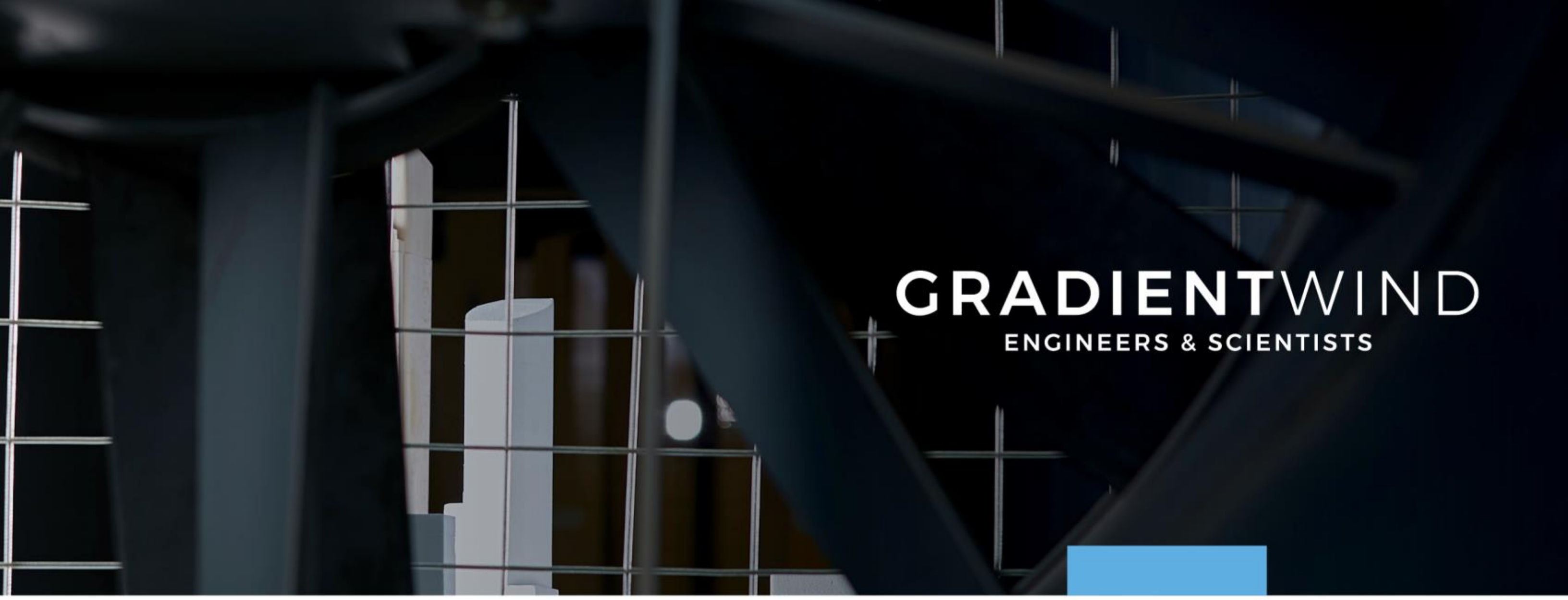
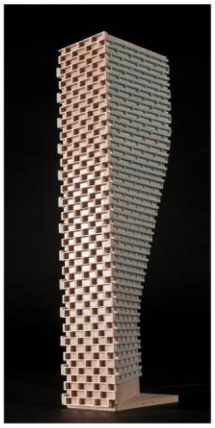
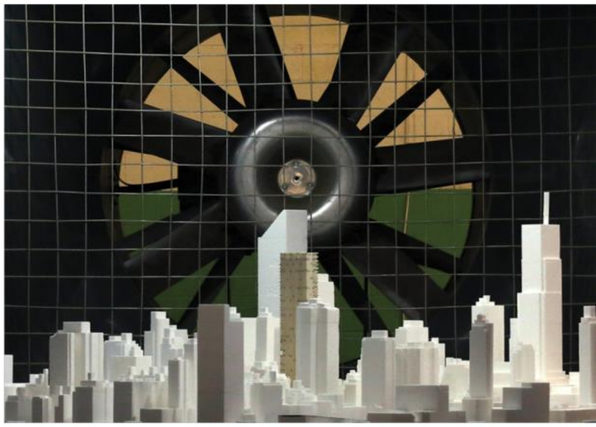


TRANSPORTATION NOISE AND VIBRATION FEASIBILITY ASSESSMENT

LeBreton Flats
Ottawa, Ontario

Report: 23-150- Transportation Noise and Vibration Feasibility





May 6, 2024

PREPARED FOR
Stantec Consulting Ltd.
400-1331 Clyde Avenue
Ottawa, ON K2C 3G4

PREPARED BY
Essraa Alqassab, BASc., Junior Environmental Scientist
Joshua Foster, P.Eng., Lead Engineer

EXECUTIVE SUMMARY

This report describes a roadway traffic noise and vibration feasibility assessment undertaken to satisfy the requirements a plan of subdivision application submission for the proposed development, known as LeBreton Flats, located in Ottawa, Ontario. The proposed development comprises a 21-hectare parcel of land with 9 hectares being parks and open spaces. The remaining will include a combination of residential, retail, and office blocks. The primary sources of transportation noise include Wellington Street, Albert Street, Kichi Zībī Mīkan, Booth Street, and the O-Train light rail transit Line 1, running through the site. The LRT line is also a source of ground-borne vibration. 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) NPC-300, Ministry of Transportation Ontario (MTO), and City of Ottawa Environmental Noise Control Guidelines (ENCG) guidelines; (ii) future vehicular traffic volumes corresponding to roadway classification, roadway traffic volumes obtained from the City of Ottawa, and LRT information from the environmental assessment; (iii) concept drawings by Stantec Consulting Ltd., dated March 2024; and (iv) ground borne vibration criteria as specified by the Federal Transit Authority (FTA) Protocol.

As the site plan may be subject to change, GWE took the approach to establish noise contours around the site, without the massing of any future proposed buildings. The contours were used to determine what level of noise control for various areas on site would be required, based on the City of Ottawa noise criteria. The results of the current analysis indicate that noise levels will range between 62 and 71 dBA during the daytime period (07:00-23:00) and between 60 and 67 dBA during the nighttime period (23:00-07:00). The highest noise level (71 dBA) occurs at the north facades of Block 10, which is nearest and most exposed to the Wellington Street and Booth Street intersection.

Upgraded building components and central air conditioning will be required for blocks fronting Booth Street, Albert Street, Wellington Street, and the LRT line. For the remaining blocks, standard building construction would be sufficient, however the ventilation systems should be designed with provisions for central air conditioning, but in reality, most buildings will be designed to have air conditioning. As this is a preliminary assessment, noise control recommendations are of a general nature; specific mitigation requirements would be the work of future studies at the time of subdivision block development (i.e., during Site Plan Control). The following preliminary noise control measures have been documented:

Blocks	Upgraded Building Components	Ventilation Requirements	Warning Clauses
Blocks 1, 2, 3, 4, 5, 6, 7, 8,9,10, 11, 15, 16 (partial),17	Yes	Central air conditioning, or a similar mechanical system	Type D
Blocks 12, 13, 14, 16 (partial)	No	Forced air heating with provisions for air conditioning	Type C

Estimated vibration levels at the foundation nearest to the OC Transpo LRT Confederation Line are expected to be 0.089 mm/s RMS (71 dBV), based on the FTA protocol and an offset distance of 9 m to the nearest block line. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.1 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.

At the time of development approval, future detailed noise assessments would be performed for each block to determine site specific noise mitigation and appropriate warning clauses. These studies would also include review of the proposed mechanical systems for each building to ensure stationary sound level limits can be satisfied.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Stantec Consulting Ltd. to undertake a transportation noise and vibration feasibility assessment, to satisfy the requirements for a plan of subdivision application submission for the proposed development, known as LeBreton flats in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations related to the assessment of exterior noise and vibration levels generated by local transportation traffic.

This assessment is based on theoretical noise calculation methods conforming to the Ministry of the Environment, Conservation and Parks (MECP) NPC-300[1], Ministry of Transportation Ontario (MTO)[2], and City of Ottawa Environmental Noise Control Guidelines (ENCG)[3] guidelines. Noise calculations were based on concept plan drawings by Stantec Consulting Ltd., dated March 2024, with future traffic volumes corresponding to roadway classification and theoretical roadway capacities, and recent satellite imagery.

2. TERMS OF REFERENCE

The focus of this transportation noise and vibration feasibility assessment is a proposed mixed-use development, which is expected to comprise a number of residential towers, retail buildings, office buildings, and outdoor amenity spaces The expansive development is boarded by Wellington Street and Kichi Zībī Mīkan to the north, Booth Street to the east, Albert Street to the south, and the Trillium Pathway to the west. Figure 1 illustrates the study site location with surrounding context.

At the time of writing this report, only the lot fabric has been established and there are no concept designs for the individual parcels of land. Therefore, GWE took the approach to establish noise contours around the site without future proposed building massing. The contours were used to determine what level of noise control would be required for various areas on site, based on the City of Ottawa noise criteria.

