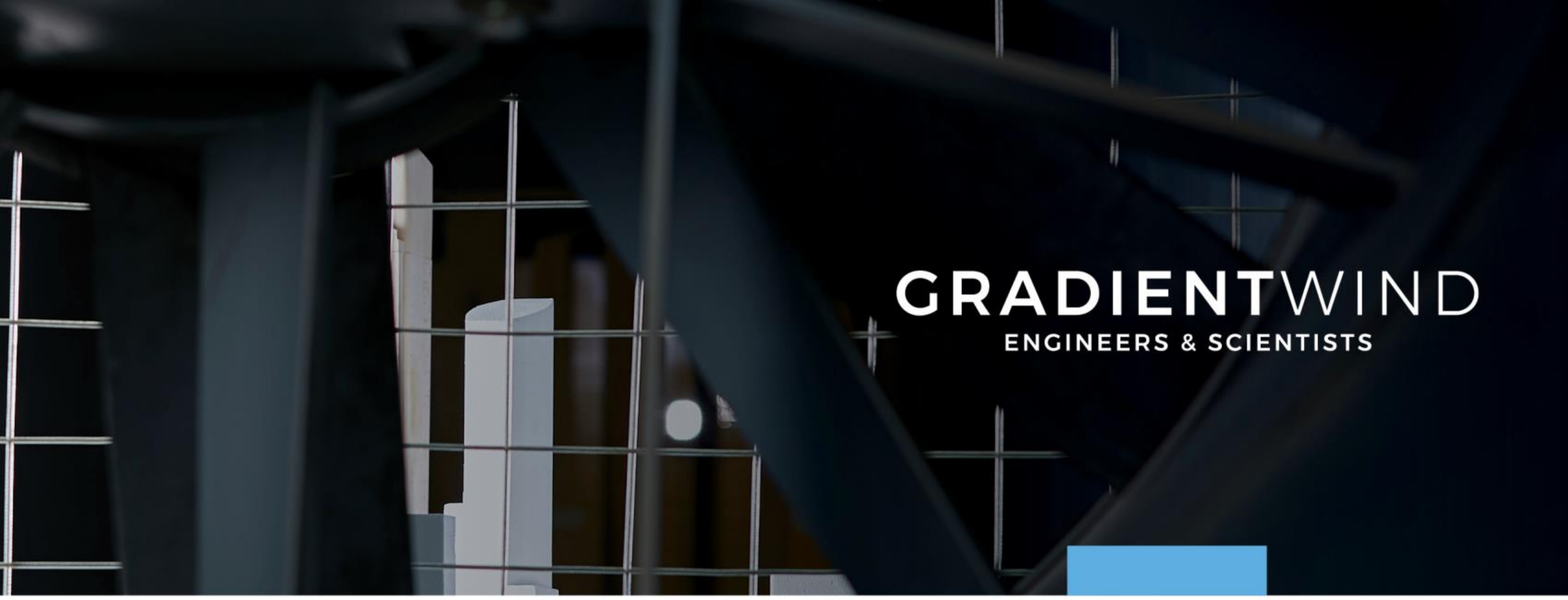
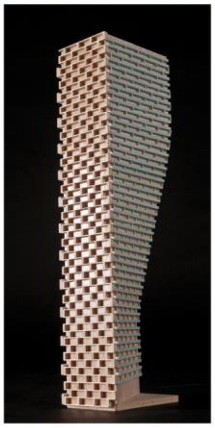


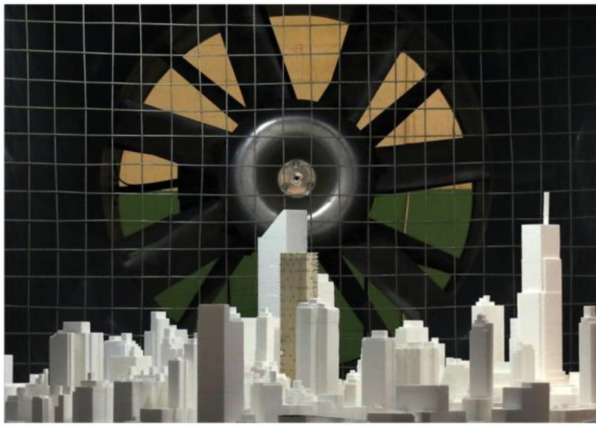
GRADIENTWIND
ENGINEERS & SCIENTISTS

TRANSPORTATION NOISE AND VIBRATION FEASIBILITY ASSESSMENT

2046-2050 Scott Street
Ottawa, Ontario

Report: 19-246-Noise & Vibration Feasibility





April 24, 2020

PREPARED FOR
Scott Street Developments Inc.
88 Spadina Avenue
Ottawa, ON K1Y 2C1

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

EXECUTIVE SUMMARY

This feasibility report describes a transportation noise and vibration assessment undertaken in support of a Zoning By-Law Amendment (ZBA) for a proposed mixed-use development located at 2050 Scott Street in Ottawa, Ontario. The proposed development comprises a 30-storey building with an irregular planform at grade. A 3-storey podium is located at the south of the building. The building steps back on all elevations at Level 7, with a common amenity space atop the 6-storey podium. The tower planform is nearly consistent up to Level 30. The ground floor comprises commercial, amenity, lobby, and residential space, while Levels 2 and above comprise residential units. The primary sources of transportation noise are Scott Street and the future Light Rail Transit (LRT) corridor operated by the OC Transpo. The report also provides an analysis of ground borne vibration impacts from light rail traffic from the transit corridor toward the north. Figure 1 illustrates a complete site plan with surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the Ministry of the Environment, Conservation and Parks (MECP) 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; (iv) ground borne vibration criteria as specified by the Federal Transit Authority (FTA) Protocol; and (v) site plan drawings prepared by RLA Architecture.

The results of the current analysis indicate that noise levels will range between 55 and 69 dBA during the daytime period (07:00-23:00) and between 48 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs at the north façade, which is nearest, and most exposed to Scott Street. Upgraded building components, including STC rated glazing elements and exterior walls, will be required along the building's north and west façades, where noise levels exceed 65 dBA. Based on the current plans, noise levels at the 7th Floor terrace are expected fall below the ENCG 55 dBA criteria. Should the terrace configuration change significantly, mitigation can be explored during detailed analysis.

Results of the calculations also indicate that the development will require 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 be placed on all Lease, Purchase and Sale

Agreements. A detailed roadway traffic noise study will be required at the time of site plan approval to determine specific noise control measures for the development.

