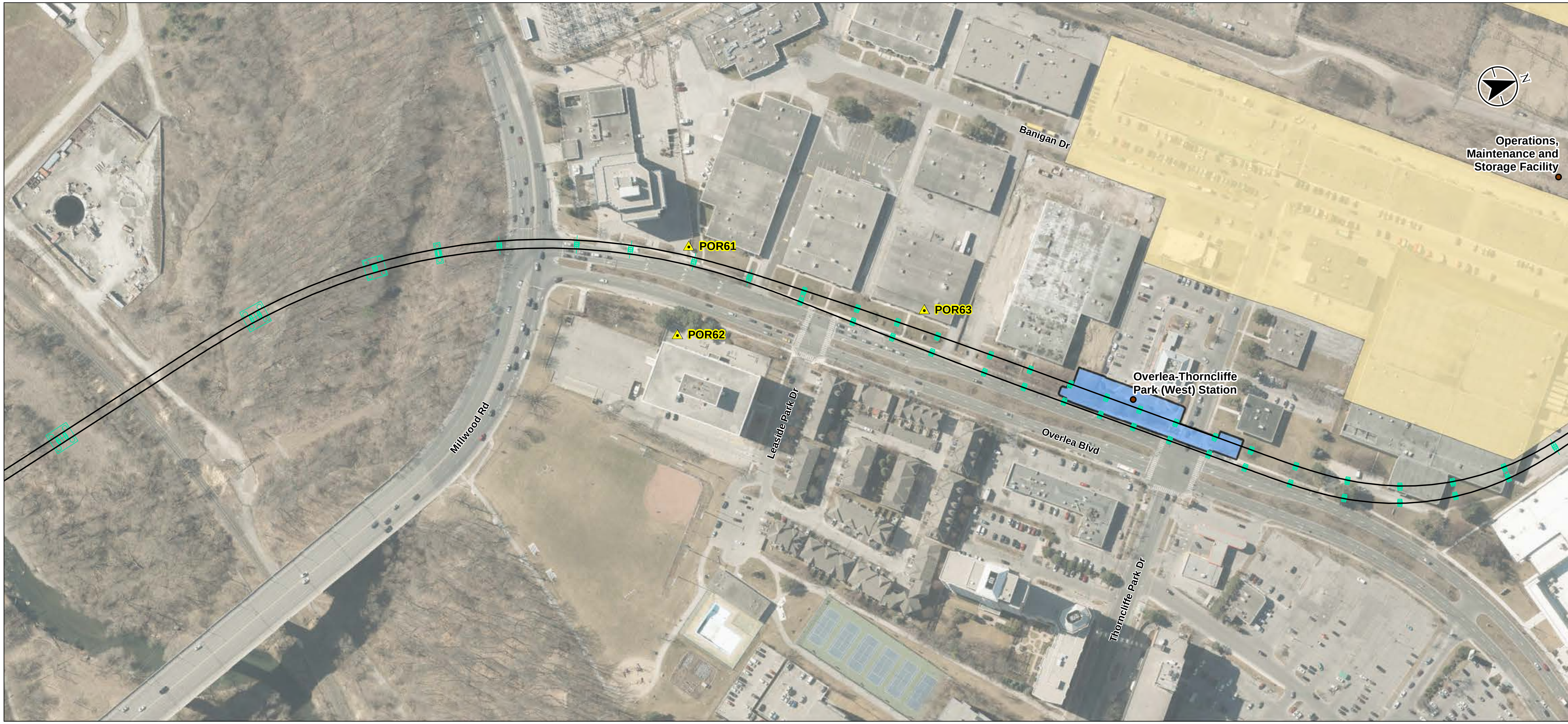

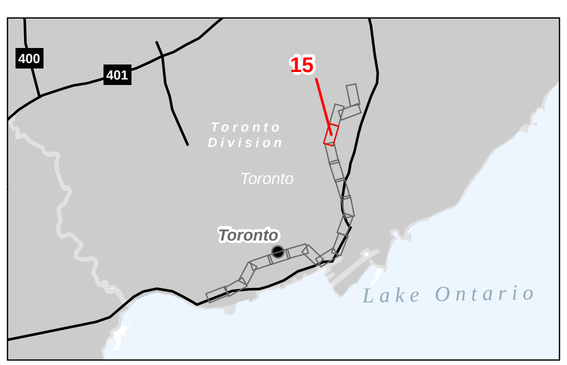

Legend

Representative POR

Alignment - Current

Track Alignment Centerline

Elevated Guideway

Station

Operations, Maintenance and Storage Facility

0 40 80 metres

1:2,500 (At original document size of 11x17)

Notes

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Project Location
Toronto, ON

Prepared by BCC on 2022-03-10
TR by ABC on yyyy-mm-dd

Client/Project
HDR CORPORATION
ONTARIO LINE TA

160560009 REVA

Figure No.
I-1-15

Title
Representative Points of Reception for Operational Vibration Assessment

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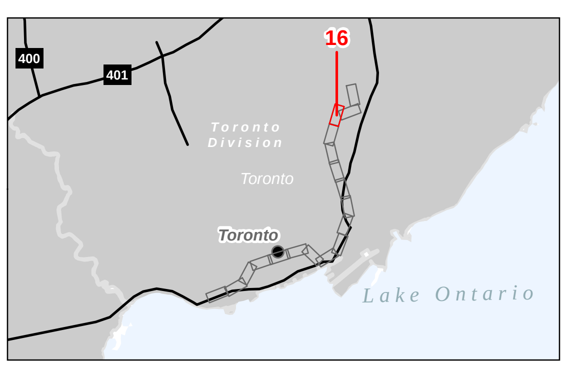

Legend

Alignment - Current

Track Alignment Centerline

Elevated Guideway

Operations, Maintenance and Storage Facility

0 40 80 metres

1:2,500 (At original document size of 11x17)

Notes

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Project Location
Toronto, ON

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Client/Project
HDR CORPORATION
ONTARIO LINE TA

160560009 REVA

Figure No.
I-1-16

Title
Representative Points of Reception for Operational Vibration Assessment

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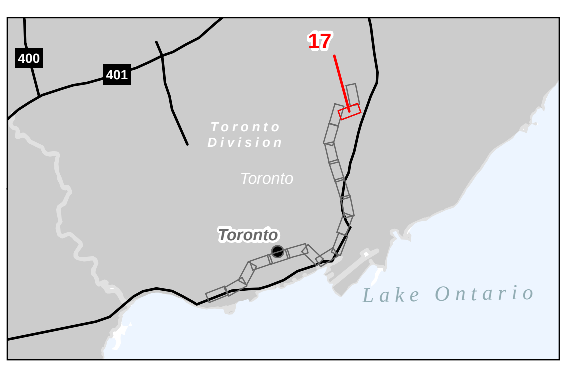

Legend

Alignment - Current

- Track Alignment Centerline
- Elevated Guideway
- Station
- Operations, Maintenance and Storage Facility

0 40 80 metres

1:2,500 (At original document size of 11x17)

