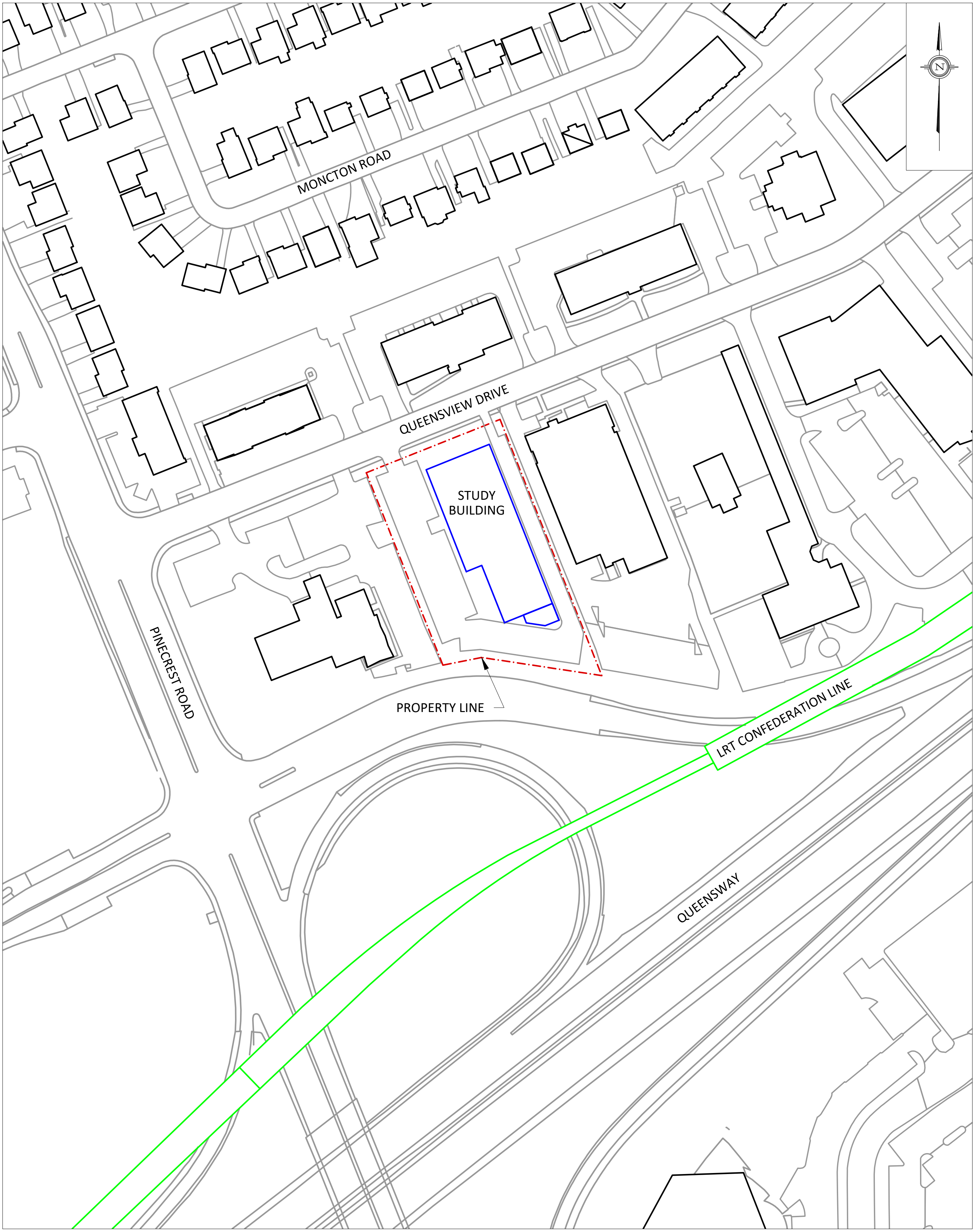
Sincerely,

Gradient Wind Engineering Inc.