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[1] Ontario Ministry of the Environment and Climate Change – Environmental Noise Guidelines, Publication NPC-300, Queens Printer for Ontario, Toronto, 2013
[2] Ministry of Transportation Ontario, "*Environmental Guide for Noise*", August 2021
[3] City of Ottawa Environmental Noise Control Guidelines, January 2016

Based on the City of Ottawa's Official Plan Schedule E, the major sources of traffic noise on the development are Albert Street, Wellington Street, Booth Street, Kichi Zībī Mīkan, and the Light Rail Transit (LRT) Line 1 of the O-Train Network. The LRT is also a source of ground-borne vibration. Surrounding the site there are no existing stationary sources of noise influencing the development.

3. OBJECTIVES

The principal objectives of this study are to (i) calculate the future noise levels on the study building produced by local transportation sources, (ii) predict vibration levels on the study building produced from the LRT system, and (iii) explore potential noise mitigation where required.

4. METHODOLOGY

4.1 Background

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

4.2 Roadway Traffic Noise

4.2.1 Criteria for Roadway Traffic Noise

For surface roadway traffic noise, the equivalent sound energy level, L_{eq}, provides a measure of the time varying noise levels, which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a period of time. For roadways, the L_{eq} is commonly calculated on the basis of a 16-hour (L_{eq16}) daytime (07:00-23:00) / 8-hour (L_{eq8}) nighttime (23:00-07:00) split to assess its impact on residential buildings. NPC-300 specifies that the recommended indoor noise limit range (that is relevant to this study) is 50, 45 and 40 dBA for retail/office/indoor amenity space, living rooms, and sleeping quarters, respectively, as listed in Table 1.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD)[4]

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

Predicted noise levels at the plane of window (POW) dictate the action required to achieve the recommended sound levels. An open window is considered to provide a 10 dBA reduction in noise, while a standard closed window is capable of providing a minimum 20 dBA noise reduction[5]. A closed window due to a ventilation requirement will bring noise levels down to achieve an acceptable indoor environment[6]. 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[7].

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 should be provided to reduce noise levels where technically and administratively feasible to acceptable levels at or below the criterion.

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[4] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Table C-9
[5] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[6] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8
[7] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3

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[8] which provide additional details on future roadway expansions. Average Annual Daily Traffic (AADT) volumes are then based on data in Table B1 of the ENCG for each roadway classification. Daytime and nighttime volumes for the LRT line are based on the environmental assessment. 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 Volume
Albert Street	4-Lane Urban Arterial Divided (4-UAD)	50	**35,000**
Booth Street (North of Albert Street)	4-Lane Urban Arterial Divided (4-UAD)	50	**35,000**
Wellington Street / Kichi Zībī Mīkan	4-Lane Urban Arterial Divided (4-UAD) Federally Owned	60	**35,000**
Confederation Line 1	4-Lane Urban Arterial Divided (4-UAD)	80	**452/144***

*Day / Night volumes

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

4.2.3 Theoretical Roadway Traffic Noise Predictions

The impact of transportation noise sources on the development was determined by computer modelling. Transportation noise source modelling is based on the software program *Predictor-Lima* which utilizes the United States Federal Highway Administration's Traffic Noise Model (TNM) to represent the roadway line sources. The TNM model is also being accepted in the updated Environmental Guide for Noise of Ontario, 2021 by the Ministry of Transportation (MTO)[9]. This computer program can represent three-dimensional surfaces and first reflections of sound waves over a suitable spectrum for human hearing. A set of comparative calculations were performed in the current Ontario traffic noise prediction model STAMSON for comparisons to Predictor simulation results. The STAMSON model is, however, older and requires each receptor to be calculated separately. STAMSON also does not accurately account for building reflections and multiple screening elements, and curved road geometry. A total of 6 discrete receptor locations were identified around the site, as illustrated in Figure 2, in addition to a receptor grid with has receptors spaced at 10 m x 10 m.

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

- Truck traffic on all roadways was taken to comprise 5% heavy trucks and 7% medium trucks, as per ENCG requirements for noise level predictions.
- The day/night split for all roads was taken to be 92% / 8%, respectively.
- Default 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.
- Noise receptors were strategically placed at 6 locations around the study area (see Figure 2).

4.3 Ground Vibration and Ground-borne Noise

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

[9] Ministry of Transportation Ontario, "*Environmental Guide for Noise*", August 2021, pg. 16

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

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

4.3.1 Ground Vibration Criteria

The Canadian Railway Association and Canadian Association of Municipalities have set standards for new sensitive land developments within 300 metres of a railway right-of-way, as published in their document *Guidelines for New Development in Proximity to Railway Operations*[10], which indicate 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 a main line LRT corridor 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.

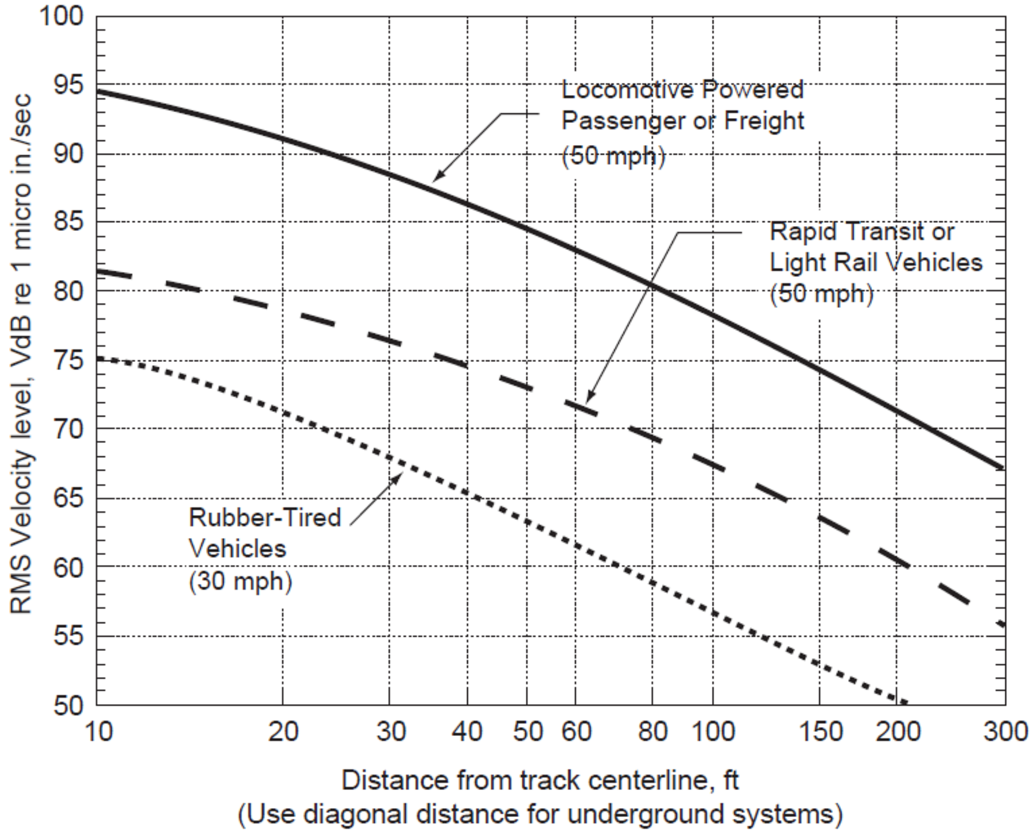
[10] Dialog and J.E. Coulter Associates Limited, prepared for The Federation of Canadian Municipalities and The Railway Association of Canada, May 2013

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*[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 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 Rapid Transit at a speed of 50 mph. Adjustment factors were considered based on the following information:

- The maximum operating speed of the LRT line is 50 mph (80 km/h) at peak.
- The setback distance between the block property line and the track centerline is 9 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 is large masonry on piles.
- Type of transit structure is open cut.

[11] John A. Volpe National Transportation Systems Center, Transit Noise and Vibration Impact Assessment, Federal Transit Administration, September 2018



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

5. RESULTS

5.1 Roadway Traffic Noise Levels

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

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROADWAY TRAFFIC SOURCES

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	Roadway Noise Level (dBA)		LRT Noise Level (dBA)		Total (dBA)	
			Day	Night	Day	Night	Day	Night
R1_A	1.5	POW – Block 7, North Façade	68	62	54	54	**68**	**63**
R1_B	4.5	POW – Block 7, North Façade	69	62	53	53	**69**	**63**
R1_C	25	POW – Block 7, North Façade	68	61	52	51	**68**	**61**
R2_A	1.5	POW – Block 10, North Façade	71	64	53	52	**71**	**64**
R2_B	4.5	POW – Block 10, North Façade	71	64	52	52	**71**	**64**
R2_C	25	POW – Block 10, North Façade	70	63	50	49	**70**	**63**
R3_A	1.5	POW – Block 17, South Façade	58	51	60	60	**62**	**61**
R3_B	4.5	POW – Block 17, South Façade	62	55	59	58	**64**	**60**
R3_C	25	POW – Block 17, South Façade	63	56	58	58	**64**	**60**
R4_A	1.5	POW – Block 6, North Façade	67	60	66	66	**70**	**67**
R4_B	4.5	POW – Block 6, North Façade	67	60	66	65	**70**	**66**
R4_C	25	POW – Block 6, North Façade	67	60	62	62	**68**	**64**
R5_A	1.5	POW – Block 5, North Façade	61	54	63	63	**65**	**64**

R5_B	4.5	POW – Block 5, North Façade	63	56	63	62	**66**	**63**
R5_C	25	POW – Block 5, North Façade	63	56	61	61	**65**	**62**
R6_A	1.5	POW – Block 2, South Façade	67	60	58	58	**68**	**62**
R6_B	4.5	POW – Block 2, South Façade	67	60	57	56	**67**	**61**
R6_C	25	POW – Block 2, South Façade	67	60	56	55	**67**	**61**

The results of the current analysis indicate that noise levels will range between 62 and 71 dBA during the daytime period (07:00-23:00) and between 60 and 67 dBA during the nighttime period (23:00-07:00). The highest noise level (71 dBA) occurs at the north facades of Block 10, which is nearest and most exposed to the Wellington Street and Booth Street intersection. Figures 3 – 8 illustrate daytime and nighttime noise contours of the site 1.5, 4.5, and 25 meters above grade.