Estimated vibration levels at the foundation nearest to the LRT on Scott Street are expected to be 0.017 mm/s RMS (58 dBV), based on the FTA protocol and an offset distance of 46 m to the nearest track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.10 mm/s RMS at the foundation, concerns due to vibration impacts on the site are not expected. As vibration levels are acceptable, correspondingly, regenerated noise levels are also expected to be acceptable.

Noise impacts from the building itself on sensitive areas around the building are expected to be minimal and a detailed acoustic report will address any potential concerns. This report will be competed once the mechanical information for the building is known. Typically, noise levels can be controlled by judicious selection and placement of the equipment and the introduction of silencers or noise screens where needed.

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TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Scott Street Developments Inc. to undertake a transportation noise and vibration feasibility assessment in support of a Zoning By-Law Amendment (ZBA) for a proposed mixed-use development at 2046-2050 Scott Street in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations related to the assessment of exterior and interior noise levels generated by local roadway and light rail 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 architectural drawings prepared by RLA Architecture, with future vehicle and light rail traffic volumes corresponding to the City of Ottawa's Official Plan (OP) roadway classifications.

2. TERMS OF REFERENCE

The focus of this transportation and vibration noise feasibility assessment is a proposed mixed-use development at 2046-2050 Scott Street in Ottawa, Ontario. The study site is located on a nearly rectangular parcel of land south of Scott Street between Athlone Street and Winona Avenue.

The proposed development comprises a 30-storey building with an irregular planform at grade. A 3-storey podium is located at the south of the building. The building steps back on all elevations at Level 7, with a common amenity space atop the 6-storey podium. The tower planform is nearly consistent up to Level 30. The ground floor comprises commercial, amenity, lobby, and residential space, while Levels 2 and above comprise residential units.

The site is surrounded by low and medium rise residential buildings, as well as commercial property immediately east. The primary sources of transportation noise are Scott Street and the future Light Rail Transit (LRT) corridor operated by the OC Transpo. The report also provides an analysis of ground borne vibration impacts from light rail traffic from the transit corridor toward the north. Figure 1 illustrates a complete site plan with surrounding context.

[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

3. OBJECTIVES

The principal objectives of this study are to (i) calculate the future noise levels on the study buildings produced by local transportation traffic, (ii) predict vibration levels on the study building produced from passing light rail trains, (iii) ensure that interior and exterior 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, and (iv) ensure vibration levels do not exceed the allowable limits specified by the FTA.

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 Traffic Noise

4.2.1 Criteria for Transportation Traffic Noise

For surface transportation 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 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, 45 and 40 dBA for retail, living rooms, and sleeping quarters respectively as listed in Table 1. However, to account for deficiencies in building construction and control peak noise, these levels should be targeted toward 47, 42 and 37 dBA respectively.

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

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 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.

[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] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8
[6] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3

4.2.2 Theoretical Roadway Noise Predictions

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

Transportation 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 due to the presence of hard (paved) ground.
- Topography was assumed to be a flat/gentle slope surrounding the study building. The LRT sits approximately 5 m below grade in an open trench.
- Noise receptors were strategically placed at 4 locations around the study area (see Figure 2).
- Receptor distances and exposure angles are illustrated in Figures 3-4.
- LRT noise assessed in STAMSON using RT Custom based on 4 car SRT.

4.2.1 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[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. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment.

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

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway Traffic Data	Speed Limit (km/h)	Traffic Volumes
Scott Street	2-Lane Urban Arterial (2-UAU)	50	**15,000**
O-Train (Confederation Line)	Light Rail Transit (LRT)	70	**540/60***

* Daytime/Nighttime volumes based on the City of Ottawa's Environmental Assessment for the LRT Project

4.3 Ground Vibration and Ground-borne Noise

Rail systems and heavy vehicles on roadways can produce perceptible levels of ground vibrations, especially when they are in close proximity to residential neighbourhoods or vibration-sensitive buildings. Similar to sound waves in air, vibrations in solids are generated at a source, propagated through a medium, and intercepted by a receiver. In the case of ground vibrations, the medium can be uniform, or more 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 the MECP. These standards indicate that the appropriate criteria for residences is 0.10 mm/s RMS for vibrations. For main line railways, a document titled *Guidelines for New Development in Proximity to Railway Operations*[8], indicates that vibration conditions should not exceed 0.14 mm/s RMS averaged over a one second time-period at the first floor and above of the proposed building. The Federal Transportation Authority (FTA) criterion was adopted as the appropriate standard for this study. As the main vibration source is due to the light rail line which has 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

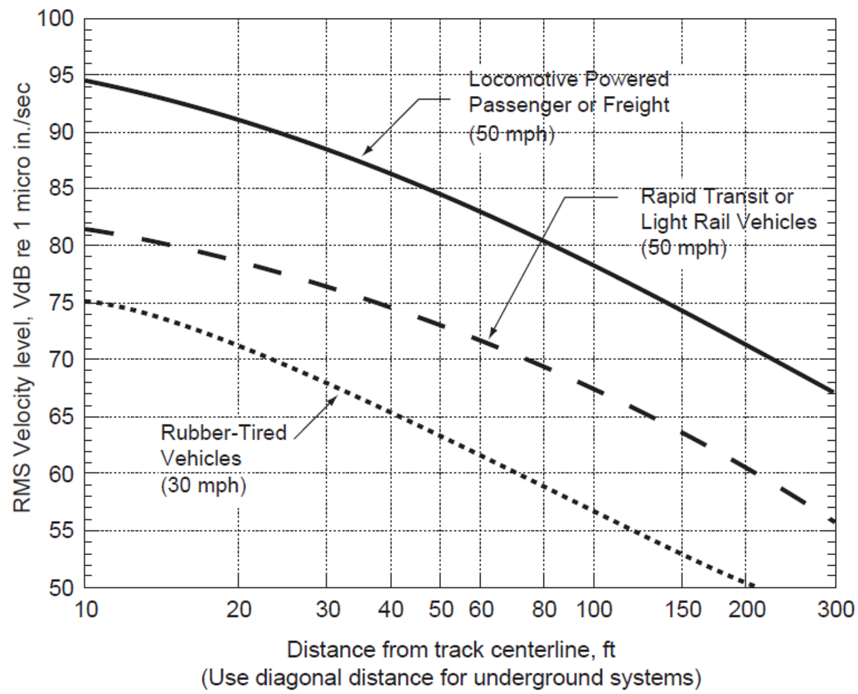
Potential vibration impacts of the trains were predicted using the Federal Transit Authority's (FTA) *Transit Noise and Vibration Impact Assessment*[9] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure on the following page, are based on ground vibration measurements at various transit systems throughout North America. Vibration levels at points of reception are adjusted by various factors to incorporate known characteristics of the system being analyzed, such as operating speed of vehicle, conditions of the track, construction of the track and geology, as well as the structural type of the impacted building structures. The vibration impact on the building was determined using a set of curves for LRT at a speed of 50 mph. Adjustment factors were considered based on the following information:

---

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

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

- The maximum operating speed of the light rail assumed to be 43 mph (70 km/h) at peak
- The offset distance between the development and the closest track is 40 m
- The vehicles are assumed to have soft primary suspensions
- Tracks are not welded, though in otherwise good condition
- Soil conditions do not efficiently propagate vibrations
- The building's foundation coupling is large masonry on piles



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 traffic noise calculations are summarized in Table 3 below. A complete set of input and output data from all STAMSON 5.04 calculations are available in Appendix A.