Tanyon Matheson-Fitchett, B.Eng.
Junior Environmental Scientist

Joshua Foster, P.Eng.
Principal

Gradient Wind File #21-159-Noise&Vibration



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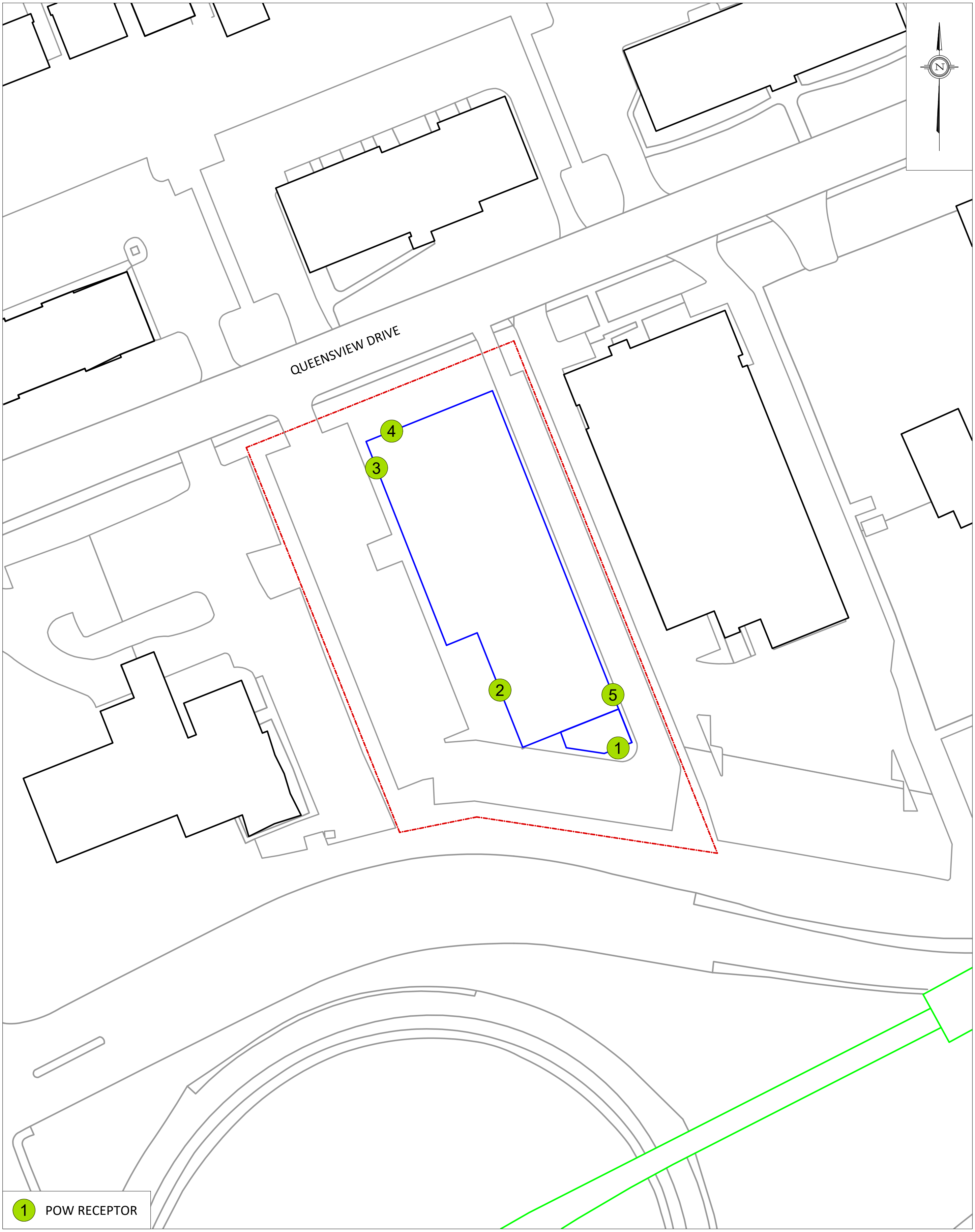
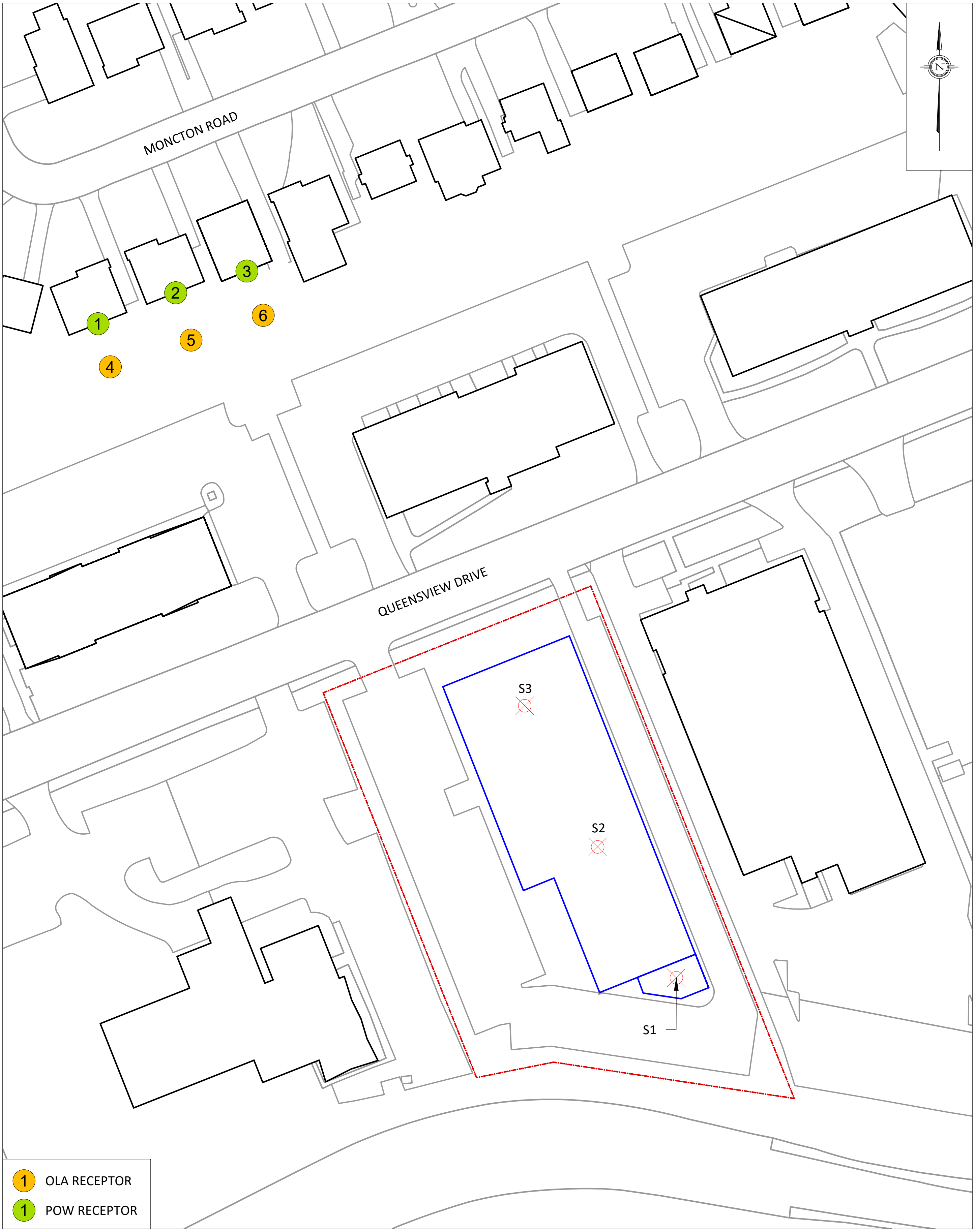
PROJECT	2740 QUEENSVIEW DRIVE, OTTAWA TRANSPORTATION NOISE AND VIBRATIONS ASSESSMENT		
SCALE	1:2000 (APPROX.)	DRAWING NO.	GWE21-159-1
DATE	MAY 27, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE 1:
SITE PLAN AND SURROUNDING CONTEXT



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 2740 QUEENSVIEW DRIVE, OTTAWA TRANSPORTATION NOISE AND VIBRATIONS ASSESSMENT		DESCRIPTION: FIGURE 2: TRANSPORTATION NOISE RECEPTOR LOCATIONS
	SCALE: 1:1000 (APPROX.)	DRAWING NO.: GWE21-159-2	
	DATE: MAY 27, 2021	DRAWN BY: T.M.F.	



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PROJECT	2740 QUEENSVIEW DRIVE, OTTAWA TRANSPORTATION NOISE AND VIBRATIONS ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GWE21-159-3
DATE	MAY 31, 2021	DRAWN BY	T.M.F.
DESCRIPTION	FIGURE 3: STATIONARY NOISE SOURCE/RECEPTOR LOCATIONS		

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PROJECT	2740 QUEENSVIEW DRIVE, OTTAWA TRANSPORTATION NOISE AND VIBRATIONS ASSESSMENT		
SCALE	1:500 (APPROX.)	DRAWING NO.	GWE21-159-4
DATE	MAY 27, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE 4:
WINDOW STC REQUIREMENTS