Table 4 shows a comparison in results between Predictor-Lima and STAMSON. Noise levels calculated in STAMSON were found to have a good correlation with Predictor-Lima and variability between the two programs was within an acceptable level of ±0-3 dBA. STAMSON input parameters are shown in Figure A1.

TABLE 4: RESULTS OF STAMSON/PREDICTOR-LIMA CORRELATION

Receptor ID	Receptor Height (m)	Receptor Location	STAMSON 5.04 Noise Level (dBA)		PREDICTOR-LIMA Noise Level (dBA)	
			Day	Night	Day	Night
R2_A	1.5	POW – Block 10, North Façade	74	67	71	64
R3_A	1.5	POW – Block 17, South Façade	64	58s	62	61

5.1.1 Noise Control Measures

The results indicate that upgraded building components and central air conditioning will be required for blocks fronting Booth Street, Albert Street, Wellington Street, and the LRT line. For the remaining blocks, standard building construction would be sufficient, however the ventilation systems should be designed with provisions for central air conditioning. These measures, illustrated in Figure 3, are based on the contour noise levels shown on Figure 4-7. Therefore, noise control measures as described below in Table 5, may be required for the various blocks. As this is a preliminary assessment, noise control recommendations are of a general nature; specific mitigation requirements would be the work of a future studies. Applicable Warning Clauses for tenants and owners would be included according to the noise recommendations.

TABLE 5: PRELIMINARY NOISE CONTROL MEASURES

Blocks	Upgraded Building Components	Ventilation Requirements	Warning Clauses
Blocks 1, 2, 3, 4, 5, 6, 7, 8,9,10, 11, 15, 16 (partial),17	Yes	Central air conditioning, or a similar mechanical system	Type D
Blocks 12, 13, 14, 16 (partial)	No	Forced air heating with provisions for air conditioning	Type C

The outdoor noise levels predicted due to roadway traffic, at a number of locations, exceed the criteria listed in the ENCG for outdoor living areas, as discussed in Section 4.2. Therefore, noise control measures as described below from Table 2.3a in the ENCG, in order of preference, will be required to reduce the L_{eq} to 55 dBA at outdoor amenity areas:

- Distance setback with soft ground
- Insertion of noise insensitive land uses between the source and sensitive points of reception
- Orientation of buildings to provide sheltered zones for terraces and parks
- Earth berms (sound barriers)
- Acoustic barriers

Examining the noise control measures listed above, not all terraces are oriented to provide screening elements against traffic sources. Short of reorienting these terraces, the most feasible measures are inclusion of acoustic wall barriers around the perimeter of the terraces to block line of sight between the terraces and sources of noise. Both options can likely reduce OLA noise levels to below 60 dBA, where technically and administratively feasible. Site-specific mitigation would be explored as part of future studies.

5.2 Ground Vibrations and Ground-Borne Noise Levels

Estimated vibration levels at the foundation nearest to the OC Transpo LRT Confederation Line are expected to be 0.089 mm/s RMS (71 dBV), based on the FTA protocol and an offset distance of 9 m to the nearest block line. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.1 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 62 and 71 dBA during the daytime period (07:00-23:00) and between 60 and 67 dBA during the nighttime period (23:00-07:00). The highest noise level (71 dBA) occurs at the north facades of Block 10, which is nearest and most exposed to the Wellington Street and Booth Street intersection.

Upgraded building components and central air conditioning will be required for blocks fronting Booth Street, Albert Street, Wellington Street, and the LRT line. For the remaining blocks, standard building construction would be sufficient, however the ventilation systems should be designed with provisions for central air conditioning. As this is a preliminary assessment, noise control recommendations are of a general nature; specific mitigation requirements would be the work of a future studies.

Based on preliminary vibration calculations following FTA methodology, ground vibrations at the property line of the closest parcel of land are expected to fall below FTA vibration criteria, and vibration mitigation is not anticipated. For any development within 75 m of the LRT line, a future detailed vibration study will be required.

At the time of development approval, future detailed noise assessments would be performed for each block to determine site specific noise mitigation and appropriate warning clauses. These studies would also include review of the proposed mechanical systems for each building to ensure stationary sound level limits can be satisfied.

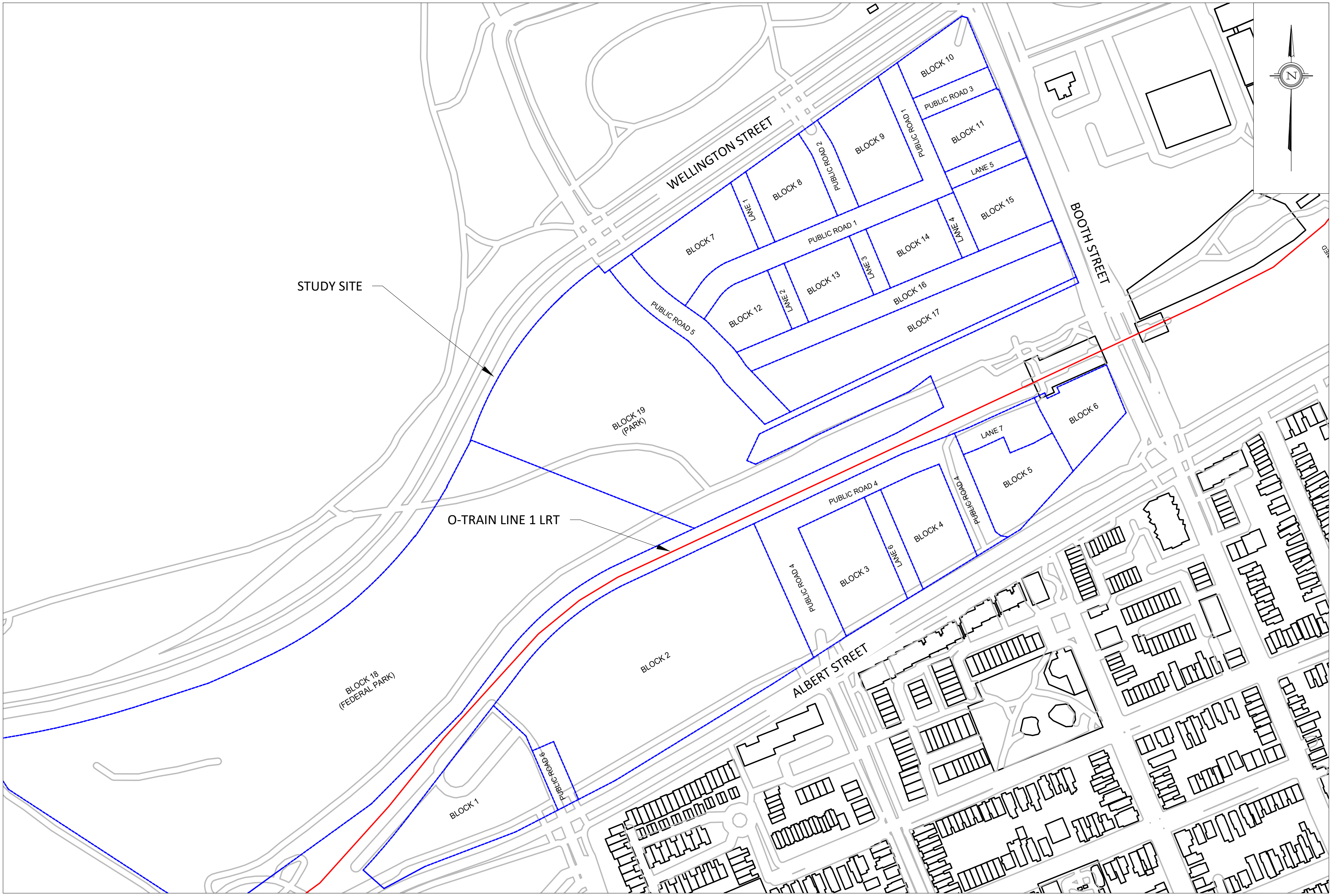
This concludes our transportation noise and vibration feasibility assessment and report. If you have any questions or wish to discuss our findings, please advise us. In the interim, we thank you for the opportunity to be of service.