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROAD TRAFFIC

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	STAMSON 5.04 Noise Level (dBA)	
			Day	Night
1	1.5	POW – 25th Floor – North Façade	69	61
2	1.5	POW – 25th Floor – East Façade	65	57
3	1.5	POW – 25th Floor – West Façade	66	59
4	75.3	OLA – 7th Floor Terrace	55	48

The results of the current analysis indicate that noise levels will range between 55 and 69 dBA during the daytime period (07:00-23:00) and between 48 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs at the north façade, which is nearest, and most exposed to Scott Street. Upgraded building components and air conditioning will be required. Based on the current plans, noise levels at the 7th Floor terrace are expected fall below the ENCG 55 dBA criteria. Detailed mitigation measures would be subject of a detailed noise assessment during the site plan approval stage.

5.2 Ground Vibrations and Ground-Borne Noise Levels

Estimated vibration levels at the foundation nearest to the LRT on Scott Street are expected to be 0.017 mm/s RMS (58 dBV), based on the FTA protocol and an offset distance of 46 m to the nearest track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.10 mm/s RMS at the foundation, concerns due to vibration impacts on the site are not expected. As vibration levels are acceptable, correspondingly, regenerated noise levels are also expected to be acceptable.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 55 and 69 dBA during the daytime period (07:00-23:00) and between 48 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs at the north façade, which is nearest, and most exposed to Scott Street. Upgraded building components, including STC rated glazing elements and exterior walls, will be required along the building's north and west façades, where noise levels exceed 65 dBA. Based on the current plans, noise levels at the 7th Floor terrace are expected fall below the ENCG 55 dBA criteria. Should the terrace configuration change significantly, mitigation can be explored during detailed analysis.

Results of the calculations also indicate that the development will require 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 be placed on all Lease, Purchase and Sale Agreements. A detailed roadway traffic noise study will be required at the time of site plan approval to determine specific noise control measures for the development.

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Noise impacts from the building itself on sensitive areas around the building are expected to be minimal and a detailed acoustic report will address any potential concerns. This report will be competed once the mechanical information for the building is known. Typically, noise levels can be controlled by judicious selection and placement of the equipment and the introduction of silencers or noise screens where needed.

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.

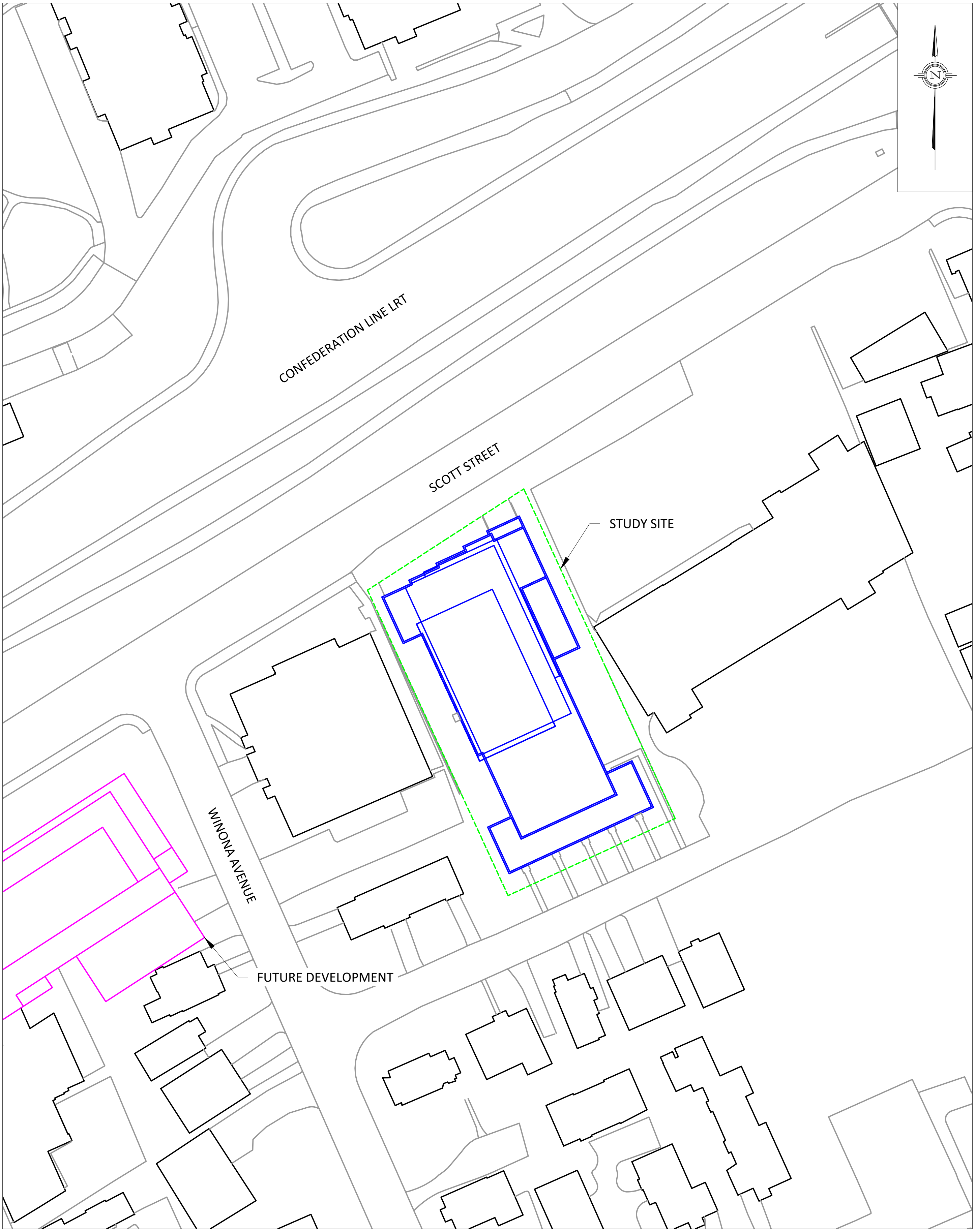
Sincerely,

Gradient Wind Engineering Inc.