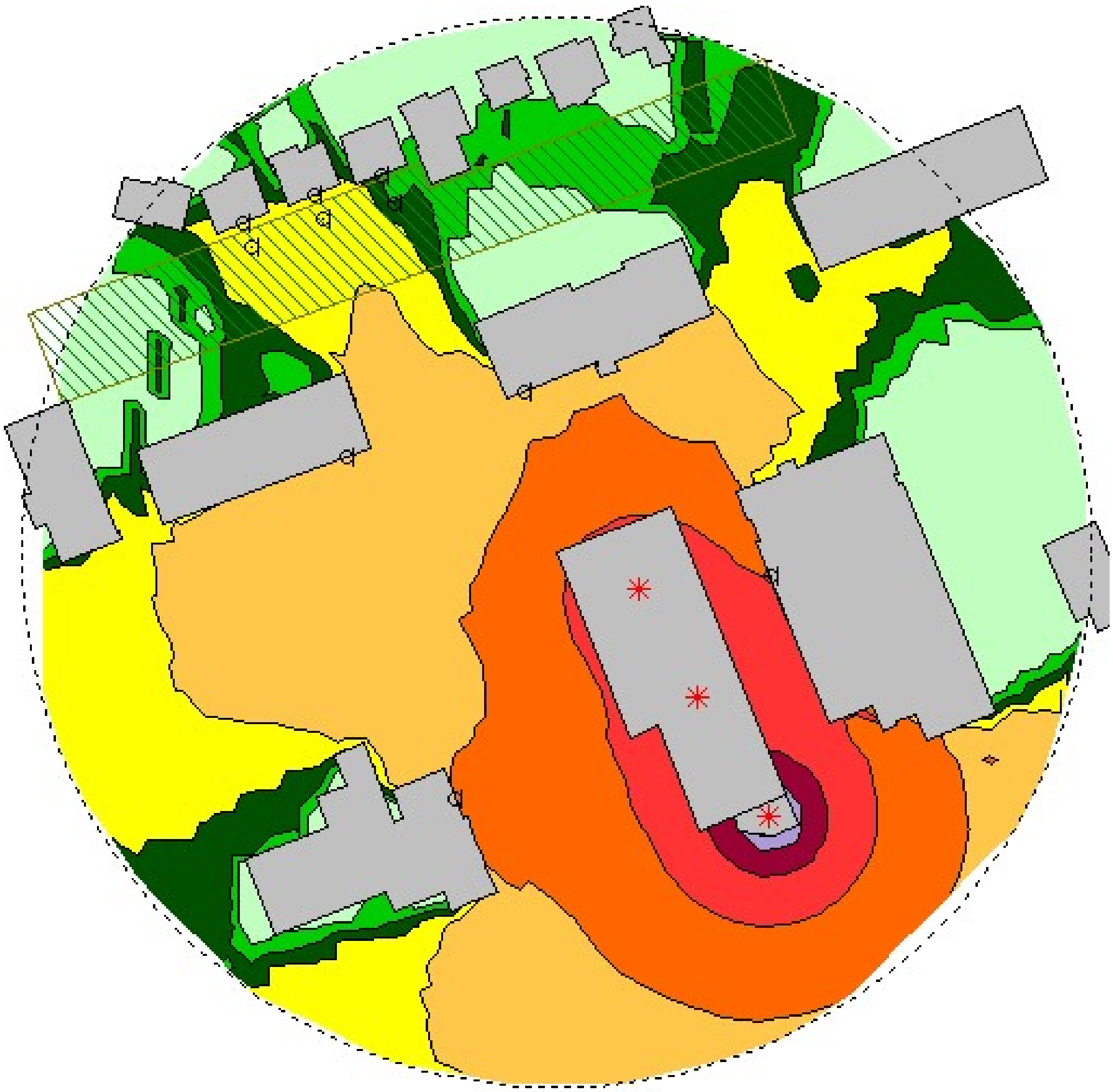
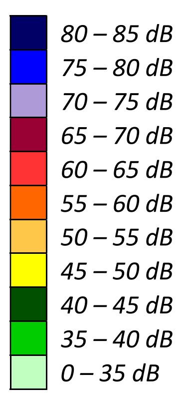


FIGURE 5: DAYTIME NOISE CONTOURS (1.5M ABOVE GRADE)



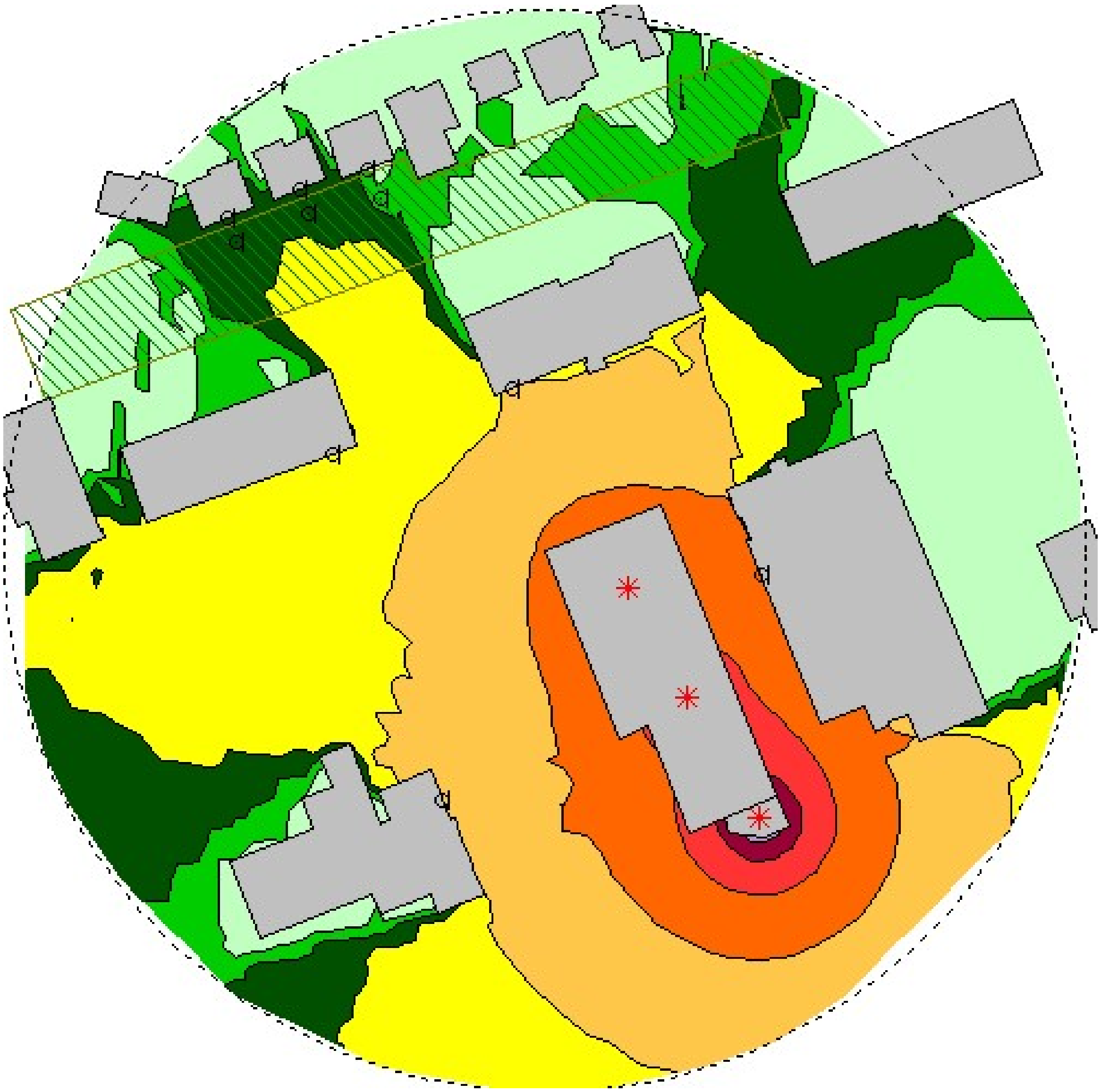
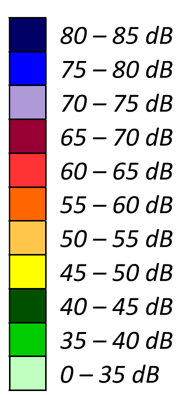
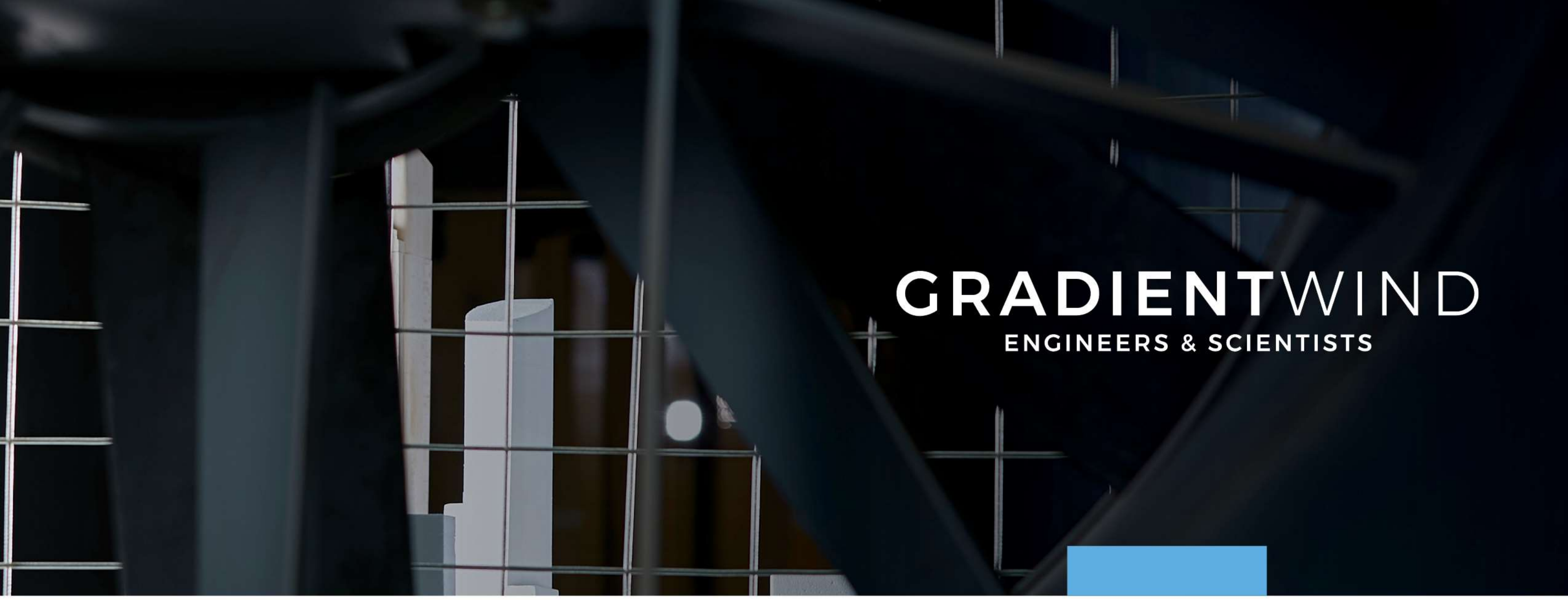
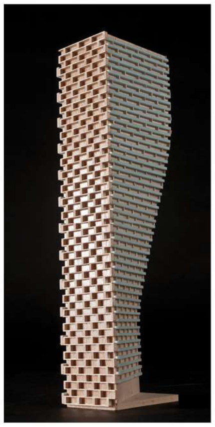
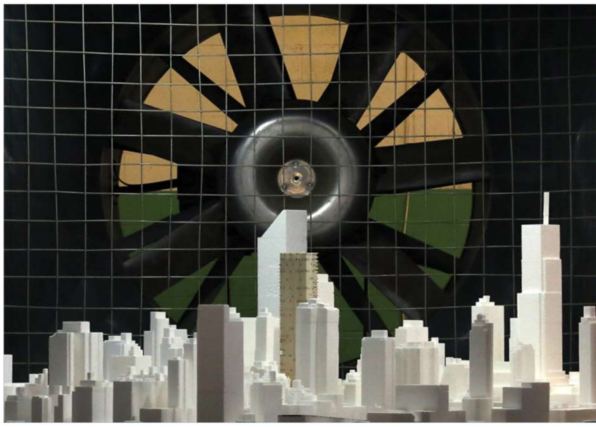