Stantec

Project Location
Toronto, ON

Prepared by BCC on 2022-03-10
TR by ABC on yyyy-mm-dd

Client/Project
160560009 REVA

HDR CORPORATION
ONTARIO LINE TA

Figure No.
I-1-17

Title
Representative Points of Reception for Operational Vibration Assessment

Notes
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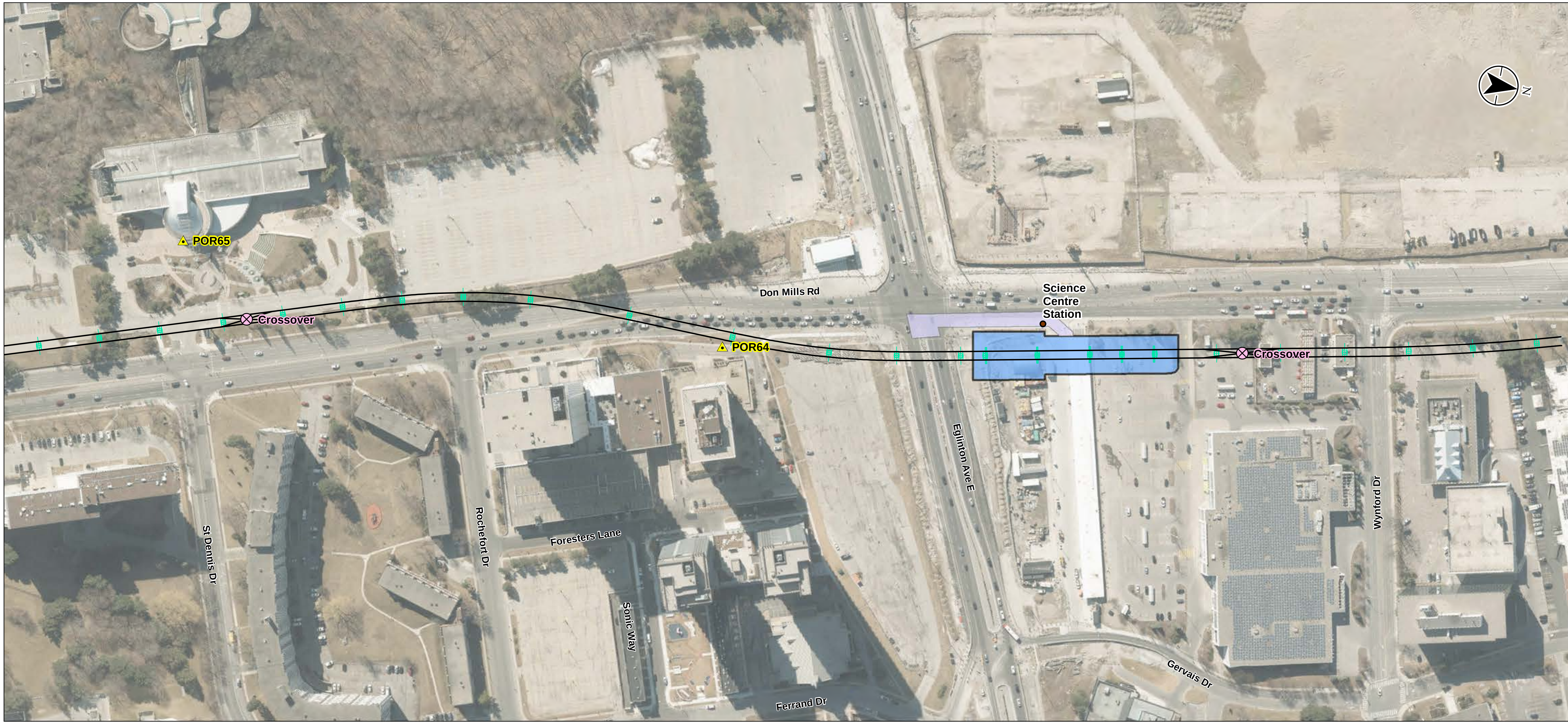

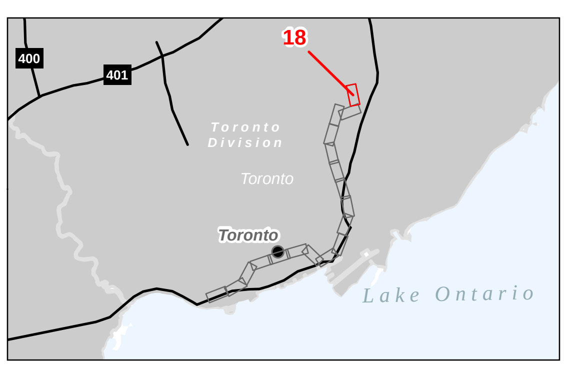

Legend

- Representative POR
- Crossover

Alignment - Current

- Track Alignment Centerline
- Elevated Guideway
- Station
- Pedestrian Tunnel

0 40 80
metres
1:2,500 (At original document size of 11x17)

Stantec

Project Location
Toronto, ON

Prepared by BCC on 2022-03-10
TR by ABC on yyyy-mm-dd

Client/Project
160560009 REVA

HDR CORPORATION
ONTARIO LINE TA

Figure No.
I-1-18

Title
Representative Points of Reception for Operational Vibration Assessment

Notes
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Appendix J. Example Construction Hoarding Noise Barrier Installations

Appendix J - Example Construction Hoarding Noise Barrier Installations

Acoustic Curtain - Construction Hoarding:

Wooden - Construction Hoarding:

Appendix J - Example Construction Hoarding Noise Barrier Installations

Mass Loaded Vinyl - Construction Hoarding:

Appendix K. Construction Best Practices

<u>**Best Construction Practices for Noise and Vibration Control**</u>

1. Adopt working hours to restrict noisy activities (such as demolition or pile driving) to regular working hours of the week.

2. Arrange delivery times to suit the area – in general, daytime for residential areas and nighttime for commercial areas.

3. Plan deliveries and vehicle movements so that vehicles are not waiting or queuing on public roads. If waiting and queuing is unavoidable then engines should be turned off.

4. Plan site layout to ensure that reversing is kept to a minimum and, where practicable, eliminated altogether.

5. Where reversing is required, use broadband reverse sirens/alarms or, where it is safe to do so, disengage all sirens and alarms and use flag-men.

6. Locate noisy plant and equipment as far away as possible from sensitive receptors and orient it judiciously.

7. Use plant and equipment only in tasks for which they are designed.

8. Use equipment with the lowest noise and vibration emission levels.

9. Use equipment powered by electricity rather than diesel engines.

10. Minimize the use of diesel electric generators and use mains electricity where available.

11. Shut down or throttle down to a minimum all plant and equipment between works.

12. Fit all plant and equipment with appropriate mufflers and silencers of thee type recommended by the manufacturer.

13. Reduce the need for noisy assembly practices; e.g., by fabricating off site.

14. Rather than breaking in-situ, remove larger sections and break them either in an area away from sensitive receptors or off-site.

15. Locate the site access points and the construction vehicle routes as far away as possible from sensitive receptors.

16. Keep haul roads well maintained.

17. Avoid steep gradients on internal haul routes.

18. During weekends and nights, stockpile material within the site such that it can be removed during normal working hours.

19. Where site space is limited and volume of vehicles attending the site is high, seek vehicle holding location(s) to use with just-in-time delivery systems.

20. Minimise the drop height into hoppers, trucks and other plant/equipment.

21. Choose the working method with the lowest N&V impacts; e.g.,

    - in demolition work, avoid the use of percussive demolition techniques, use hydraulic shears instead of hydraulic impact breakers;
    - when breaking payments, use methods other than pneumatic breakers and drills, including chemical splitters and falling weight breakers; and
    - when excavating hard material, use rotary drills and bursters actuated by hydraulic or electrical power.

22. Adopt the following hierarchy of groundwork/piling methods:

    - Pressed-in methods, e.g. hydraulic jacking
    - Auger / bored piling
    - Diaphragm walling
    - Vibratory piling
    - Driven piling

23. Use vibratory equipment in a mode that minimizes the incident vibration at nearby receptors; e.g., by using smaller equipment, turning off the mechanical vibration on vibratory rollers and conducting more passes, engaging concentric weights only when running at speed.

24. Avoid sound traps that amplify noise.

25. Maximize the screen effect of buildings and temporary stockpiles.

26. Minimize opening and closing of site access gates through good co-ordination of deliveries and vehicle movements.

Appendix L. Example Monitoring Requirements

Appendix L

Example Monitoring Requirements

In areas where it is predicted that the noise and vibration limits may be exceeded after mitigation, a noise and/or vibration monitoring is required. Monitoring may also be warranted when:

- Construction duration is over a month;
- Construction includes pile driving;
- Nighttime construction is anticipated; or
- The anticipated community response to the construction is negative.