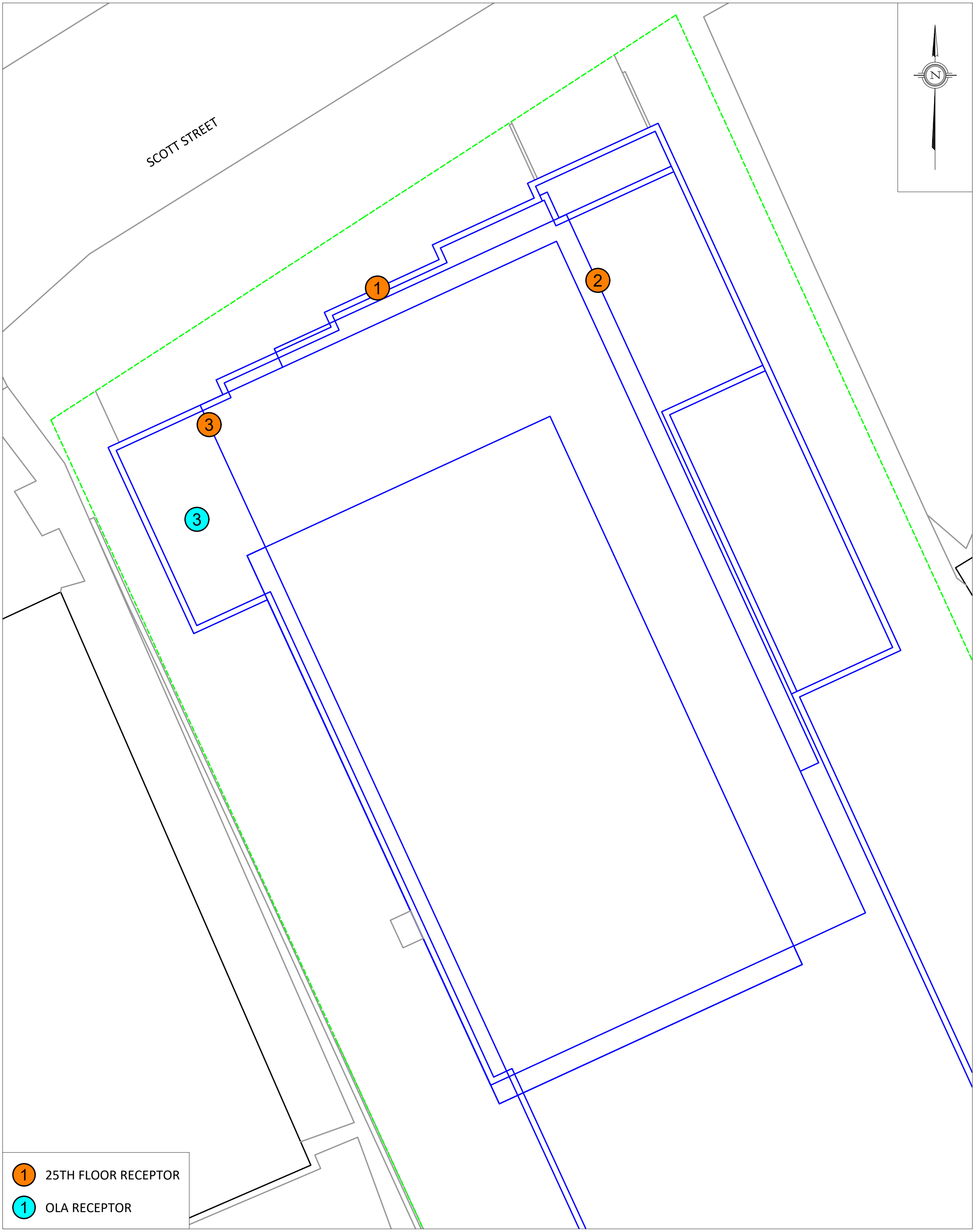
Michael Lafortune, C.E.T.
Environmental Scientist

Joshua Foster, P.Eng.
Principal

Gradient Wind File #19-246 – Noise & Vibration Feasibility



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 2050 SCOTT STREET, OTTAWA TRANSPORTATION NOISE & VIBRATION FEASIBILITY ASSESSMENT		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
	SCALE: 1:1000 (APPROX.)	DRAWING NO. GWE19-246-1	
	DATE: APRIL 24, 2020	DRAWN BY: M.L.	