FIGURE 6: NIGHTTIME NOISE CONTOURS (1.5M ABOVE GRADE)









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: 26-05-2021 10:15:55
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R1.te               Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Pinecrest (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 # 1: Pinecrest (day/night)
-------------------------------------------
Angle1   Angle2           : -90.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  : 151.00 / 151.00 m
Receiver height           :   1.50 / 1.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Road data, segment # 2: Queensway (day/night)
---------------------------------------------
Car traffic volume  : 118739/10325 veh/TimePeriod  *
Medium truck volume :  9445/821   veh/TimePeriod  *
Heavy truck volume  :  6747/587   veh/TimePeriod  *
Posted speed limit  :   100 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): 146664
    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: Queensway (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  : 131.00 / 131.00 m
Receiver height           :   1.50 / 1.50   m
Topography                :      3       (Elevated; no barrier)
Elevation                 :   3.00 m
Reference angle           :   0.00

Results segment # 1: Pinecrest (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 59.12 + 0.00) = 59.12 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      0   0.00  72.16   0.00 -10.03  -3.01   0.00   0.00   0.00  59.12
----------------------------------------------------------------------------

Segment Leq : 59.12 dBA

Results segment # 2: Queensway (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 75.00 + 0.00) = 75.00 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  84.41   0.00  -9.41   0.00   0.00   0.00   0.00  75.00
----------------------------------------------------------------------------

Segment Leq : 75.00 dBA

Total Leq All Segments: 75.11 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 51.52 + 0.00) = 51.52 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      0   0.00  64.56   0.00 -10.03  -3.01   0.00   0.00   0.00  51.52
----------------------------------------------------------------------------

Segment Leq : 51.52 dBA

Results segment # 2: Queensway (night)
--------------------------------------

Source height = 1.50 m

ROAD (0.00 + 67.40 + 0.00) = 67.40 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  76.81   0.00  -9.41   0.00   0.00   0.00   0.00  67.40
----------------------------------------------------------------------------

Segment Leq : 67.40 dBA

Total Leq All Segments: 67.51 dBA

RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    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  :  73.00 / 73.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      3       (Elevated; no barrier)
Elevation                 :   3.00 m
Reference angle           :   0.00

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

Source height = 0.50 m
```

```
RT/Custom (0.00 + 56.57 + 0.00) = 56.57 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -6.87   0.00   0.00   0.00   0.00  56.57
----------------------------------------------------------------------

Segment Leq : 56.57 dBA

Total Leq All Segments: 56.57 dBA

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

Source height = 0.50 m

RT/Custom (0.00 + 50.03 + 0.00) = 50.03 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -6.87   0.00   0.00   0.00   0.00  50.03
----------------------------------------------------------------------

Segment Leq : 50.03 dBA

Total Leq All Segments: 50.03 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 75.17
                         (NIGHT): 67.59
```

```
STAMSON 5.0        NORMAL REPORT        Date: 26-05-2021 10:35:03
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R2.te               Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Pinecrest (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 # 1: Pinecrest (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  : 134.00 / 134.00 m
Receiver height           :   4.50 / 4.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Road data, segment # 2: Queensway (day/night)
---------------------------------------------
Car traffic volume  : 118739/10325 veh/TimePeriod  *
Medium truck volume :  9445/821   veh/TimePeriod  *
Heavy truck volume  :  6747/587   veh/TimePeriod  *
Posted speed limit  :   100 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): 146664
    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: Queensway (day/night)
-------------------------------------------
Angle1   Angle2            :  16.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      2       (Reflective ground surface)
Receiver source distance   : 155.00 / 155.00 m
Receiver height            :   4.50 / 4.50   m
Topography                 :      3       (Elevated; no barrier)
Elevation                  :   3.00 m
Reference angle            :   0.00