Sincerely,

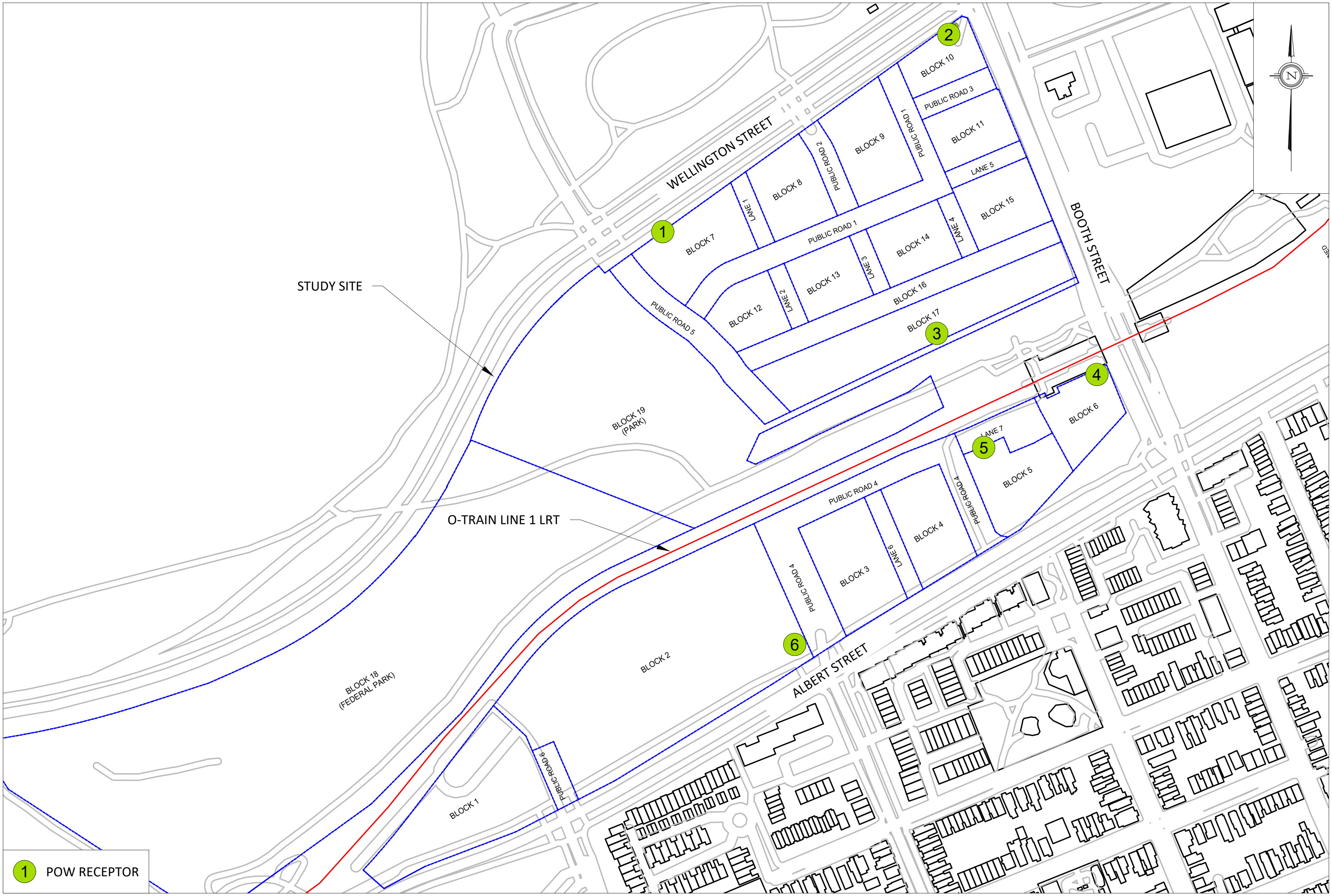
Gradient Wind Engineering Inc.

Essraa Alqassab, BASc
Junior Environmental Scientist
Gradient Wind File 23-150- Transportation Noise and Vibration

Joshua Foster, P.Eng.
Lead Engineer



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT LE BRETON FLATS, OTTAWA TRANSPORTATION NOISE ASSESSMENT		DESCRIPTION FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
	SCALE 1:4000 (APPROX.)	DRAWING NO. GW23-150-1	
	DATE APRIL 16, 2024	DRAWN BY E.A.	



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SCALE	1:4000 (APPROX.)	DRAWING NO.	GW23-150-2
DATE	APRIL 16, 2024	DRAWN BY	E.A.

DESCRIPTION

FIGURE 2:
RECEPTOR LOCATIONS

**FIGURE 3: DAYTIME TRAFFIC NOISE CONTOURS
(1.5 M ABOVE GRADE)**

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

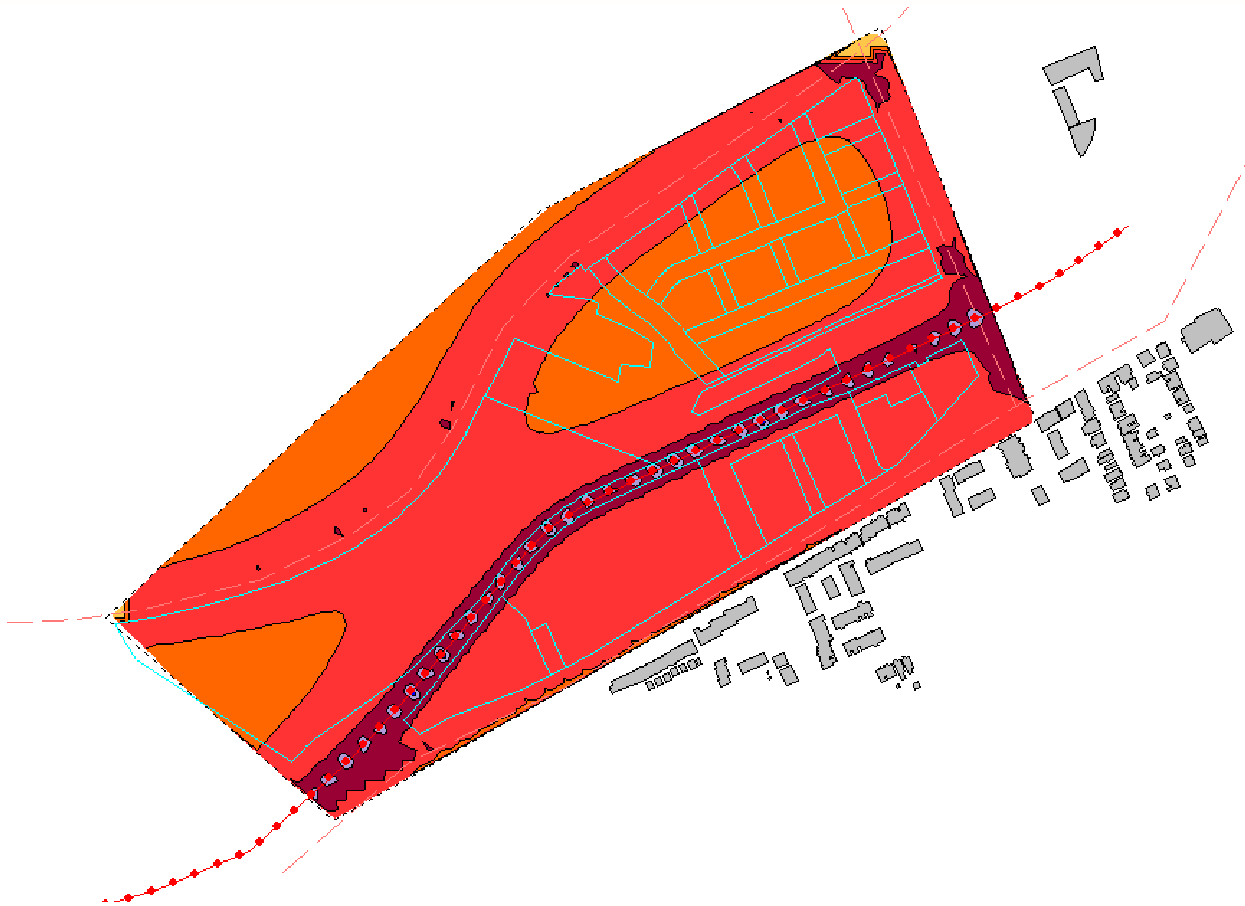


FIGURE 4: NIGHTTIME TRAFFIC NOISE CONTOURS
(1.5 M ABOVE GRADE)