Monitoring Type

Table below outlines the type of monitoring that is required under various conditions based on the project location, duration, presence of night-time activity, and receptor proximity. The monitoring types include:

- Type 1: Monitoring continuously throughout the project.
- Type 2: Monitoring during most impactful phases of the project only.
- Type 3: Monitoring in response to complaints only.

Required Noise and Vibration Monitoring

Project Parameters		Type
Project Location	Urban	1
	Suburban	2
	Rural	3
Project Duration	Over 12 months	1
	1 to 12 months	2
	Less than 1 month	3
Nighttime Activity	Major (constant, high intensity sources with frequent elevated sounds)	1
	Intermediate (occasional events, moderate sources)	2
	Minor (infrequent events or continuous minor sources)	3
Receptor Location *	Within zone of influence	1
	Near zone of influence	2
	Far from zone of influence	3

Note: * The zone of influence covers the area where, without mitigation, receptors could experience noise and vibration levels that exceed the criteria at anytime. Where a project triggers more than one type of monitoring, the more stringent type will apply.

In general, the type of monitoring shall be dictated by the parameter that calls for the most stringent type of monitoring. For instance, if the location of the project is urban, then Type 1 monitoring will be implemented irrespective of the other project parameters. Similarly, if the location of the project is suburban but the project involves major night-time activity, then Type 1 monitoring will be preferred. Given the large variability within each parameter, it is understood that this simple strategy may not be appropriate for all projects. More often than not, the project team will be called upon to apply its professional judgement to select the most appropriate type of monitoring.

Implementation

Noise and vibration monitoring should be conducted at the closest point of reception to the construction. If multiple points of reception are in close proximity to the construction, monitoring may need to occur at multiple locations to characterize variable noise and vibration impacts in the community.

Prior to construction, noise and vibration monitoring should be completed to determine the baseline levels and to help inform future attribution of elevated noise and vibration levels to construction or the ambient environment.

Monitoring must be conducted using equipment capable of satisfying the requirements of MECP NPC-103 and other applicable MECP guidance and be overseen by a qualified acoustical engineer. The noise and vibration monitoring system must output the relevant metrics considered for the construction assessment (i.e. L_{MAX}, L_{EQ}).

If noise or vibration levels above the relevant limits are measured and attributed to the construction activities, the monitoring engineer will notify Metrolinx and take action to adjust operations at the offending source to ameliorate the potential excess. If necessary, additional measurements will be conducted to determine and rectify the source of the exceedance.

Noise:

Noise monitoring is deemed to be an effective tool for enforcing noise exposure limits, avoiding legitimate public complaints, and investigating complaints. It is, however, a relatively demanding task that may need to be tailored to the type of the project. To this end, two types of projects are identified:

<u>Type 1 Projects</u>:

These are projects that are largely localized and "stationary", and they expose the same receptors to noise for an extended period of time. Examples of Type 1 projects include the construction of grade separation structures (bridges or tunnels), train stations, and rail maintenance facilities, as well as construction staging and laydown sites.

<u>Type 2 Projects</u>:

Projects that are geographically "mobile" and do not expose the same receptors to noise for an extended period of time. These include linear projects such as construction related to rail electrification and rail track or signaling improvements.

The following noise monitoring requirements are recommended for the two types of projects:

<u>Noise Monitoring in Type 1 Projects</u>:

The contractor shall monitor continuously each geographically distinct, active construction site with one monitor located strategically to capture the highest noise exposure level based on planned construction activities and the number, geographic distribution and proximity of noise sensitive receptors. The location of the monitor shall be adjusted in response to changes in construction activity to continue to capture the highest noise exposure level. The microphone of the monitor will be placed at 1.5 – 4.5 m above the ground level depending on the receptor height.

Noise Monitoring in Type 2 Projects:

The contractor shall not need to monitor noise continuously during these projects unless one of the following two conditions applies:

a) any of the processes and equipment the contractor plans to use for over 15 minutes during the daytime / nighttime has a noise emission level exceeding 85 / 75 dBA, whichever is applicable. Noise emission levels are noise levels measured at 15 m from the process or equipment, operating at maximum rate and/or power setting

or

b) any of the noise sensitive receptors is located less than 50 m from any boundary of the construction, staging or laydown site.

In projects that require noise monitoring, each work crew shall employ one portable noise monitor, which shall be located at or close to the boundary of the work site and at a location that will capture the highest noise exposure level. This location will usually be one as close as possible to the nearest unshielded noise sensitive receptor. The work crew will reposition the monitor as soon as the location of the work changes. The microphone of the monitor will be placed at 1.5 – 4.5 m above the ground level depending on the receptor height.

Noise Monitoring Provisions Common to Type 1 and 2 Projects

The contractor shall employ Type 1 or Class 1 integrating sound level meters meeting the IEC Standard 60651, 60804 or 61672. Each meter shall be calibrated within one week prior to its initial use and once per month thereafter. The frequency weighting of the meter will be set to “A” and the speed of response to “fast”.

The output of each noise meter will be continuously stored in the “cloud” and made simultaneously available to the designated Metrolinx office. The output data will contain, for each day, the maxima level recorded, each 15-minute average, and each 16-hour daytime (7:00 – 23:00) and each 8-hour night-time average.

The contractor shall submit monthly summary reports to MX for each monitoring location. The reports shall include but not be limited to the number and duration of any incident during which any of the MX noise exposure limits were exceeded, the probable cause of each exceedance, the incident-specific measure(s) implemented, and the resulting mitigated noise levels.

The noise monitors should be calibrated by independent certification lab within 2 years of measurements and should be field calibrated with a portable precision acoustic calibrator.

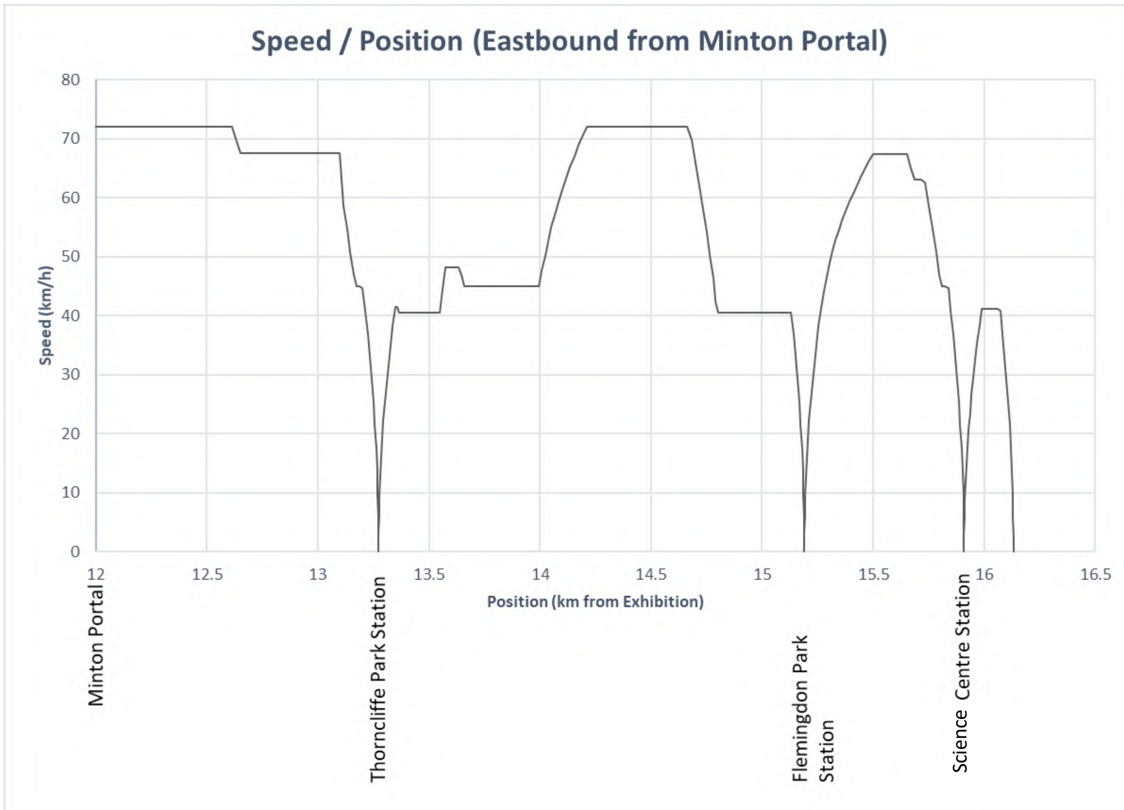
Appendix M. Train Service Levels and Speeds