Results segment # 1: Pinecrest (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 62.65 + 0.00) = 62.65 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  72.16   0.00  -9.51   0.00   0.00   0.00   0.00  62.65
----------------------------------------------------------------------------

Segment Leq : 62.65 dBA

Results segment # 2: Queensway (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 70.40 + 0.00) = 70.40 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    16     90   0.00  84.41   0.00 -10.14  -3.86   0.00   0.00   0.00  70.40
----------------------------------------------------------------------------

Segment Leq : 70.40 dBA

Total Leq All Segments: 71.07 dBA

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

Source height = 1.50 m

ROAD (0.00 + 55.05 + 0.00) = 55.05 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  64.56   0.00  -9.51   0.00   0.00   0.00   0.00  55.05
----------------------------------------------------------------------------

Segment Leq : 55.05 dBA

Results segment # 2: Queensway (night)
```

```
--------------------------------------

Source height = 1.50 m

ROAD (0.00 + 62.81 + 0.00) = 62.81 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    16     90   0.00  76.81   0.00 -10.14  -3.86   0.00   0.00   0.00  62.81
----------------------------------------------------------------------------

Segment Leq : 62.81 dBA

Total Leq All Segments: 63.48 dBA

RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2          :   5.00 deg   90.00 deg
Wood depth               :      0       (No woods.)
No of house rows         :      0 / 0
Surface                  :      2       (Reflective ground surface)
Receiver source distance :  94.00 / 94.00  m
Receiver height          :   4.50 / 4.50   m
Topography               :      3       (Elevated; no barrier)
Elevation                :   3.00 m
Reference angle          :   0.00

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

Source height = 0.50 m

RT/Custom (0.00 + 52.21 + 0.00) = 52.21 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     5     90   0.00  63.44  -7.97  -3.26   0.00   0.00   0.00  52.21
----------------------------------------------------------------------

Segment Leq : 52.21 dBA

Total Leq All Segments: 52.21 dBA
```

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

Source height = 0.50 m

RT/Custom (0.00 + 45.68 + 0.00) = 45.68 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     5     90   0.00  56.91  -7.97  -3.26   0.00   0.00   0.00  45.68
----------------------------------------------------------------------

Segment Leq : 45.68 dBA

Total Leq All Segments: 45.68 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 71.13
                         (NIGHT): 63.55
```

```
STAMSON 5.0        NORMAL REPORT        Date: 26-05-2021 10:41:19
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R3.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Pinecrest (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 # 1: Pinecrest (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  : 127.00 / 127.00 m
Receiver height           :   4.50 / 4.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Road data, segment # 2: Queensway (day/night)
---------------------------------------------
Car traffic volume  : 118739/10325 veh/TimePeriod  *
Medium truck volume :  9445/821   veh/TimePeriod  *
Heavy truck volume  :  6747/587   veh/TimePeriod  *
Posted speed limit  :   100 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): 146664
    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: Queensway (day/night)
-------------------------------------------
Angle1   Angle2           :  16.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  : 204.00 / 204.00 m
Receiver height           :   4.50 / 4.50   m
Topography                :      3       (Elevated; no barrier)
Elevation                 :   3.00 m
Reference angle           :   0.00

Results segment # 1: Pinecrest (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 62.88 + 0.00) = 62.88 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  72.16   0.00  -9.28   0.00   0.00   0.00   0.00  62.88
----------------------------------------------------------------------------

Segment Leq : 62.88 dBA

Results segment # 2: Queensway (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 69.21 + 0.00) = 69.21 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    16     90   0.00  84.41   0.00 -11.34  -3.86   0.00   0.00   0.00  69.21
----------------------------------------------------------------------------

Segment Leq : 69.21 dBA

Total Leq All Segments: 70.12 dBA

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

Source height = 1.50 m

ROAD (0.00 + 55.29 + 0.00) = 55.29 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  64.56   0.00  -9.28   0.00   0.00   0.00   0.00  55.29
----------------------------------------------------------------------------

Segment Leq : 55.29 dBA
```

```
Results segment # 2: Queensway (night)
--------------------------------------

Source height = 1.50 m

ROAD (0.00 + 61.62 + 0.00) = 61.62 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    16     90   0.00  76.81   0.00 -11.34  -3.86   0.00   0.00   0.00  61.62
----------------------------------------------------------------------------

Segment Leq : 61.62 dBA

Total Leq All Segments: 62.53 dBA

RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2           :   5.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  : 144.00 / 144.00 m
Receiver height           :   4.50 / 4.50   m
Topography                :      3       (Elevated; no barrier)
Elevation                 :   3.00 m
Reference angle           :   0.00

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

Source height = 0.50 m

RT/Custom (0.00 + 50.36 + 0.00) = 50.36 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     5     90   0.00  63.44  -9.82  -3.26   0.00   0.00   0.00  50.36
----------------------------------------------------------------------

Segment Leq : 50.36 dBA

Total Leq All Segments: 50.36 dBA

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

Source height = 0.50 m

RT/Custom (0.00 + 43.82 + 0.00) = 43.82 dBA
```

```
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     5     90   0.00  56.91  -9.82  -3.26   0.00   0.00   0.00  43.82
----------------------------------------------------------------------

Segment Leq : 43.82 dBA

Total Leq All Segments: 43.82 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 70.16
                         (NIGHT): 62.59
```