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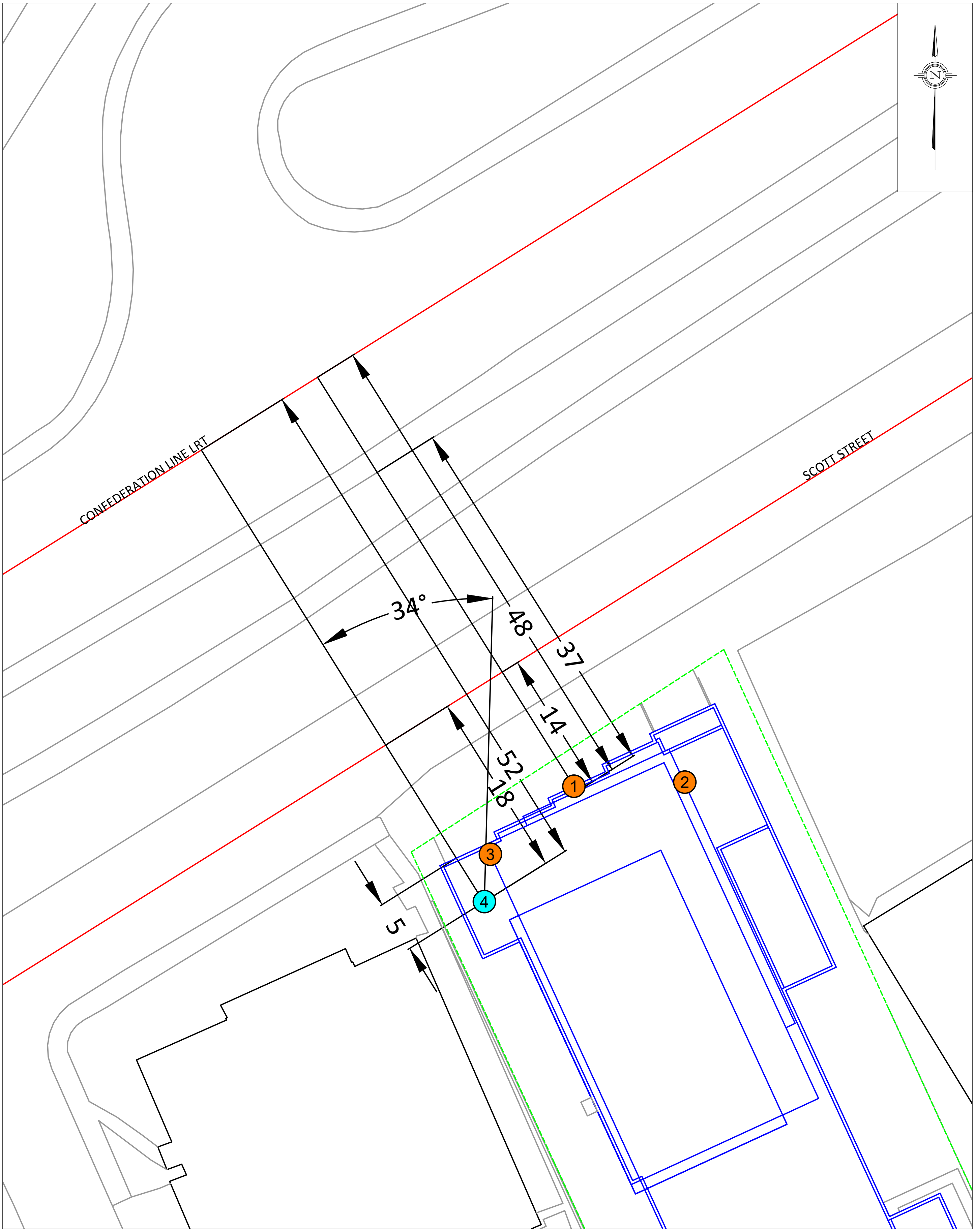
PROJECT	2050 SCOTT STREET, OTTAWA TRANSPORTATION NOISE & VIBRATION FEASIBILITY ASSESSMENT
SCALE	1:250 (APPROX.)
DRAWING NO.	GWE19-246-2
DATE	APRIL 24, 2020
DRAWN BY	M.L.
DESCRIPTION	FIGURE 2: RECEPTOR LOCATIONS



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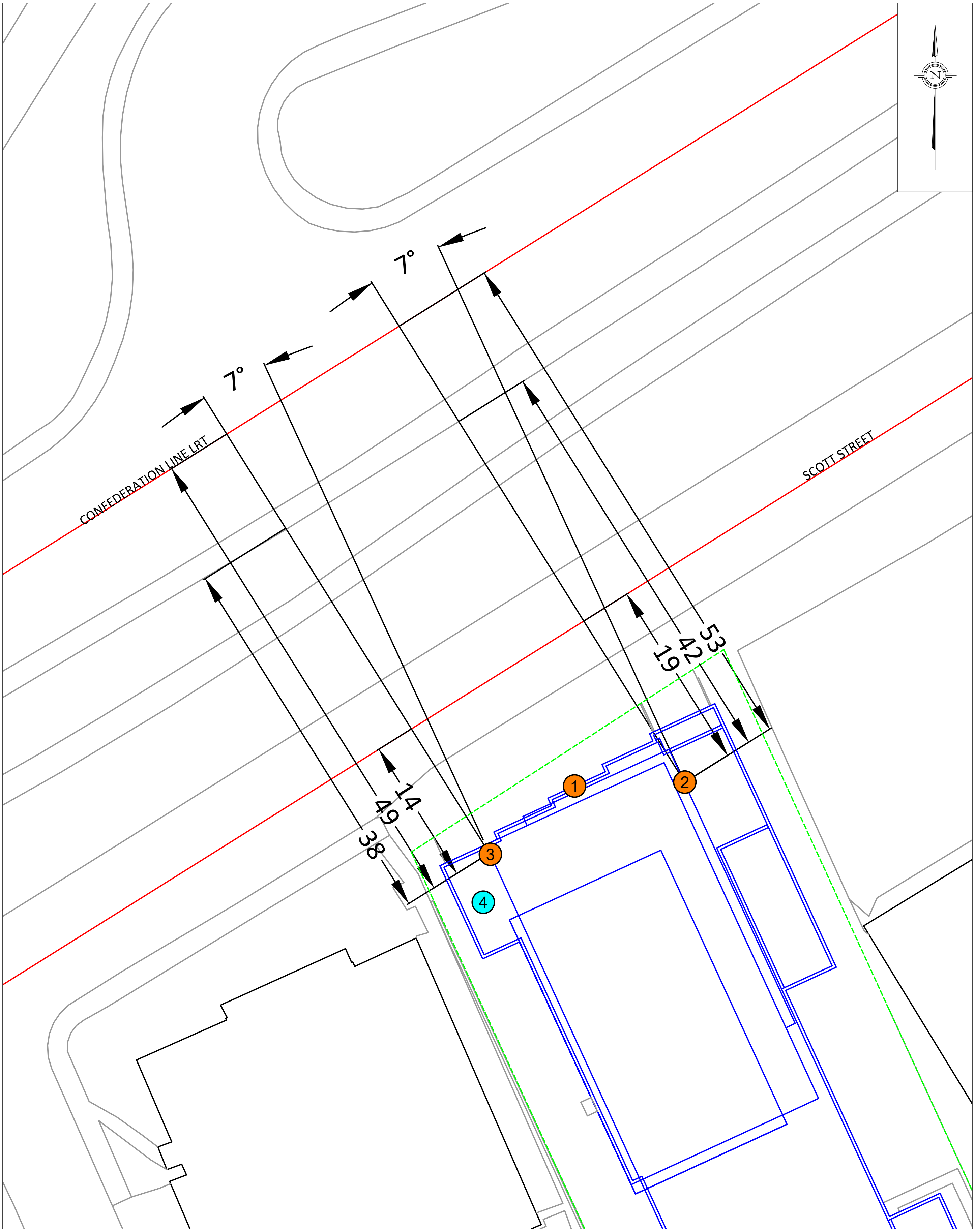
PROJECT		DESCRIPTION
2050 SCOTT STREET, OTTAWA TRANSPORTATION NOISE & VIBRATION FEASIBILITY ASSESSMENT		FIGURE 3: STAMSON INPUT PARAMETERS - RECEPTOR 1,4
SCALE 1:500 (APPROX.)	DRAWING NO. GWE19-246-3	
DATE APRIL 24, 2020	DRAWN BY M.L.	