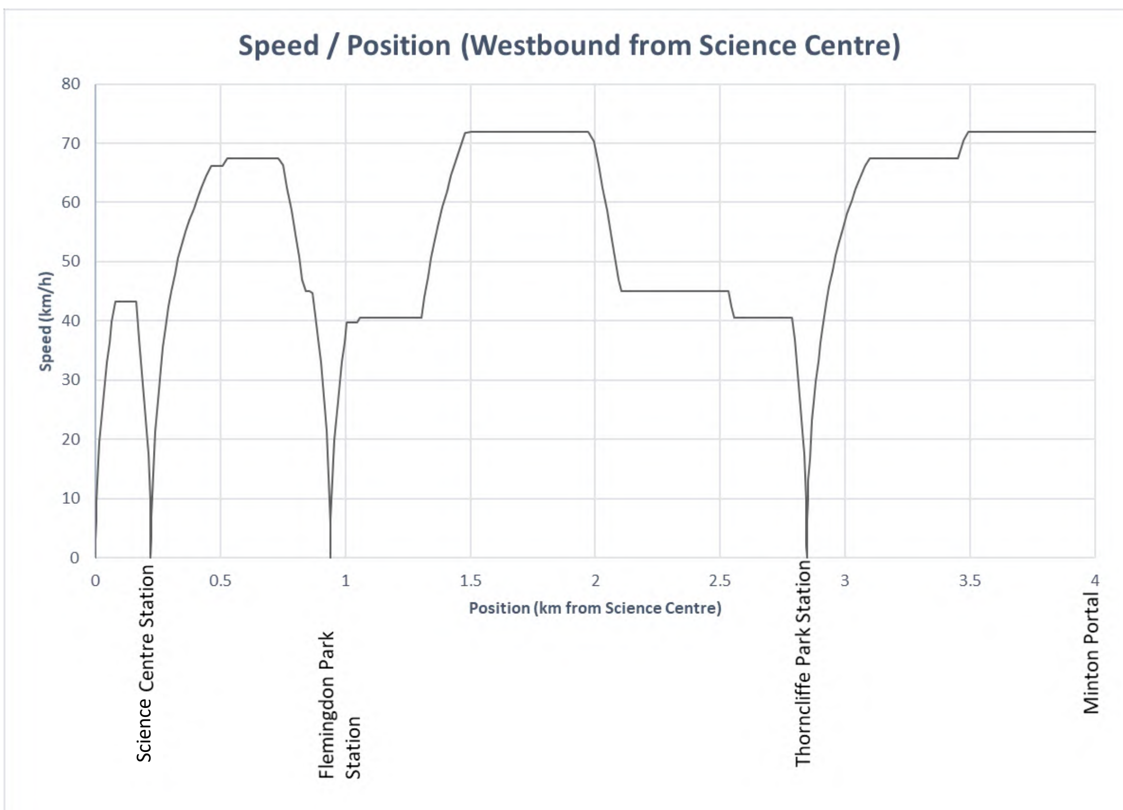
Service Level 3 (2060 - 2080)

Name of Period	Period Start	Period End	Trains per hour	# Cars in service	# Trains in service
Weekday 1	06:00	07:00	18	90	18
Weekday 2	07:00	10:00	40	190	38
Weekday 3	10:00	15:00	24	115	23
Weekday 4	15:00	19:00	40	190	38
Weekday 5	19:00	22:00	24	115	23
Weekday 6	22:00	00:00	24	115	23
Weekday 7	00:00	01:30	18	90	18
Saturday 1	06:00	08:00	18	90	18
Saturday 2	08:00	19:00	24	115	23
Saturday 3	19:00	23:00	24	115	23
Saturday 4	23:00	01:30	18	90	18
Sunday 1	08:00	09:00	18	90	18
Sunday 2	09:00	19:00	24	115	23
Sunday 3	19:00	23:00	24	115	23
Sunday 4	23:00	01:30	18	90	18
Holiday 1	06:00	08:00	18	90	18
Holiday 2	08:00	19:00	24	115	23
Holiday 3	19:00	23:00	24	115	23
Holiday 4	23:00	01:30	18	90	18

Provided by design team 2021-09-18

Note:
Service Level 1 – 2030 - 2039
Service Level 2 – 2040 - 2059
Service Level 3 – 2060 - 2080