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

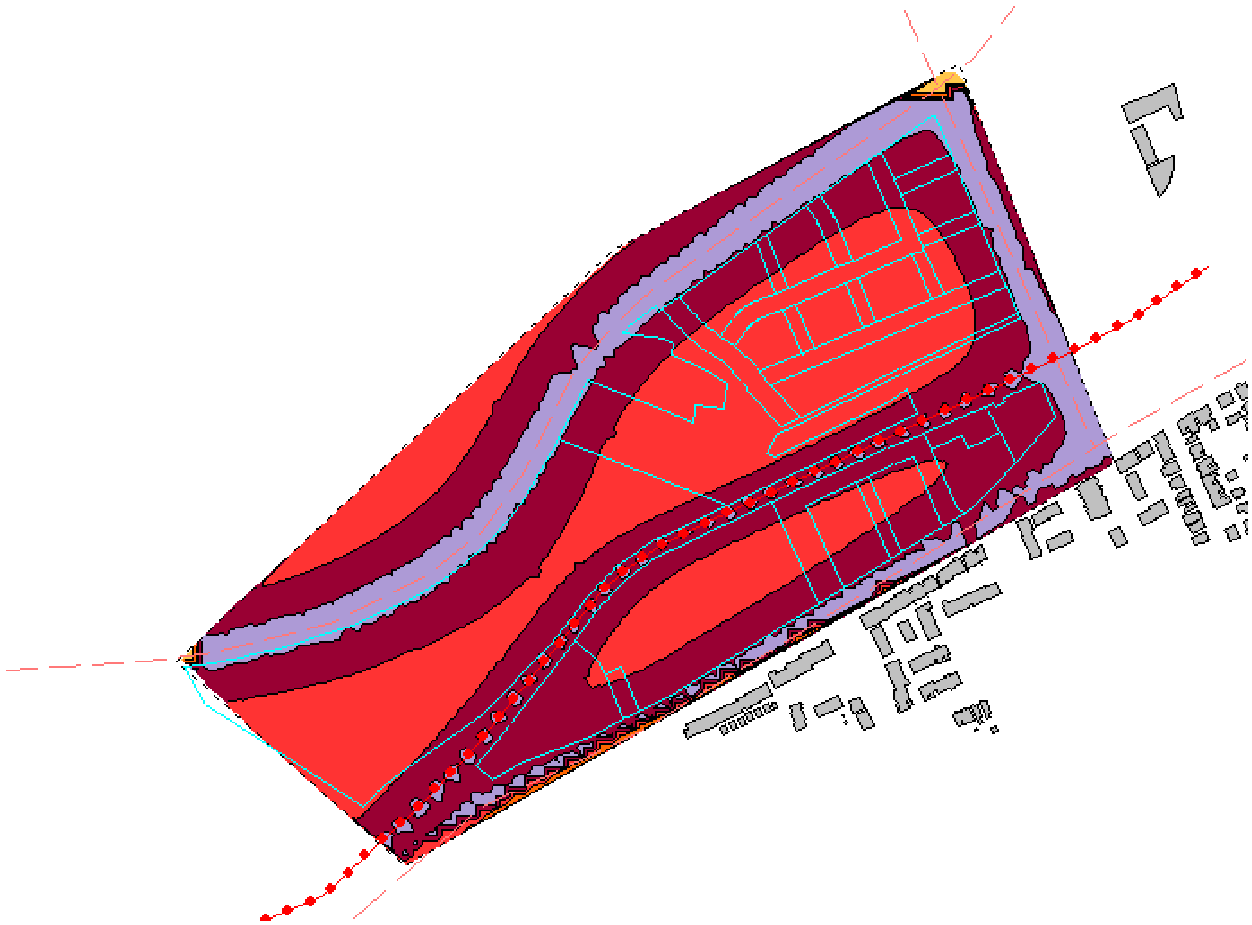
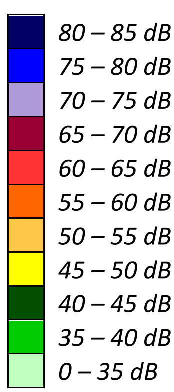


FIGURE 5: DAYTIME TRAFFIC NOISE CONTOURS
(4.5 M ABOVE GRADE)



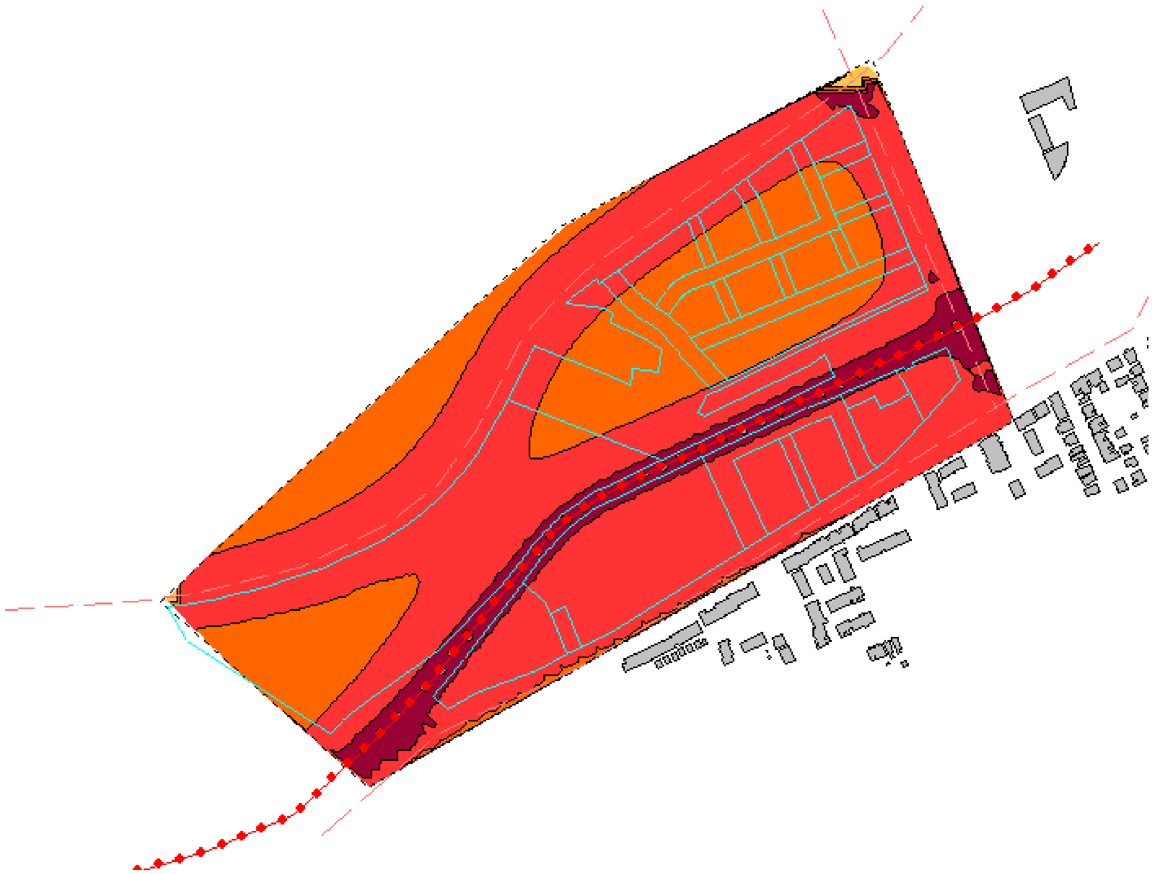
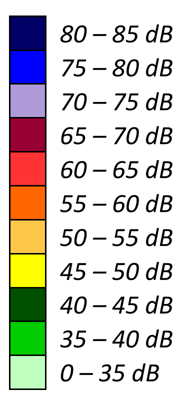


FIGURE 6: NIGHTTIME TRAFFIC NOISE CONTOURS
(4.5 M ABOVE GRADE)



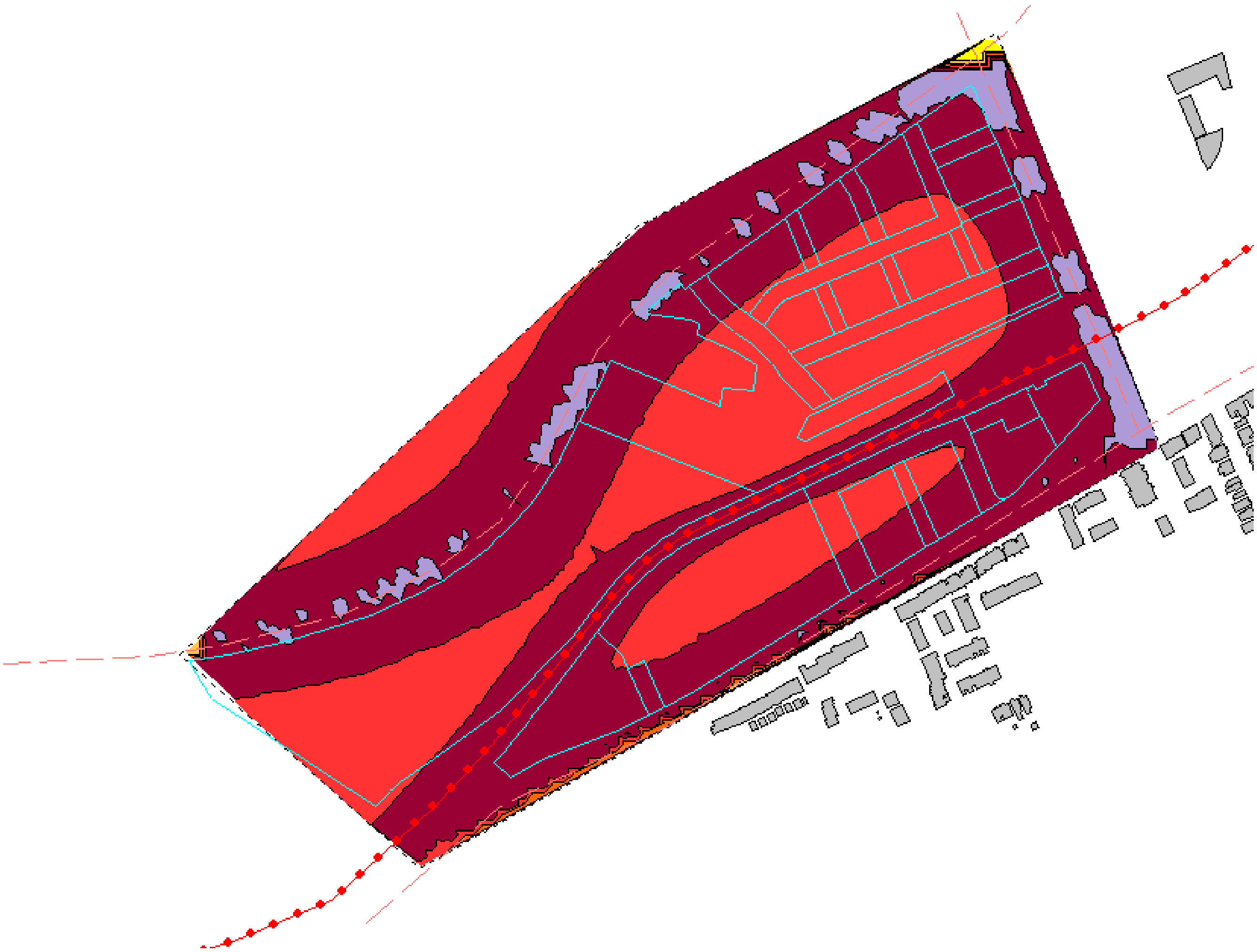
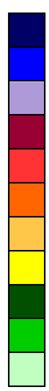