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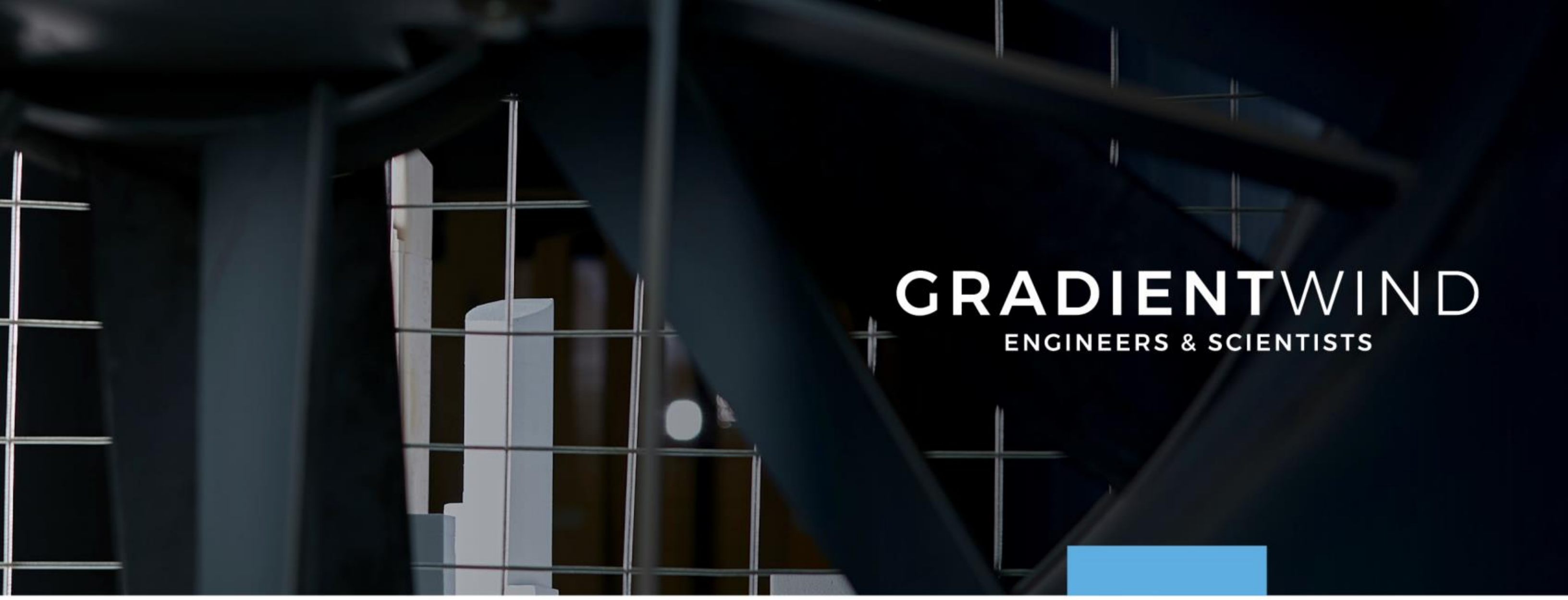
PROJECT: 2050 SCOTT STREET, OTTAWA TRANSPORTATION NOISE & VIBRATION FEASIBILITY ASSESSMENT		DESCRIPTION: FIGURE 4: STAMSON INPUT PARAMETERS - RECEPTOR 2,3
SCALE: 1:500 (APPROX.)	DRAWING NO.: GWE19-246-4	
DATE: APRIL 24, 2020	DRAWN BY: M.L.	



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: 12-12-2019 16:22:32
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r1.te                Time Period: Day/Night 16/8 hours
Description:


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

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

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

Data for Segment # 1: Scott (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  :  15.00 / 15.00  m
Receiver height           :  72.30 / 72.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

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

Source height = 1.50 m

ROAD (0.00 + 68.48 + 0.00) = 68.48 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  68.48   0.00   0.00   0.00   0.00   0.00   0.00  68.48
----------------------------------------------------------------------------

Segment Leq : 68.48 dBA

Total Leq All Segments: 68.48 dBA


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

Source height = 1.50 m

ROAD (0.00 + 60.88 + 0.00) = 60.88 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     90   0.00  60.88   0.00   0.00   0.00   0.00   0.00   0.00  60.88
----------------------------------------------------------------------------

Segment Leq : 60.88 dBA

Total Leq All Segments: 60.88 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  :  48.00 / 48.00  m
Receiver height           :  72.30 / 72.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :   5.00 m
Barrier receiver distance :  37.00 / 37.00  m
Source elevation          :  -5.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :  -5.00 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 !       72.30 !       18.10 !        13.10

RT/Custom (0.00 + 58.39 + 0.00) = 58.39 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -5.05   0.00   0.00   0.00  -0.03  58.35*
   -90     90   0.00  63.44  -5.05   0.00   0.00   0.00   0.00  58.39
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 58.39 dBA

Total Leq All Segments: 58.39 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 !       72.30 !       18.10 !        13.10

RT/Custom (0.00 + 51.85 + 0.00) = 51.85 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -5.05   0.00   0.00   0.00  -0.03  51.82*
   -90     90   0.00  56.91  -5.05   0.00   0.00   0.00   0.00  51.85
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 51.85 dBA

Total Leq All Segments: 51.85 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 68.89
                         (NIGHT): 61.39
```

```
STAMSON 5.0        NORMAL REPORT        Date: 12-12-2019 16:22:36
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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


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

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

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

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           :   7.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  19.00 / 19.00  m
Receiver height           :  72.30 / 72.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

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

Source height = 1.50 m

ROAD (0.00 + 64.09 + 0.00) = 64.09 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     7     90   0.00  68.48   0.00  -1.03  -3.36   0.00   0.00   0.00  64.09
----------------------------------------------------------------------------

Segment Leq : 64.09 dBA

Total Leq All Segments: 64.09 dBA


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

Source height = 1.50 m

ROAD (0.00 + 56.49 + 0.00) = 56.49 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     7     90   0.00  60.88   0.00  -1.03  -3.36   0.00   0.00   0.00  56.49
----------------------------------------------------------------------------

Segment Leq : 56.49 dBA

Total Leq All Segments: 56.49 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           :   7.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  53.00 / 53.00  m
Receiver height           :  72.30 / 72.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :   7.00 deg   Angle2 : 90.00 deg
Barrier height            :   5.00 m
Barrier receiver distance :  42.00 / 42.00  m
Source elevation          :  -5.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :  -5.00 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 !       72.30 !       16.44 !        11.44