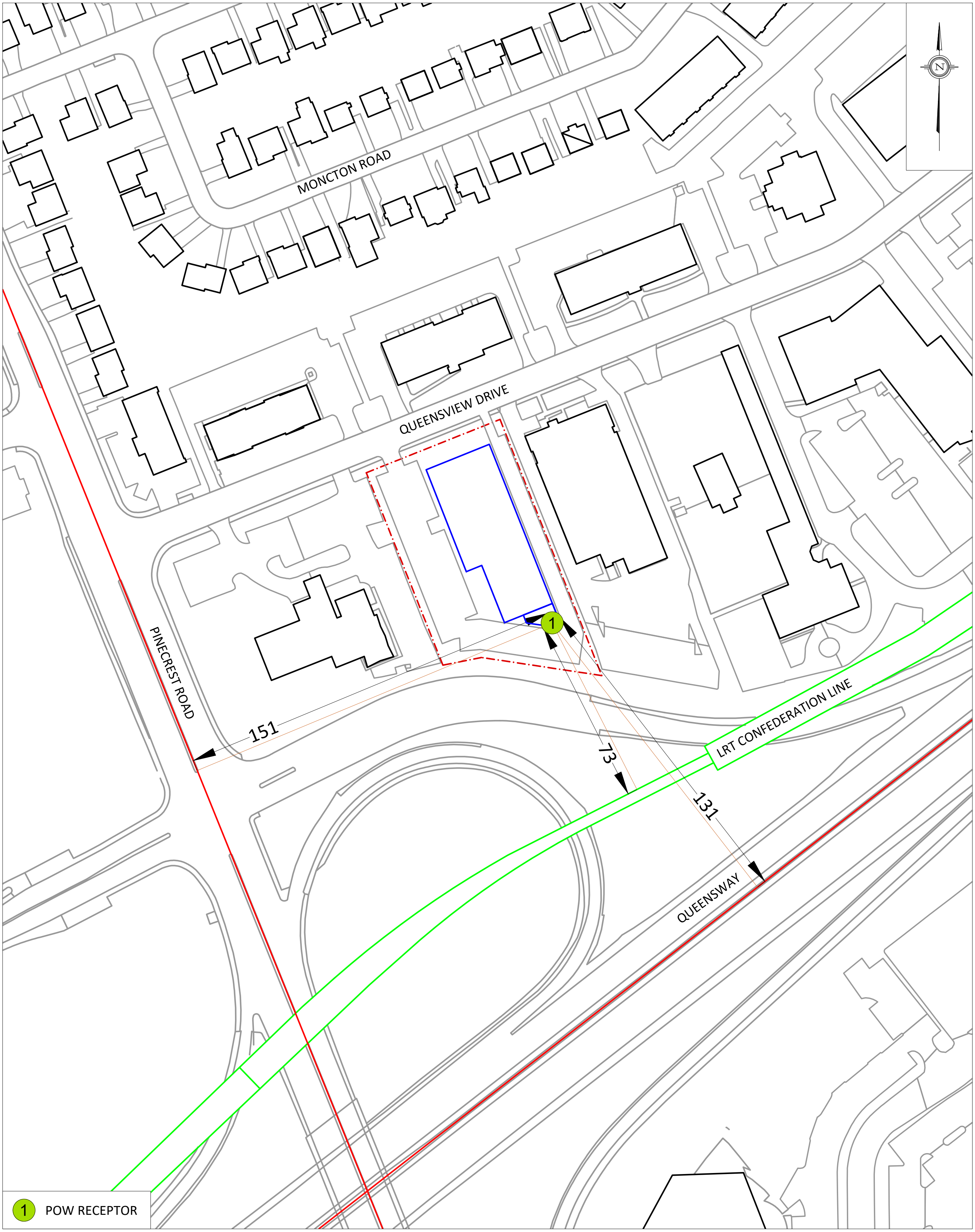
```
STAMSON 5.0        NORMAL REPORT        Date: 26-05-2021 10:45:13
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R4.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Pinecrest (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 # 1: Pinecrest (day/night)
-------------------------------------------
Angle1   Angle2           :   0.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  : 133.00 / 133.00 m
Receiver height           :   4.50 / 4.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Results segment # 1: Pinecrest (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 59.67 + 0.00) = 59.67 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     0     90   0.00  72.16   0.00  -9.48  -3.01   0.00   0.00   0.00  59.67
----------------------------------------------------------------------------

Segment Leq : 59.67 dBA

Total Leq All Segments: 59.67 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 52.08 + 0.00) = 52.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     0     90   0.00  64.56   0.00  -9.48  -3.01   0.00   0.00   0.00  52.08
----------------------------------------------------------------------------

Segment Leq : 52.08 dBA

Total Leq All Segments: 52.08 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 59.67
                         (NIGHT): 52.08
```

```
STAMSON 5.0        NORMAL REPORT        Date: 26-05-2021 10:53:03
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Queensway (day/night)
--------------------------------------------
Car traffic volume  : 118739/10325 veh/TimePeriod  *
Medium truck volume :  9445/821   veh/TimePeriod  *
Heavy truck volume  :  6747/587   veh/TimePeriod  *
Posted speed limit  :   100 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): 146664
    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: Queensway (day/night)
------------------------------------------
Angle1   Angle2           : -90.00 deg   16.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  : 140.00 / 140.00 m
Receiver height           :   4.50 / 4.50   m
Topography                :      3       (Elevated; no barrier)
Elevation                 :   3.00 m
Reference angle           :   0.00

Results segment # 1: Queensway (day)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 72.41 + 0.00) = 72.41 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     16   0.00  84.41   0.00  -9.70  -2.30   0.00   0.00   0.00  72.41
----------------------------------------------------------------------------

Segment Leq : 72.41 dBA

Total Leq All Segments: 72.41 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 64.81 + 0.00) = 64.81 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     16   0.00  76.81   0.00  -9.70  -2.30   0.00   0.00   0.00  64.81
----------------------------------------------------------------------------

Segment Leq : 64.81 dBA

Total Leq All Segments: 64.81 dBA
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2          : -90.00 deg   5.00 deg
Wood depth               :      0       (No woods.)
No of house rows         :      0 / 0
Surface                  :      2       (Reflective ground surface)
Receiver source distance :  83.00 / 83.00  m
Receiver height          :   4.50 / 4.50   m
Topography               :      3       (Elevated; no barrier)
Elevation                :   3.00 m
Reference angle          :   0.00

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

Source height = 0.50 m

RT/Custom (0.00 + 53.23 + 0.00) = 53.23 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      5   0.00  63.44  -7.43  -2.78   0.00   0.00   0.00  53.23
----------------------------------------------------------------------

Segment Leq : 53.23 dBA

Total Leq All Segments: 53.23 dBA

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

Source height = 0.50 m
```

```
RT/Custom (0.00 + 46.70 + 0.00) = 46.70 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      5   0.00  56.91  -7.43  -2.78   0.00   0.00   0.00  46.70
----------------------------------------------------------------------

Segment Leq : 46.70 dBA

Total Leq All Segments: 46.70 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 72.46
                         (NIGHT): 64.88
```