FIGURE 7: DAYTIME TRAFFIC NOISE CONTOURS (25 M ABOVE GRADE)



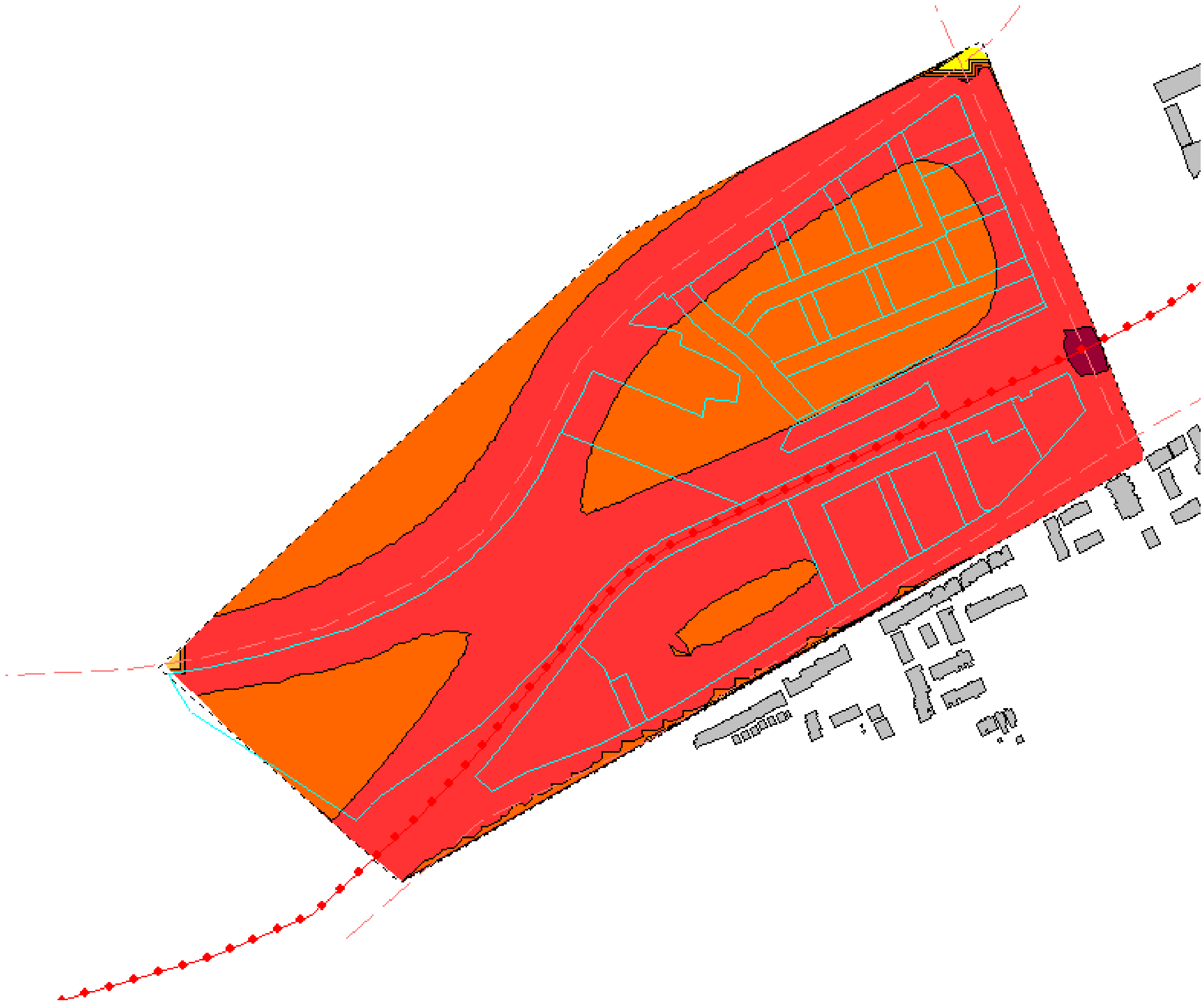
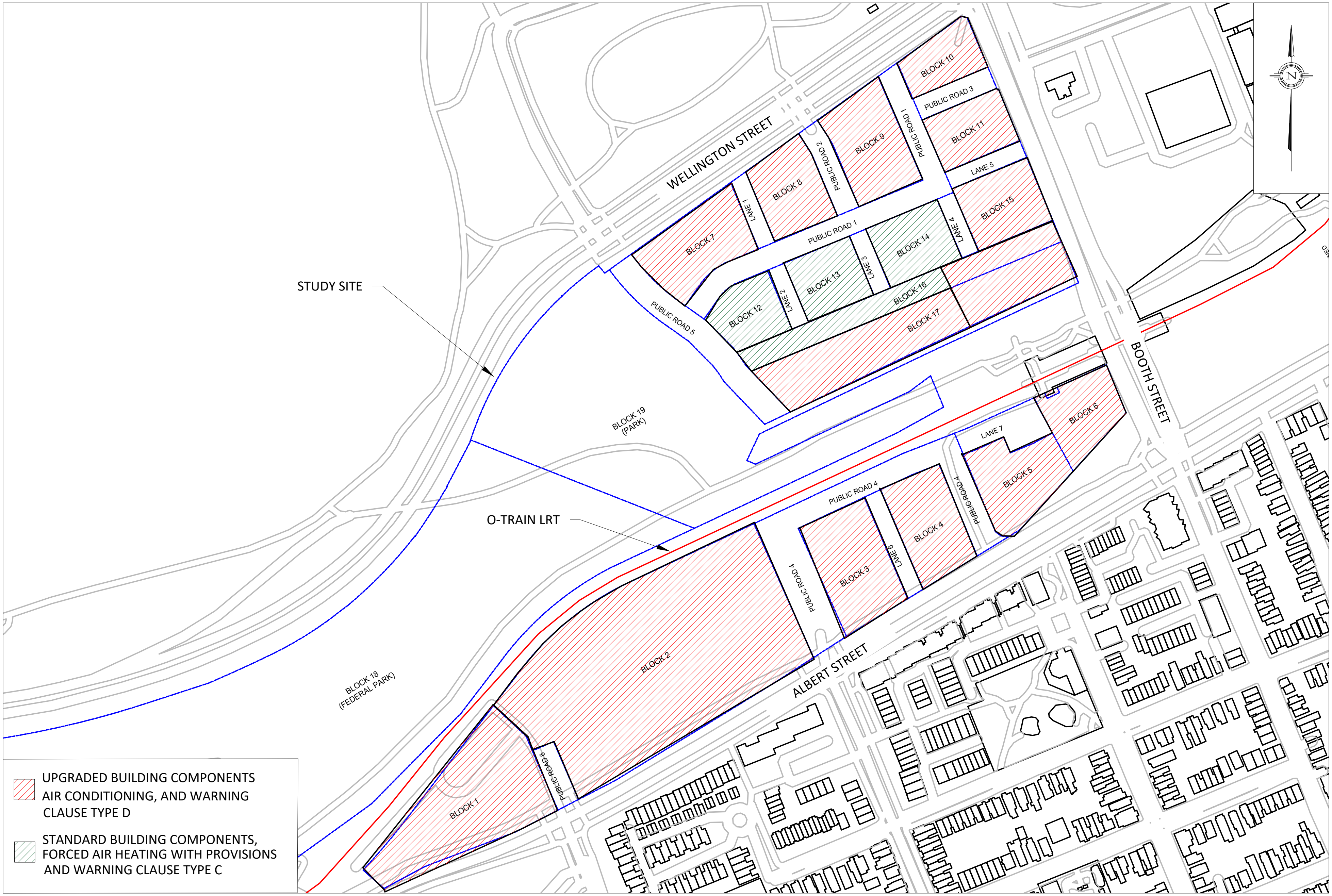