Provided by design team 2021-09-10

Appendix N. Traffic Data

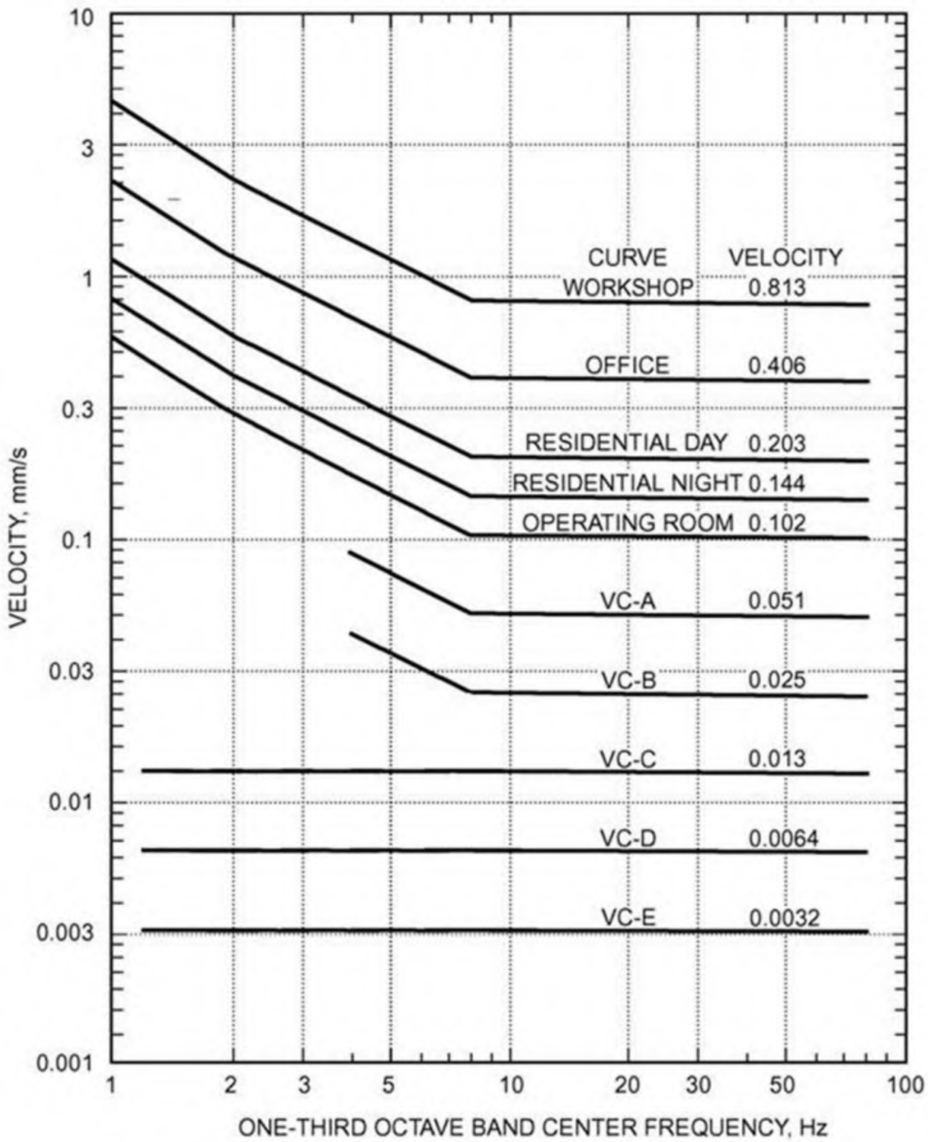
Traffic Data						
LOCATION	**Daily_ NS_CARS**	**Daily_ EW_CARS**	**Daily_ NS_TRUCKS**	**Daily_ EW_TRUCKS**	**Daily_ NS_BUS**	**Daily_ EW_BUS**
MILLWOOD RD AT OVERLEA BLVD (PX 687)	27680	8050	3820	750	930	660
OVERLEA BLVD AT THORNCLIFFE PARK W DR (PX 680)	7970	18130	220	700	260	1090
# 45 OVERLEA BLVD AT EAST YORK TOWN CENTRE (PX 1834)	2460	17600	0	750	0	700
OVERLEA BLVD AT THORNCLIFFE PARK DR & E TCS (PX 679)	11210	24740	380	660	290	1040
OVERLEA BLVD AT WILLIAM MORGAN DR (PX 1800)	1160	24520	70	1590	0	1160
DON MILLS RD AT GATEWAY S BLVD & OVERLEA BLVD (PX 620)	40410	20850	910	680	420	730
DON MILLS RD AT GATEWAY N BLVD (PX 1389)	31420	3760	2610	290	860	180
DON MILLS RD AT ST DENNIS DR (PX 621)	42280	3760	3500	200	1020	110
DON MILLS RD AT EGLINTON AVE (PX 454)	46670	38750	1010	2240	800	900
DON MILLS RD AT WYNFORD DR (PX 822)	40010	9480	1100	50	940	0

Provided by design team 2021-06-03 - based on City of Toronto 2019 data

Appendix O. Criteria for Vibration Sensitive Equipment

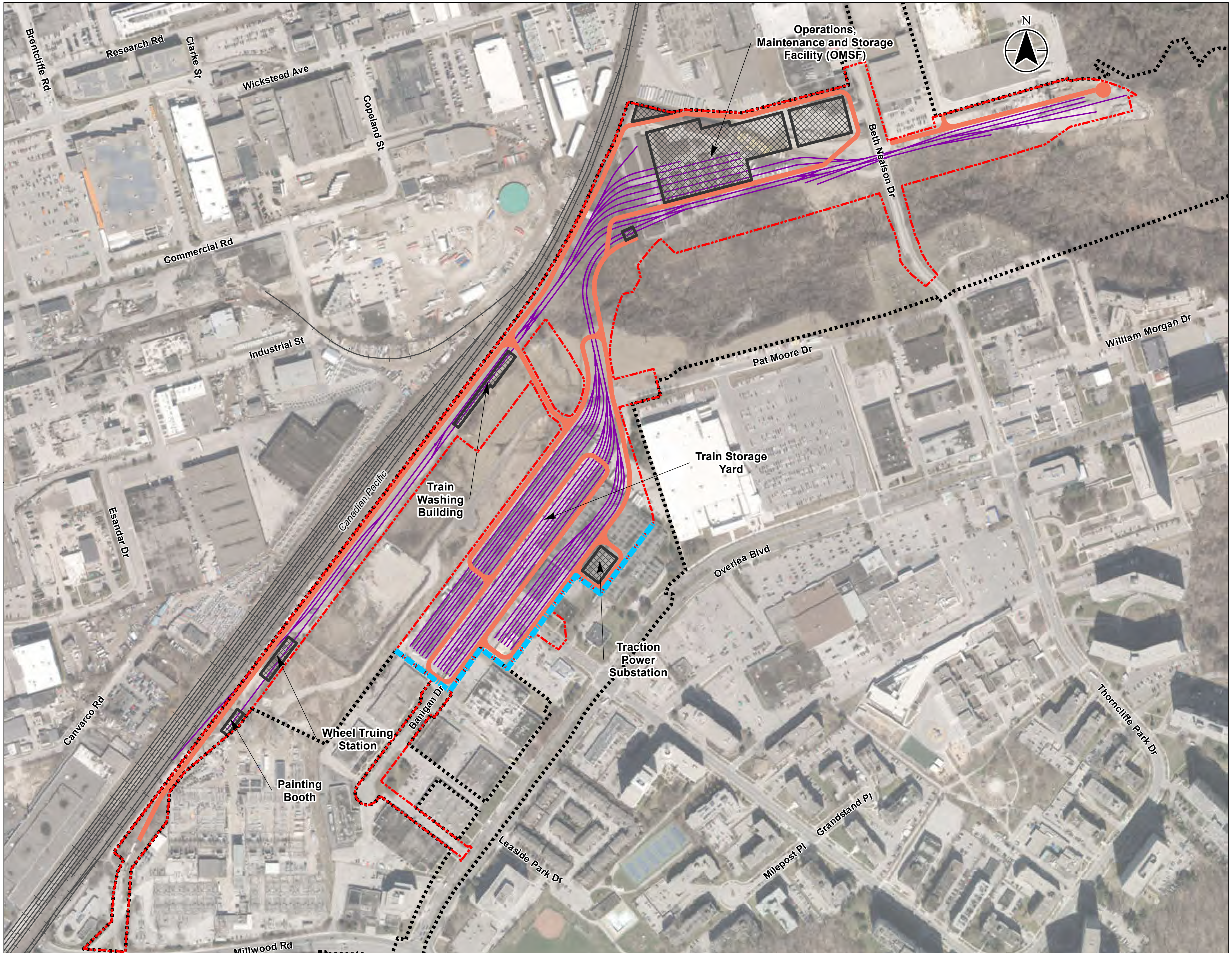
Vibration Criteria for Vibration Sensitive Equipment (ASHRAE 2007 and CDOT 2013)

Criterion Curve	Description of Use	Vibration Limit (mm/s, RMS)
Operation Room	Vibration not perceptible. Suitable in most instances for surgical suites; microscopes to 100x and for other equipment of low sensitivity; laboratory robots.	0.1
VC-A	Adequate in most instances for optical microscopes to 400x; microbalances; optical and other precision balances; proximity and projection aligners; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment.	0.051
VC-B	Appropriate for inspection and lithography equipment (including steppers) to 3 µm line widths; Microsurgery; Eye surgery; neurosurgery; bench microscopes at magnification greater than 400x; optical equipment isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 micro-m line widths.	0.025
VC-C	High-precision balances, spectrophotometers, magnetic resonance imagers (MRI); Microtomes and cryotomes for <5 µm slices, chemotaxis; Appropriate standard for optical microscopes to 30,000x, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1 µ detail size, TFT-LCD stepper/scanner processes.	0.013
VC-D	Suitable in most instances for the most demanding equipment including many electron microscopes (SEMs and TEMs) and E-Beam systems. Cell implant equipment, micromanipulation; Confocal microscopes, high-resolution mass spectrometers; Electron microscopes (SEMs, TEMs) at greater than 30,000×	0.0064
VC-E	Unisolated optical research systems, extraordinarily sensitive systems; A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems, E-beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.	0.0032
VC-F	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.	0.0016
VC-G	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.	0.0008