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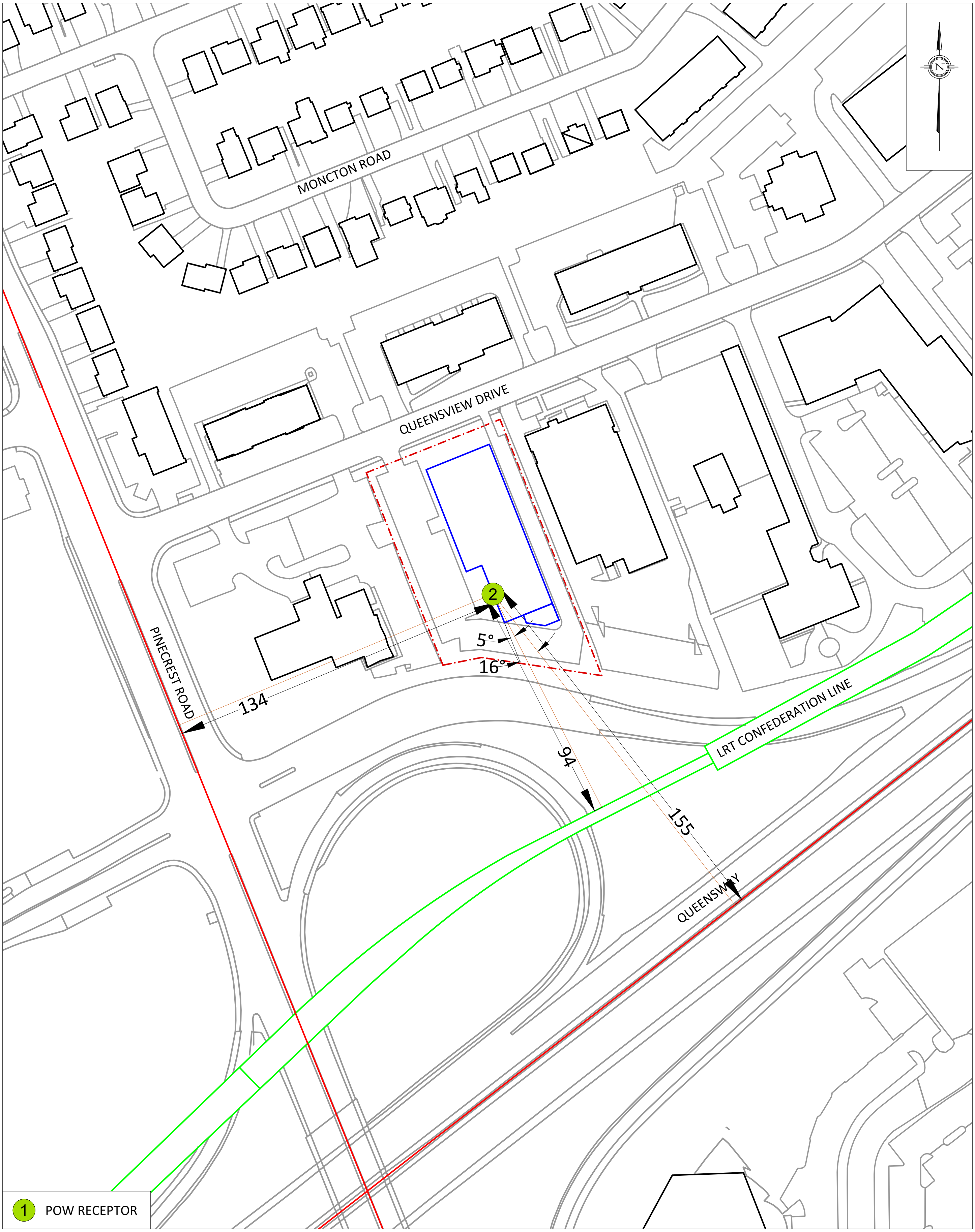
SCALE	1:2000 (APPROX.)
DRAWING NO.	GWE21-159-A1
DATE	MAY 27, 2021
DRAWN BY	T.M.F.
DESCRIPTION	FIGURE A1: TRANSPORTATION NOISE RECEPTOR 1 STAMSON INPUT PARAMETERS



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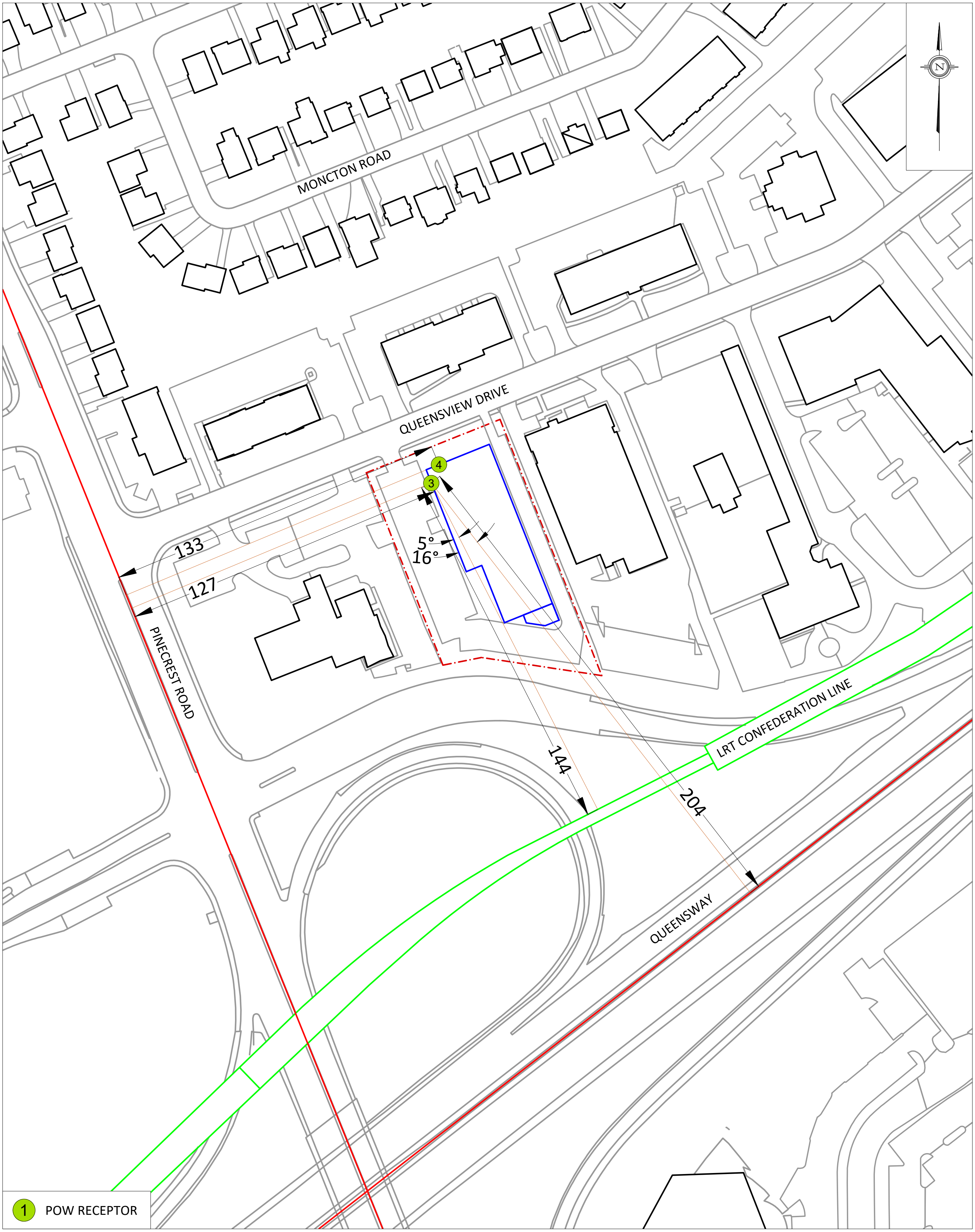
SCALE	1:2000 (APPROX.)	DRAWING NO.	GWE21-159-A2
DATE	MAY 27, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE A2:
TRANSPORTATION NOISE RECEPTOR 2 STAMSON INPUT PARAMETERS