FIGURE 8: NIGHTTIME TRAFFIC NOISE CONTOURS (25 M ABOVE GRADE)

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



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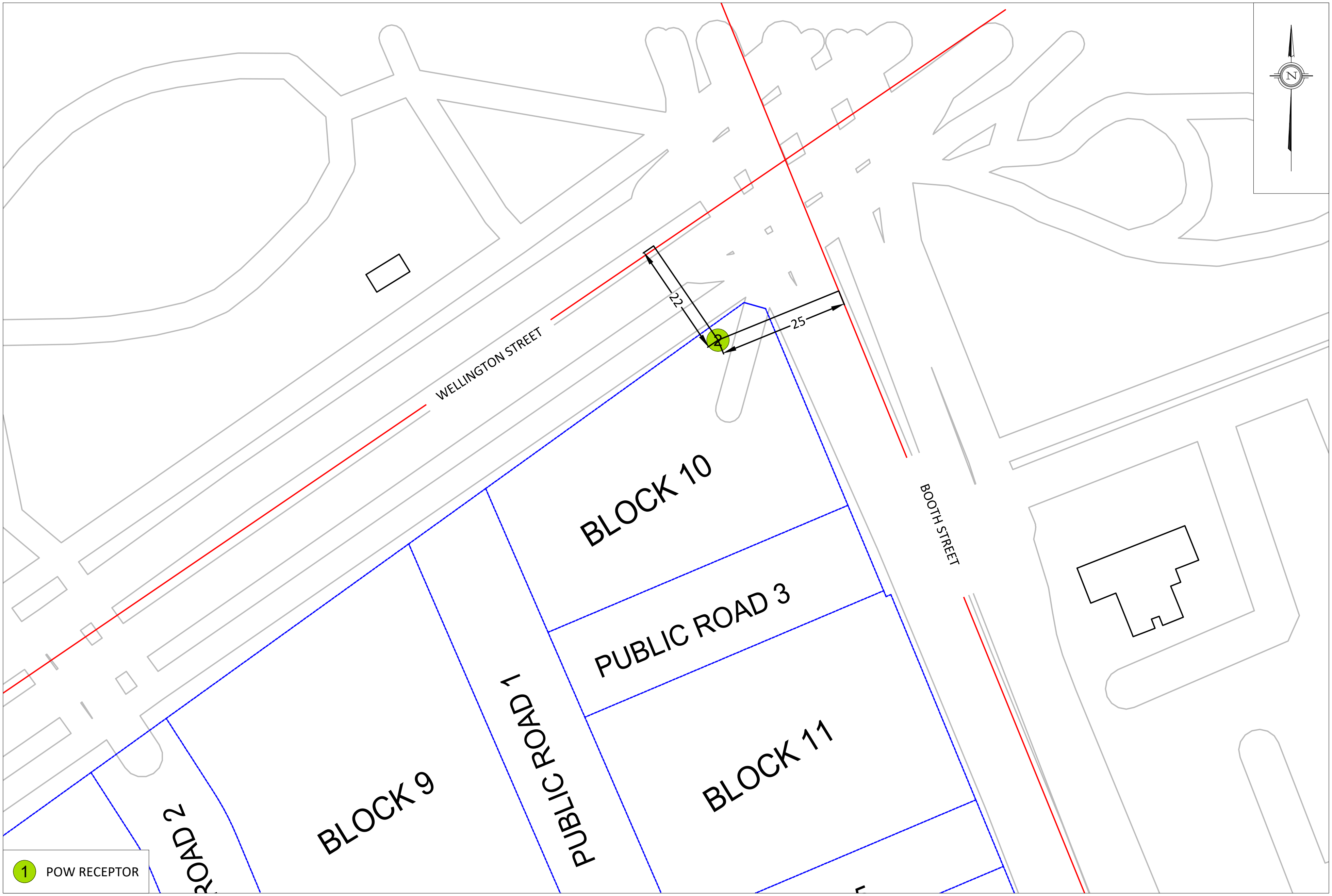
PROJECT	LE BRETON FLATS, OTTAWA TRANSPORTATION NOISE ASSESSMENT		
SCALE	1:4000 (APPROX.)	DRAWING NO.	GW23-150-9
DATE	MAY 7, 2024	DRAWN BY	E.A.

DESCRIPTION

FIGURE 9:
NOISE CONTROL MEASURES

APPENDIX A

STAMSON 5.04 Input and Output Data and Supporting Information



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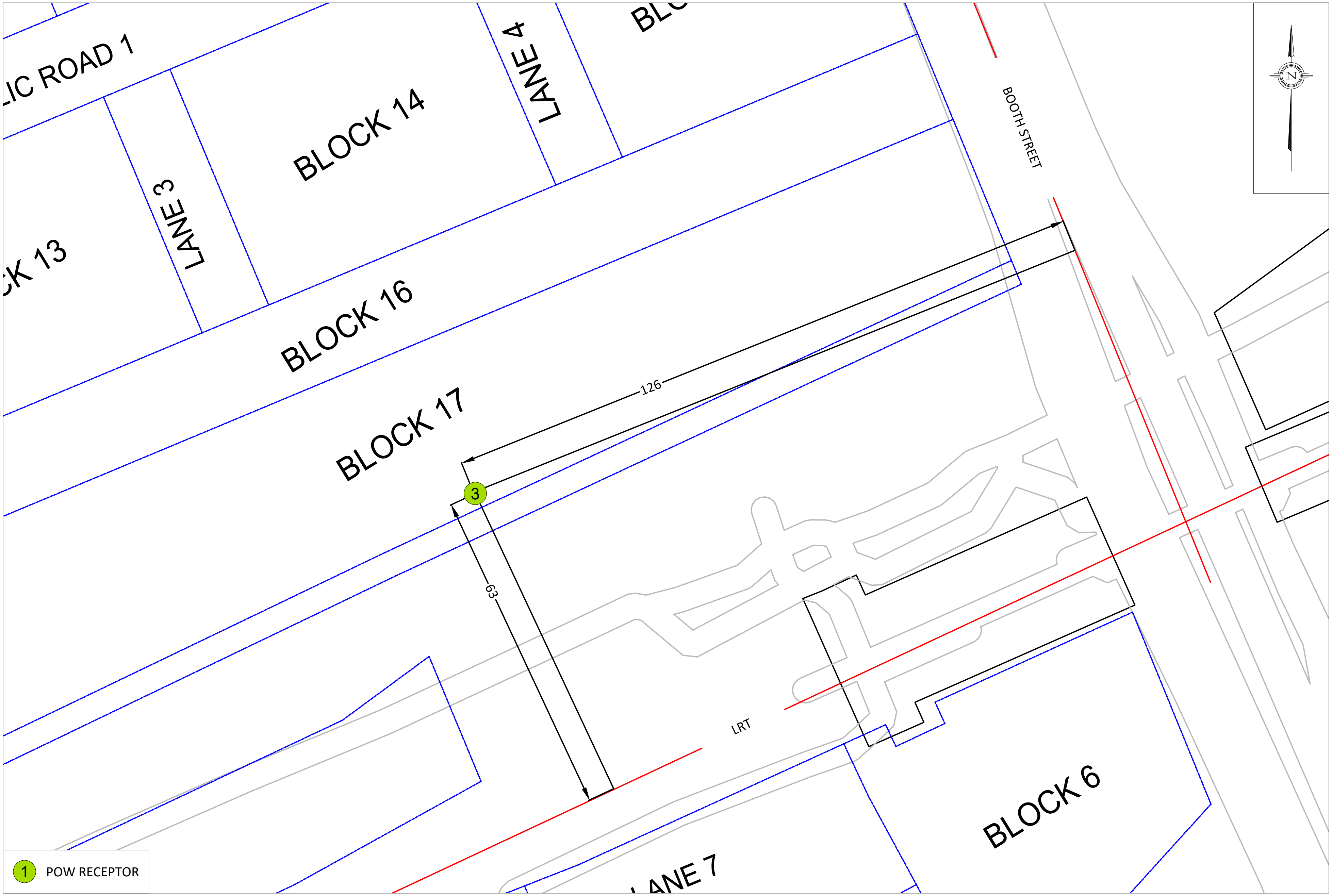
PROJECT: LE BRETON FLATS, OTTAWA TRANSPORTATION NOISE ASSESSMENT		DESCRIPTION: FIGURE A1: R2 PARAMETERS
SCALE: 1:1000 (APPROX.)	DRAWING NO.: GW23-150-A1	
DATE: APRIL 16, 2024	DRAWN BY: E.A.	



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PROJECT	LE BRETON FLATS, OTTAWA TRANSPORTATION NOISE ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW23-150-A2
DATE	APRIL 16, 2024	DRAWN BY	E.A.