RT/Custom (0.00 + 54.59 + 0.00) = 54.59 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     7     90   0.00  63.44  -5.48  -3.36   0.00   0.00  -0.04  54.55*
     7     90   0.00  63.44  -5.48  -3.36   0.00   0.00   0.00  54.59
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 54.59 dBA

Total Leq All Segments: 54.59 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 !       72.30 !       16.44 !        11.44

RT/Custom (0.00 + 48.06 + 0.00) = 48.06 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     7     90   0.00  56.91  -5.48  -3.36   0.00   0.00  -0.04  48.02*
     7     90   0.00  56.91  -5.48  -3.36   0.00   0.00   0.00  48.06
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 48.06 dBA

Total Leq All Segments: 48.06 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 64.55
                         (NIGHT): 57.07
```

```
STAMSON 5.0        NORMAL REPORT        Date: 12-12-2019 16:22:42
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r3.te               Time Period: Day/Night 16/8 hours
Description:


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

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

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

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   7.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  15.00 / 15.00  m
Receiver height           :  72.30 / 72.30  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

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

Source height = 1.50 m

ROAD (0.00 + 65.80 + 0.00) = 65.80 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      7   0.00  68.48   0.00   0.00  -2.69   0.00   0.00   0.00  65.80
----------------------------------------------------------------------------

Segment Leq : 65.80 dBA

Total Leq All Segments: 65.80 dBA


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

Source height = 1.50 m

ROAD (0.00 + 58.20 + 0.00) = 58.20 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      7   0.00  60.88   0.00   0.00  -2.69   0.00   0.00   0.00  58.20
----------------------------------------------------------------------------

Segment Leq : 58.20 dBA

Total Leq All Segments: 58.20 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   7.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  49.00 / 49.00  m
Receiver height           :  72.30 / 72.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 7.00 deg
Barrier height            :   5.00 m
Barrier receiver distance :  38.00 / 38.00  m
Source elevation          :  -5.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :  -5.00 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 !       72.30 !       17.74 !        12.74

RT/Custom (0.00 + 55.61 + 0.00) = 55.61 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      7   0.00  63.44  -5.14  -2.69   0.00   0.00  -0.03  55.58*
   -90      7   0.00  63.44  -5.14  -2.69   0.00   0.00   0.00  55.61
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 55.61 dBA

Total Leq All Segments: 55.61 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 !       72.30 !       17.74 !        12.74

RT/Custom (0.00 + 49.08 + 0.00) = 49.08 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      7   0.00  56.91  -5.14  -2.69   0.00   0.00  -0.03  49.05*
   -90      7   0.00  56.91  -5.14  -2.69   0.00   0.00   0.00  49.08
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 49.08 dBA

Total Leq All Segments: 49.08 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 66.20
                         (NIGHT): 58.70
```

```
STAMSON 5.0        NORMAL REPORT        Date: 24-04-2020 10:07:02
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r4n.te               Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Scott1 (day/night)
------------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

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

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

Data for Segment # 1: Scott1 (day/night)
----------------------------------------
Angle1   Angle2           : -90.00 deg   34.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  18.00 / 18.00  m
Receiver height           :  18.30 / 18.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 34.00 deg
Barrier height            :  16.80 m
Barrier receiver distance :   5.00 / 5.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Road data, segment # 2: Scott2 (day/night)
------------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

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

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

Data for Segment # 2: Scott2 (day/night)
----------------------------------------
Angle1   Angle2           :  34.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  18.00 / 18.00  m
Receiver height           :  18.30 / 18.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  34.00 deg   Angle2 : 90.00 deg
Barrier height            :  73.80 m
Barrier receiver distance :   5.00 / 5.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

Results segment # 1: Scott1 (day)

Source height = 1.50 m

Barrier height for grazing incidence

Source Height (m)	Receiver Height (m)	Barrier Height (m)	Elevation of Barrier Top (m)
1.50	18.30	13.63	13.63

ROAD (0.00 + 53.07 + 0.00) = 53.07 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	34	0.00	68.48	0.00	-0.79	-1.62	0.00	0.00	-13.00	53.07

Segment Leq : 53.07 dBA

Results segment # 2: Scott2 (day)

Source height = 1.50 m

Barrier height for grazing incidence

Source Height (m)	Receiver Height (m)	Barrier Height (m)	Elevation of Barrier Top (m)
1.50	18.30	13.63	13.63

ROAD (0.00 + 42.82 + 0.00) = 42.82 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
34	90	0.00	68.48	0.00	-0.79	-5.07	0.00	0.00	-19.79	42.82