Vibration Criteria for Vibration Sensitive Equipment (ASHRAE 2007)

Appendix P. Additional Project Information



Stantec

Legend

- Project Footprint
- Railway
- Operations, Maintenance and Storage Facility (OMSF) Construction Limits
- Approximate Location of Additional Barrier to be Provided by Metrolinx
- Track Alignment Centerline
- OMSF Building
- OMSF Access Road

0 130 260 Metres

1:5,000 (At original document size of 11x17)

Notes

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Project Location
Coity of Toronto, ON

160560009 REV4
Prepared by BCC on 2022-01-19
Technical Review by ABC on yyyy-mm-dd
Independent Review by ABC on yyyy-mm-dd

Client/Project
HDR CORPORATION
ONTARIO LINE TA

Figure No.
P-1

Title
Approximate Location of Additional Barrier to be Provided by Metrolinx

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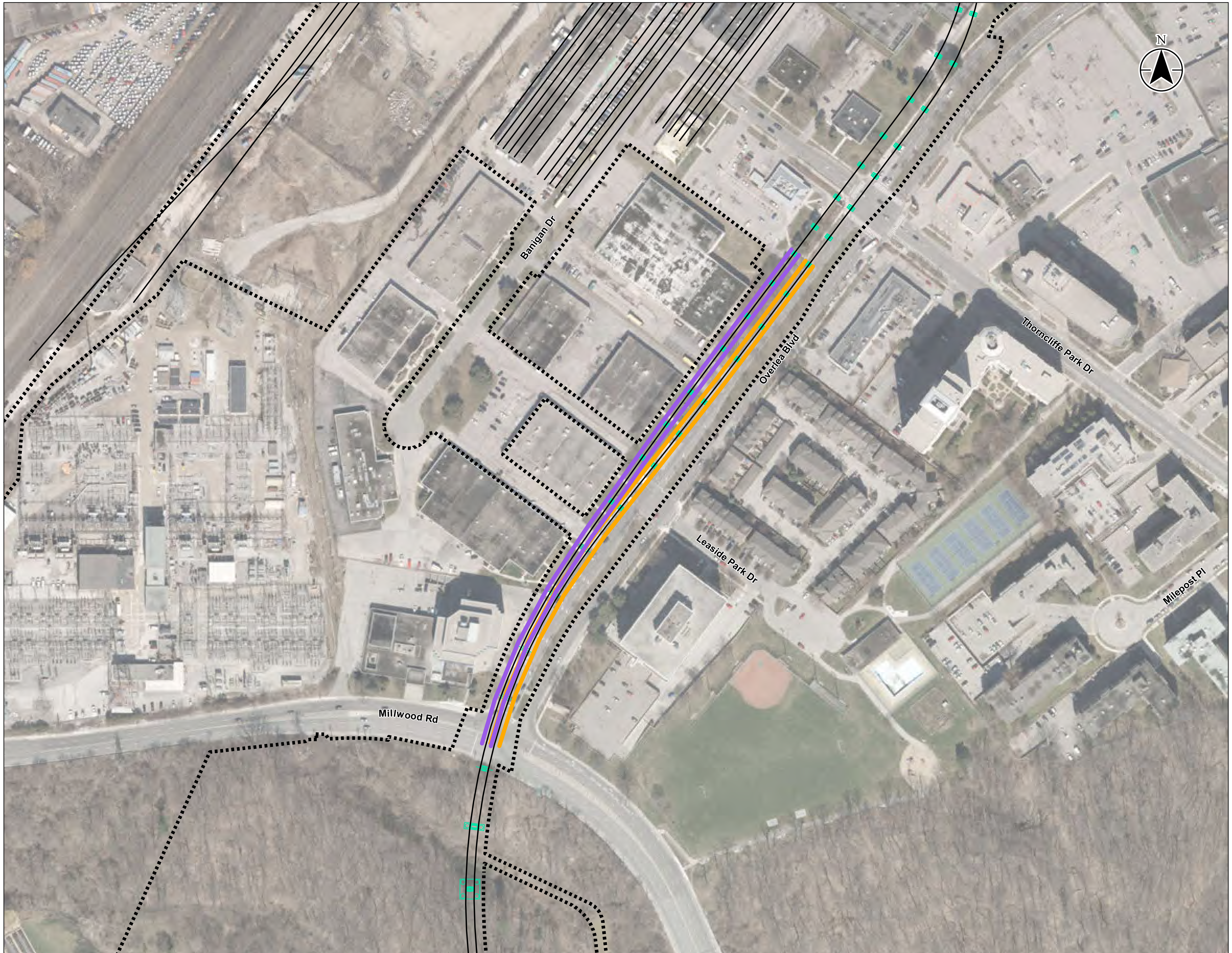

Stantec

Legend

Project Footprint

Ontario Line Tracks

Elevated Guideway Pier

Approximate Location of Additional Barrier to be Provided by Metrolinx

Eastbound Rail Barrier

Westbound Rail Barrier

0 60 120 Metres

1:2,567 (At original document size of 11x17)

Notes

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Project Location
Coity of Toronto, ON

160560009 REV4
Prepared by BCC on 2022-01-19
Technical Review by ABC on yyyy-mm-dd
Independent Review by ABC on yyyy-mm-dd

Client/Project
HDR CORPORATION
ONTARIO LINE TA

Figure No.
P-2

Title
Approximate Location of Additional Barrier to be Provided by Metrolinx

Appendix Q. Additional Project Noise and Vibration Reports

Noise and Vibration Operations Report – Ontario Line – Lakeshore East Joint Corridor, November 2021, AECOM

Metrolinx

Noise and Vibration Operations Report

Ontario Line - Lakeshore East Joint Corridor

Prepared by:

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5090 Explorer Drive, Suite 1000
Mississauga, ON L4W 4X6
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T: 905 238 0007
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www.aecom.com

Date: November 2021

Project #: 60611173

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The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

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- represents AECOM's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
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Executive Summary

ES.1 Ontario Line and GO Lakeshore East Joint Corridor Operations

Metrolinx, an agency of the Province of Ontario, is proceeding with the planning and development of four priority transit projects under the Transit Plan for the Greater Toronto Area (GTA), one of which is the Ontario Line, extending from Exhibition/Ontario Place to the Ontario Science Centre in the City of Toronto. AECOM Canada Limited (AECOM) was retained by Metrolinx and Infrastructure Ontario (IO) to complete this Joint Corridor Operational Noise and Vibration Impact Assessment Report for the portion of the proposed Ontario Line Project (the Project) which will operate in the GO Union Station and Lakeshore East rail corridors approximately between Tannery Road and Pape Avenue (referred to in this report as the Lakeshore East Joint Corridor).

The Project is proposed to be a new approximately 16-kilometre subway line with connections to Line 1 (Yonge-University) subway service at Osgoode and Queen Stations, Line 2 (Bloor-Danforth) subway service at Pape Station, and Line 5 (Eglinton Crosstown) Light Rail Transit (LRT) service at the future Science Centre Station. Fifteen stations are proposed, with additional connections to three GO Transit lines (Lakeshore East, Lakeshore West and Stouffville), and the Queen, King, Bathurst, Spadina, Harbourfront and Gerrard/Carlton streetcar routes. The Project will reduce crowding on Line 1 and provide connections to new high-order rapid transit neighbourhoods.

The Project will be constructed in a dedicated right-of-way with a combination of elevated (i.e., above existing rail corridor/roadway), tunneled (i.e., underground), and at-grade (i.e., at grade with existing rail corridor/roadway) segments at various locations.