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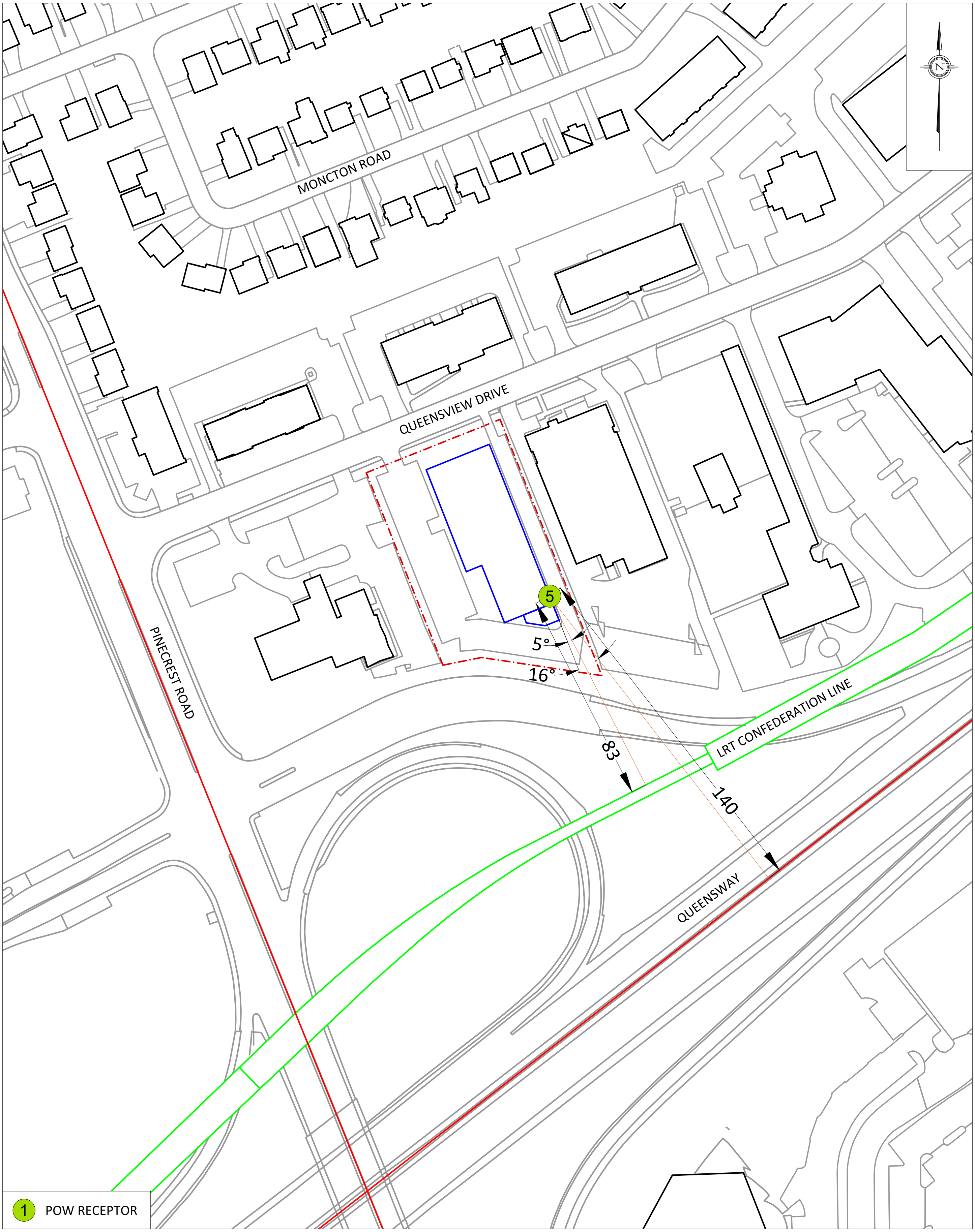
DATE	MAY 27, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE A3:
TRANSPORTATION NOISE RECEPTORS 3 AND 4
STAMSON INPUT PARAMETERS



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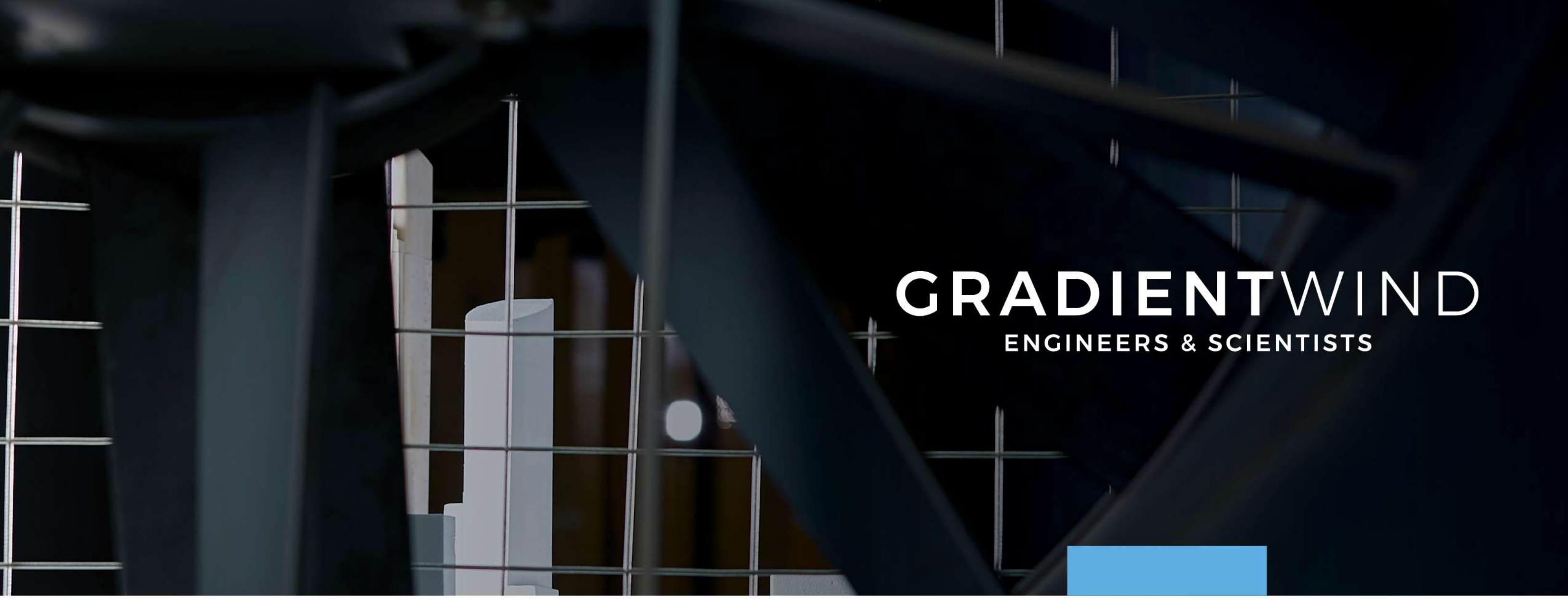
SCALE 1:2000 (APPROX.)	DRAWING NO. GWE21-159-A4	
DATE MAY 27, 2021	DRAWN BY T.M.F.	

DESCRIPTION

FIGURE A4:
TRANSPORTATION NOISE RECEPTOR 5 STAMSON INPUT PARAMETERS



APPENDIX B

FTA VIBRATION CALCULATIONS

GW21-159 18-Aug-21

Possible Vibration Impacts on 2740 Queensview Drive
Predicted using FTA General Assesment

Train Speed 70 km/h 43.4 mph

	Distance	
	(m)	(ft)
LRT	72.0	236.2

Vibration

From FTA Manual Fig 10-1

Vibration Levels at distance from tra	59	dBV re 1 micro in/sec	

Adjustment Factors FTA Table 10-1

Speed reference 50 mph	-1	Train at full speed 70 km/h (43.4 mph)	
Vehicle Parameters	0	Assume Soft primary suspension, Wheels run true	
Track Condition	0	None	
Track Treatments	0	None	
Type of Transit Structure	0	None	
Efficient vibration Propagation	0	None	
Vibration Levels at Fdn	58		0.020
Coupling to Building Foundation	0	Founded in rock	
Floor to Floor Attenuation	-1.0	Ground Floor Occupied	
Amplification of Floor and Walls	6		
Total Vibration Level	63	dBV or	0.036 mm/s
Noise Level in dBA	28	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.