Segment Leq : 42.82 dBA

Total Leq All Segments: 53.46 dBA

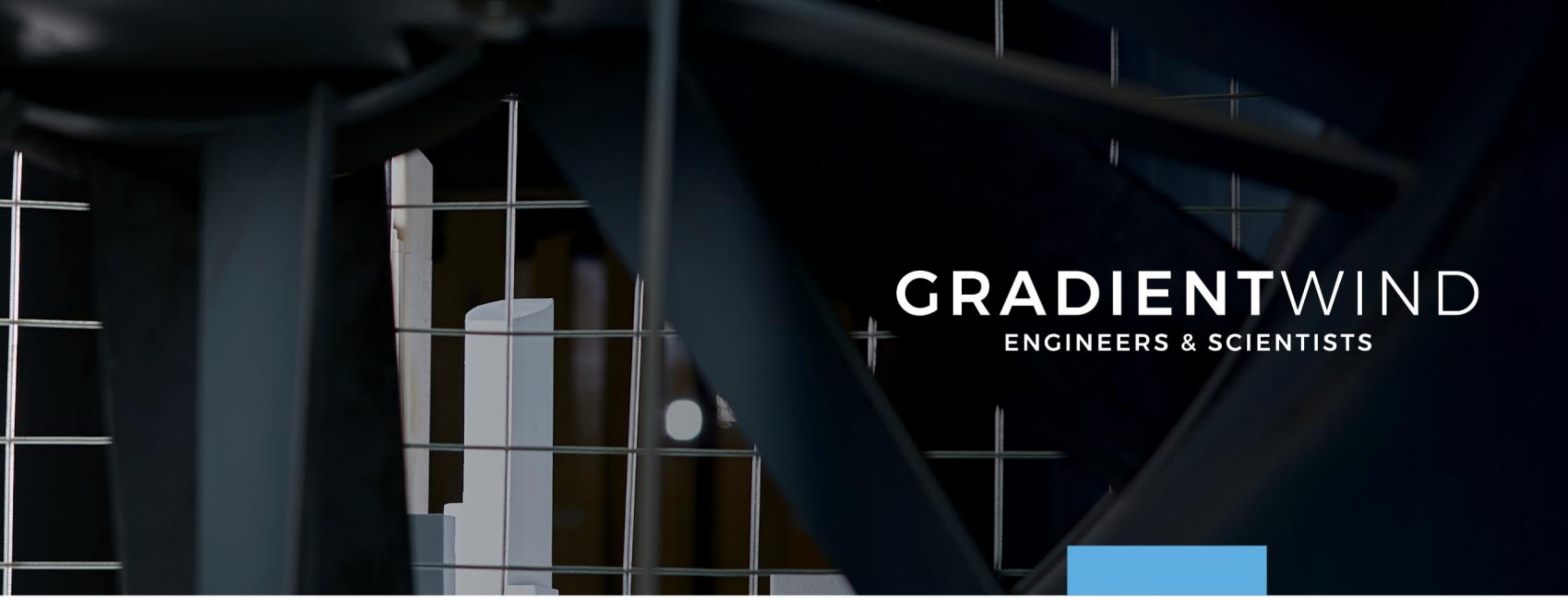
```
Results segment # 1: Scott1 (night)
-----------------------------------

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 !       18.30 !       13.63 !        13.63

ROAD (0.00 + 45.47 + 0.00) = 45.47 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     34   0.00  60.88   0.00  -0.79  -1.62   0.00   0.00 -13.00  45.47
----------------------------------------------------------------------------

Segment Leq : 45.47 dBA


Results segment # 2: Scott2 (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 !       18.30 !       13.63 !        13.63

ROAD (0.00 + 35.23 + 0.00) = 35.23 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
    34     90   0.00  60.88   0.00  -0.79  -5.07   0.00   0.00 -19.79  35.23
----------------------------------------------------------------------------

Segment Leq : 35.23 dBA

Total Leq All Segments: 45.86 dBA
```

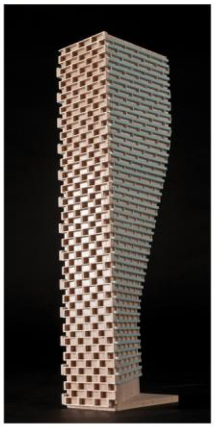
```
RT/Custom data, segment # 1: LRT1 (day/night)
---------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT1 (day/night)
--------------------------------------
Angle1   Angle2           : -90.00 deg   34.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  52.00 / 52.00  m
Receiver height           :  18.30 / 18.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 34.00 deg
Barrier height            :  16.80 m
Barrier receiver distance :   5.00 / 5.00   m
Source elevation          :  -5.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

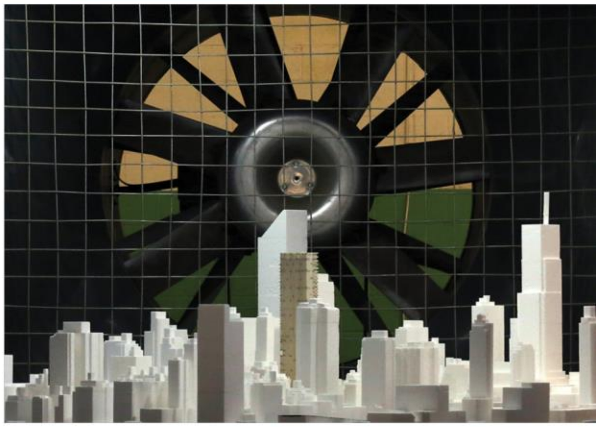
```
RT/Custom data, segment # 2: LRT2 (day/night)
---------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 2: LRT2 (day/night)
--------------------------------------
Angle1   Angle2           :  34.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  52.00 / 52.00  m
Receiver height           :  18.30 / 18.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  34.00 deg   Angle2 : 90.00 deg
Barrier height            :  73.80 m
Barrier receiver distance :   5.00 / 5.00   m
Source elevation          :  -5.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: LRT1 (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 !       18.30 !       16.11 !        16.11

RT/Custom (0.00 + 50.04 + 0.00) = 50.04 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     34   0.00  63.44  -5.40  -1.62   0.00   0.00  -6.38  50.04
----------------------------------------------------------------------

Segment Leq : 50.04 dBA


Results segment # 2: LRT2 (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 !       18.30 !       16.11 !        16.11

RT/Custom (0.00 + 33.20 + 0.00) = 33.20 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
    34     90   0.00  63.44  -5.40  -5.07   0.00   0.00 -19.76  33.20
----------------------------------------------------------------------

Segment Leq : 33.20 dBA

Total Leq All Segments: 50.13 dBA
```

```
Results segment # 1: LRT1 (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 !       18.30 !       16.11 !        16.11

RT/Custom (0.00 + 43.51 + 0.00) = 43.51 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     34   0.00  56.91  -5.40  -1.62   0.00   0.00  -6.38  43.51
----------------------------------------------------------------------

Segment Leq : 43.51 dBA


Results segment # 2: LRT2 (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 !       18.30 !       16.11 !        16.11

RT/Custom (0.00 + 26.67 + 0.00) = 26.67 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
    34     90   0.00  56.91  -5.40  -5.07   0.00   0.00 -19.76  26.67
----------------------------------------------------------------------

Segment Leq : 26.67 dBA

Total Leq All Segments: 43.60 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 55.12
                         (NIGHT): 47.89
```







APPENDIX B

FTA VIBRATION CALCULATIONS

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

GWE19-246 12-Dec-19

Possible Vibration Impacts on 2050 Scott Street
Perdicted using FTA General Assesment

Train Speed 70 km/h 43 mph

	Distance from C/L	
	(m)	(ft)
LRT	46.0	150.9

Vibration

From FTA Manual Fig 10-1			
Vibration Levels at distance from track	64	dBV re 1 micro in/sec	
Adjustment Factors FTA Table 10-1			
Speed reference 50 mph	-1	Speed Limit of 70 km/h (43 mph)	
Vehicle Parameters	0	None	
Track Condition	0	None	
Track Treatments	0	None	
Type of Transit Structure	0	None	
Efficient vibration Propagation	0	Propagation through rock	
Vibration Levels at Fdn	63		0.035
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	56.68997	dBV or	0.017 mm/s
Noise Level in dBA	21.68997	dBA	

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

Source Factor	Adjustment to Propagation Curve			Comment
Factors Affecting Vibration Source				
		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.