This Lakeshore East Joint Corridor Operational Noise and Vibration Impact Assessment Report has been completed in accordance with Section 15 of *Ontario Regulation 341/20: Ontario Line Project* under the *Environmental Assessment Act.* Ontario Regulation 341/20 is a proponent-driven, self-assessment process that provides a defined framework for the proponent to follow. Ontario Regulation 341/20 includes provisions for consultation with the public, agencies and Indigenous communities in addition to Environmental Conditions, Early Works and Environmental Impact Assessment reporting requirements.

In addition to the planned Ontario Line, the Union Station and Lakeshore East rail corridor segments are planned to be expanded as part of the regional GO Expansion program to increase train frequency and availability. The planned expansion includes new track and facilities, alignment changes, and increased train volumes. A Significant Addendum to the 2017 GO Rail Network Electrification Environmental Project Report was completed in 2021 to assess any changes from noise and vibration associated with increased service levels across six Metrolinx-owned rail corridors, including Union Station and Lakeshore East but with the exception of the Lakeshore East Joint Corridor operational noise and vibration of which is assessed in this report.

For clarity, tracks used by Ontario Line vehicles will be referred to as Ontario Line tracks and tracks used by other vehicles will be referred to as GO tracks in this report.

The purpose of this Report is to:

- Document the assessment of the combined noise impacts and the combined vibration impacts associated with both the operation of vehicles on the Ontario Line tracks and the operation of trains on the GO tracks within the Lakeshore East Joint Corridor; and,
- Provide noise and vibration mitigation recommendations to be further developed and refined during detailed design.

This Report supports the Ontario Line Environmental Impact Assessment Report prepared in accordance with Ontario Regulation 341/20: Ontario Line Project. Assessments of other Ontario Line segments have been documented under separate cover.

A glossary of terminology is provided in **Appendix A**.

ES.2 Assessed Points of Reception

The Study Area encompasses segments of the Lakeshore East and Union Station rail corridors and surrounding noise and vibration sensitive areas. The west boundary of the Study Area is approximately at the Ontario Line tunnel portal in the Union Station rail corridor and near the Don Yard, west of the Don River, east of Tannery Road (see Figure 1). The east boundary of the Study Area is at Jones Avenue, east of the Ontario Line tunnel portal located north-east of Gerrard Street East and Carlaw Avenue. The boundaries extend beyond the portals in order to assess noise impacts to sensitive receptors that would be exposed to project noise and to integrate seamlessly with noise mitigation proposed for the GO Expansion program.

Assessed points of reception (PORs) were selected to represent noise and vibration sensitive receptors within the Study Area. These assessed PORs are at the worst case (typically closest) sensitive properties with reference to nearby railway noise and vibration within each sensitive land use area. Assessed PORs for both noise and vibration analysis are shown in **Figures 1, 2 and 3** as well as in the noise and vibration mitigation figures in **Appendix D**.

ES.3 Operational Noise Assessment

This Report documents the operational noise and vibration assessment of Ontario Line vehicles and GO trains within the Lakeshore East Joint Corridor. Impacts associated with Project construction will be addressed under separate cover. A number of the Lakeshore East Joint Corridor infrastructure components, including noise barriers investigated in this report, will be constructed as part of the Lakeshore East Joint Corridor early works. Impacts associated with the construction of those components are addressed within the *Noise and Vibration Early Works Report – Ontario Line Lakeshore East Joint Corridor Early Works* document. Details of the noise assessment methods are provided in **Section 3**.

The noise impact from train operations was assessed using the noise assessment method presented in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (the FTA Guide; FTA 2018), with implementation in the Cadna/A acoustic software package. Noise models were prepared for both the existing and future "with project" scenarios. Noise impacts were evaluated in accordance with the MOEE[1]/GO Transit *Draft Protocol for Noise and Vibration Assessment* (the MOEE/GO Protocol; MOEE/GO Transit, 1995) and the MOEE/TTC *Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop* (the MOEE/TTC Protocol; MOEE/TTC, 1993). In addition to protocol objectives, Metrolinx is seeking to limit $L_{eq,16hr}$ (daytime) and $L_{eq,8hr}$ (night-time) noise impacts from the project to existing predicted levels at receptors between Eastern Avenue and Pape Avenue, where feasible, even for receptors with predicted noise impacts that do not require mitigation investigation per the MOEE/GO Protocol and/or MOEE/TTC Protocol. To meet this goal, implementation of noise barriers was investigated along both sides of the Lakeshore East Joint Corridor between approximately Eastern Avenue and Pape Avenue.

The results indicated that noise barriers implemented along both sides of the corridor are predicted to be effective in satisfying the goal of reducing 16-hour Day-time L_{eq}, and 8-hour Night-time L_{eq} noise levels to predicted existing railway noise levels at assessed worst case receptor locations facing the corridor between Eastern Avenue and Pape Avenue with the exception of five high-rise buildings, where noise impacts are expected to be in the "insignificant" to "noticeable" range and are below the MOEE/GO and MOEE/TTC Protocols criteria limits. At all other assessed receptors, noise barriers are predicted to achieve reductions of 0.4 to 10 dB, resulting in $L_{eq,16hr}$ (daytime) and $L_{eq,8hr}$ (night-time) noise levels below the predicted existing noise levels. Implemented noise barriers are shown in **Appendix D**, ranging in height from 2.5 to 6.5 metres. Noise contour figures are presented in **Appendix F**.

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[1] Now operating as the Ministry of the Environment, Conservation and Parks (MECP).

Though barriers presented in this report range in height from 2.5 to 6.5 metres, Metrolinx will install noise barriers with a minimum height of 5 metres, in alignment with the noise barrier implementation approach planned to be undertaken by GO Expansion. Installing noise barriers with a minimum height of 5 metres will provide additional mitigation. To facilitate this and barrier detailed design development, refinements to the noise model and recommended barrier design presented in this report will be performed, and changes to barrier height, extent and surface types will be implemented where required. Mitigation measures will still be designed to meet MOEE/GO and MOEE/TTC protocol criteria, and limit $L_{eq,16hr}$ (daytime) and $L_{eq,8hr}$ (night-time) noise impacts from the project to existing predicted levels at receptors between Eastern and Pape Avenue, where feasible, even for receptors with predicted noise impacts that do not require mitigation investigation per the MOEE/GO Protocol and/or MOEE/TTC Protocol.

ES.4 Operational Vibration Assessment

As noted above, this Report documents the operational noise and vibration assessment of Ontario Line vehicles and GO trains within the Lakeshore East Joint Corridor. A number of the Lakeshore East Joint Corridor infrastructure components, including realigned GO tracks and the new fourth track as well as associated vibration mitigation investigated in this report, will be installed as part of the Lakeshore East Joint Corridor early works. Impacts associated with the construction of those components are addressed within the *Noise and Vibration Early Works Report – Ontario Line Lakeshore East Joint Corridor Early Works* document. Details of the vibration assessment methods are provided in **Section 4**.

Vibration levels were predicted at receptor locations selected to represent the most exposed or impacted within a sensitive area. Vibration levels have been predicted in accordance with the General Vibration Assessment procedures described in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (FTA, 2018). The vibration impacts from GO vehicle operations were evaluated in accordance with the MOEE/GO Protocol, while the vibration impacts from the Ontario Line vehicles were evaluated in accordance with the MOEE/TTC protocol.

Based on MOEE/GO or MOEE/TTC Protocol requirements, mitigation investigation is recommended for nine receptor locations. As the required vibration reductions presented in **Table 4-2** range between 2 to 8 dB, the predicted vibration levels are anticipated to be reduced to below required criteria using conventional mitigation measures. Results and mitigation requirements are detailed in **Section 4.3**. The locations and extents of areas requiring vibration reduction are presented in **Appendix D**.