DESCRIPTION

FIGURE A2:
R3 PARAMETERS

```
STAMSON 5.0        NORMAL REPORT        Date: 16-04-2024 11:45:01
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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


Road data, segment # 1: WELLINGTON (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  :    60 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

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

    24 hr Traffic Volume (AADT or SADT):  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: WELLINGTON (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  :  22.00 / 22.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00


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

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

    24 hr Traffic Volume (AADT or SADT):  35000
    Percentage of Annual Growth        :   0.00
```

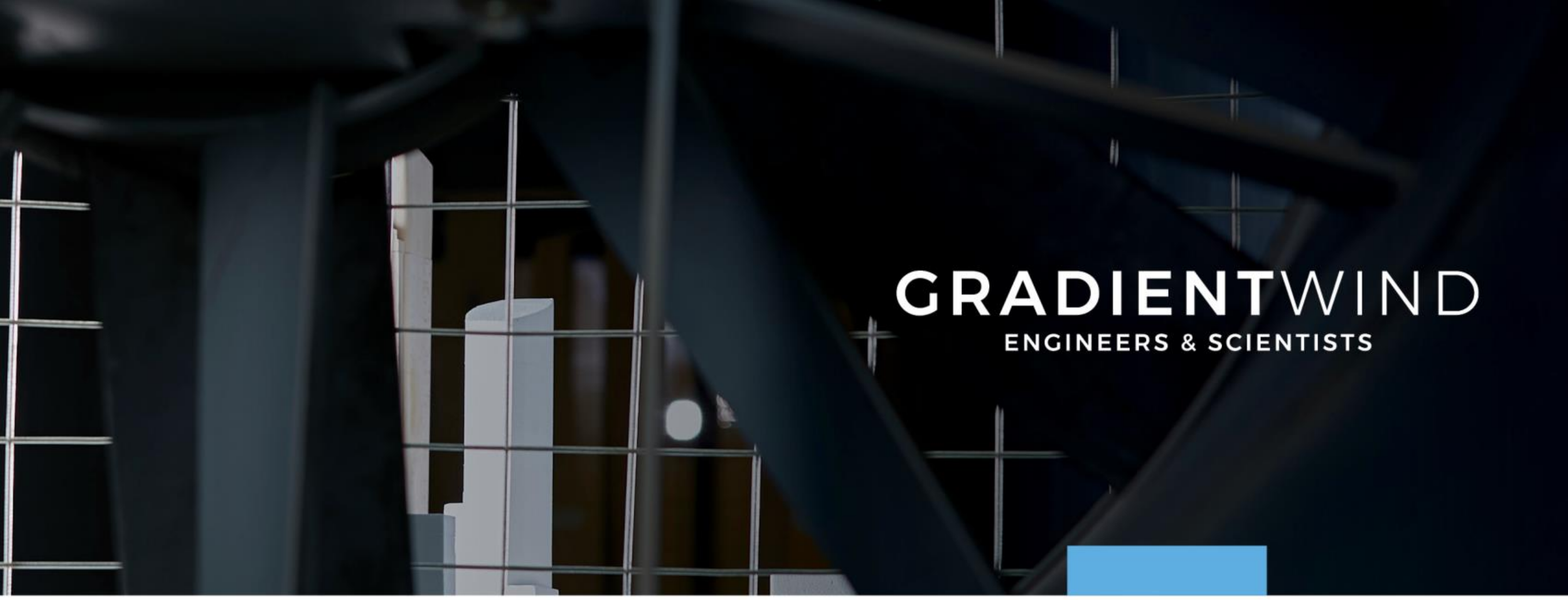
```
    Number of Years of Growth             :   0.00
    Medium Truck % of Total Volume        :   7.00
    Heavy Truck  % of Total Volume        :   5.00
    Day (16 hrs) % of Total Volume        :  92.00

Data for Segment # 2: BOOTH (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  :  25.00 / 25.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00


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

Source height = 1.50 m

ROAD (0.00 + 72.01 + 0.00) = 72.01 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90     90   0.00  73.68   0.00  -1.66   0.00   0.00   0.00   0.00
72.01
--------------------------------------------------------------------------
--

Segment Leq : 72.01 dBA


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

Source height = 1.50 m

ROAD (0.00 + 69.94 + 0.00) = 69.94 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  -2.22   0.00   0.00   0.00   0.00
69.94
--------------------------------------------------------------------------
--

Segment Leq : 69.94 dBA
```

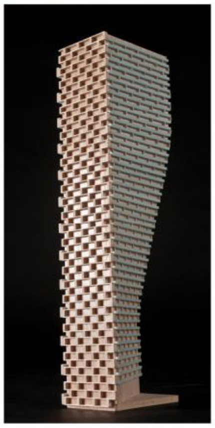
```
Total Leq All Segments: 74.11 dBA


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

Source height = 1.50 m

ROAD (0.00 + 64.42 + 0.00) = 64.42 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90     90   0.00  66.08   0.00  -1.66   0.00   0.00   0.00   0.00
64.42
--------------------------------------------------------------------------
--

Segment Leq : 64.42 dBA


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

Source height = 1.50 m

ROAD (0.00 + 62.34 + 0.00) = 62.34 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  -2.22   0.00   0.00   0.00   0.00
62.34
--------------------------------------------------------------------------
--

Segment Leq : 62.34 dBA

Total Leq All Segments: 66.51 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 74.11
                         (NIGHT): 66.51
```

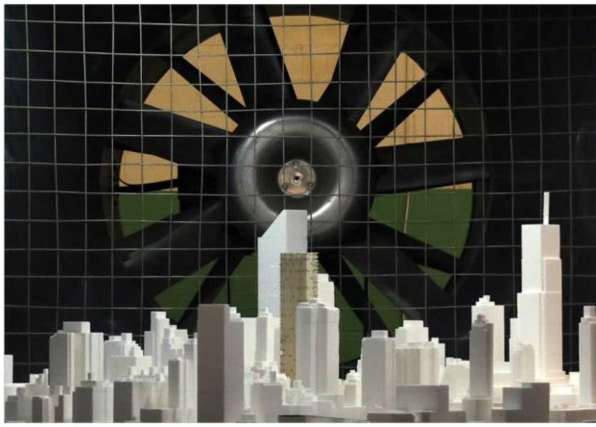
```
STAMSON 5.0        NORMAL REPORT        Date: 16-04-2024 11:53:27
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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


Road data, segment # 1: BOOTH (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: BOOTH (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  : 126.00 / 126.00 m
Receiver height           :   1.50 / 1.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00


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

Source height = 1.50 m

ROAD (0.00 + 62.92 + 0.00) = 62.92 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  -9.24   0.00   0.00   0.00   0.00
62.92
--------------------------------------------------------------------------
--
```

```
Segment Leq : 62.92 dBA

Total Leq All Segments: 62.92 dBA


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

Source height = 1.50 m

ROAD (0.00 + 55.32 + 0.00) = 55.32 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  -9.24   0.00   0.00   0.00   0.00
55.32
--------------------------------------------------------------------------
--

Segment Leq : 55.32 dBA

Total Leq All Segments: 55.32 dBA


RT/Custom data, segment # 1: lrt (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   452/144   veh/TimePeriod
Speed             :    80 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   :  63.00 / 63.00   m
Receiver height            :   1.50 / 1.50    m
Topography                 :      1       (Flat/gentle slope; no barrier)
Reference angle            :   0.00


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

Source height = 0.50 m

RT/Custom (0.00 + 57.59 + 0.00) = 57.59 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
```

```
----------------------------------------------------------------------
   -90      90    0.00   63.82   -6.23    0.00    0.00    0.00    0.00   57.59
----------------------------------------------------------------------

Segment Leq : 57.59 dBA

Total Leq All Segments: 57.59 dBA


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

Source height = 0.50 m

RT/Custom (0.00 + 55.63 + 0.00) = 55.63 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      90    0.00   61.87   -6.23    0.00    0.00    0.00    0.00   55.63
----------------------------------------------------------------------

Segment Leq : 55.63 dBA

Total Leq All Segments: 55.63 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 64.04
                         (NIGHT): 58.49
```







APPENDIX B

FTA VIBRATION CALCULATIONS

GWE23-150 16-Apr-24

Possible Vibration Impacts on Le Breton Flats
Perdicted using FTA General Assesment

train spee 80 km/h 49.6 mph

	Distance	
	(m)	(ft)
LRT	9.2	30.2

		Vibration	
From FTA Manual Fig 10-1			
Vibration Levels at distance from track		77	dBV re 1 micro in/sec
Adjustment Factors FTA Table 10-1			
Speed reference 50 mph		0	Speed limt of 80 km/h (55 mph)
Vehicle Parameters		0	Assume Soft primary suspension, Weels run true
Track Condition		0	None
Track Treatments		0	None
Type of Transit Structure		0	Open Cut
Efficient vibration Propagation		0	Propagation through rock
	Vibration Level	77	
Coupling to Building Foundation		-10	Large Massonry on Piles
Floor to Floor Attenuation		-2.0	First Floor occupied
Amplification of Floor and Walls		6	
	Total Vibration	70.93023	dBV or 0.089 mm/s
Noise Level in dBA		35.93023	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.