A detailed vibration analysis, including vibration propagation testing to consider local ground conditions, will be conducted in the detailed design stage in order to refine mitigation requirements for these locations.

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1. Introduction

Metrolinx, an agency of the Province of Ontario, is proceeding with the planning and development of four priority transit projects under the Transit Plan for the Greater Toronto Area (GTA), one of which is the Ontario Line, extending from Exhibition/Ontario Place to the Ontario Science Centre in the City of Toronto. AECOM Canada Limited (AECOM) was retained by Metrolinx and Infrastructure Ontario (IO) to complete this Operational Noise and Vibration Impact Assessment Report for the portion of the proposed Ontario Line Project (the Project) which will operate along dedicated tracks adjacent to the GO tracks in the Union Station and Lakeshore East rail corridors between approximately Tannery Road and Pape Avenue in the City of Toronto. This portion is hereafter referred to as the Lakeshore East Joint Corridor.

The Project will be a new approximately 16-kilometre subway line with connections to Line 1 (Yonge-University) subway service at Osgoode and Queen Stations, Line 2 (Bloor-Danforth) subway service at Pape Station, and Line 5 (Eglinton Crosstown) Light Rail Transit (LRT) service at the future Science Centre Station. Fifteen stations are proposed, with additional connections to three GO transit lines (Lakeshore East, Lakeshore West and Stouffville), and the Queen, King, Bathurst, Spadina, Harbourfront and Gerrard/Carlton streetcar routes. The Project will reduce crowding on Line 1 and provide connections to the new high-order rapid transit neighbourhoods.

The Project will be constructed in a dedicated right-of-way with a combination of elevated (i.e., above existing rail corridor/roadway), tunneled (i.e., underground), and at-grade (i.e., at grade with existing rail corridor/roadway) segments at various locations.

This Operational Noise and Vibration Impact Assessment Report has been completed in accordance with Section 15 of Ontario Regulation 341/20: Ontario Line Project under the *Environmental Assessment Act.* Ontario Regulation 341/20 is a proponent-driven, self-assessment process that provides a defined framework for the proponent to follow. Ontario Regulation 341/20 includes provisions for consultation with the public, agencies and Indigenous communities in addition to Environmental Conditions, Early Works and Environmental Impact Assessment reporting requirements.

In addition to the planned Ontario Line, the Union Station and Lakeshore East rail corridor segments are planned to be expanded as part of the regional GO Expansion program to increase train frequency and availability. The planned expansion includes new track and facilities, alignment changes, and increased train volumes. A Significant Addendum to the 2017 GO Rail Network Electrification Environmental Project Report was completed in 2021 to assess any changes the noise and vibration associated with increased service levels across six Metrolinx-owned rail corridors, including Union Station and Lakeshore East but with the exception of the Lakeshore East Joint Corridor, operational noise and vibration of which is assessed in this report.

For clarity, tracks used by Ontario Line vehicles will be referred to as Ontario Line tracks and tracks used by other vehicles are referred to as GO tracks in this report.

To accommodate the Ontario Line infrastructure along the Lakeshore East rail corridor, shift of the GO tracks adjacent to proposed Ontario Line infrastructure has been proposed, as shown in **Figures 1, 2 and 3**. Impacts from both the current existing GO track configuration and future proposed alignment (combined with Ontario Line tracks as part of the Lakeshore East Joint Corridor) are documented within this report.

The purpose of this Report is to:

- Document the assessment of the combined noise impacts and the combined vibration impacts associated with both the operation of vehicles on the Ontario Line tracks and the operation of trains on the GO tracks within the Lakeshore East Joint Corridor; and,
- Provide noise and vibration mitigation recommendations to be further developed and refined during detailed design.

Operational noise and vibration assessment of other segments of the Ontario Line is provided under separate cover[2]. The relevant assessment guidelines, methods, and assumptions are outlined in this report, along with predicted noise and vibration impacts and a discussion on requirements for mitigation.

A glossary of terminology is provided in **Appendix A**.

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[2] Environmental Impact Assessment Report, in development at the time of this report preparation

2. Study Area and Assessed Points of Reception

The operational noise and vibration assessment Study Area encompasses segments of the Lakeshore East and Union Station rail corridors and surrounding noise and vibration sensitive areas. The west boundary of the Study Area is approximately at the Ontario Line tunnel portal in the Union Station rail corridor and near the Don Yard, west of the Don River, east of Tannery Road (see **Figures 1, 2 and 3**). The east boundary of the Study Area is at Jones Avenue, east of the Ontario Line tunnel portal located north-east of Gerrard Street East and Carlaw Avenue. The boundaries extend beyond the portals in order to assess noise impacts to sensitive receptors that would be exposed to project noise and to integrate seamlessly with noise mitigation proposed for the GO Expansion program.

The predominant land uses within the Study Area include:

- Residential;
- Mixed use areas;
- Parks;
- General employment areas;
- Core employment areas; and
- Regeneration areas.

As defined in the MOEE/GO Transit Draft Protocol for Noise and Vibration Assessment, a sensitive land use is defined as a residential dwelling, place where people ordinarily sleep, or a commercial/industrial operation that is exceptionally sensitive to noise or vibration.

Within the Study Area, noise and vibration sensitive points of reception (PORs), or sensitive receptors, include residences (both single family dwellings and condominiums/apartments) and the currently proposed school south of Mill Street, north of the Union Station Rail Corridor. Existing sensitive receptors have been identified using aerial and street photography. Within each sensitive land use area (i.e., an area with several noise and/or vibration sensitive receptors in close proximity to each other), a sample receptor has been selected to represent the worst case receptor, which is the receptor in a given sensitive land use area that is typically in closest proximity to the project and with the highest expected project related noise and/or vibration levels. Planned and approved developments have also been considered by reviewing block plans and development applications available during the time of the assessment. **Table 2-1** below presents the representative PORs to be assessed, which are also presented in **Figure 1**.

Table 2-1: Representative Sensitive Points of Reception

Receptor ID	Location
POR1	Planned development – 6 Storey School and Community Centre Site – Located South of Mill Street, Between Tannery Road and Bayview Avenue. Location and height referenced from the West Don Lands Block Plan and Design Guidelines (2006).
POR2	791 Queen Street East (Multi-storey residential building)
POR3	14 De Grassi Street (Residential dwelling)
POR3A	22 De Grassi Street (Residential dwelling)
POR4	8 Paisley Avenue (Residential dwelling)
POR5	Planned development at 354 Pape Avenue – West of Pape Avenue, just south of the LSE tracks (Multi-storey residential building). Location and height referenced from architectural drawings and City of Toronto development application database.
POR7	31 Saulter Street (Residential dwelling)
POR8	88 Wardell Street (Residential dwelling)
POR9	89 McGee Street (Residential dwelling)
POR10	15 Tiverton Avenue (Residential dwelling)
POR11	231 First Avenue (Multi-storey residential building)
POR11A	238 First Avenue (Residential dwelling)
POR12	838 Gerrard Street East (Residential dwelling)
POR12A	456 Carlaw Avenue (Residential dwelling)
POR13	881 Gerrard Street East (Residential dwelling)
POR13D	345 Carlaw Avenue (Multi-storey residential building)
POR13E	1189 Dundas Street East (Multi-storey residential building)
POR14	Planned development – Future mixed-use development as documented in the New SmartTrack Stations Environmental Project Report (2018), south of the Lakeshore East rail corridor, between the Don Valley Parkway and Eastern Avenue. Location and height estimated for a potential mixed use multi-story building in the East Harbour Station area per the property line available on Infrastructure Ontario online materials[3].

[3] Further information on this Transit Oriented Community can be found at: https://www.infrastructureontario.ca/East-Harbour-Transit-Oriented-Community/

Receptor ID	Location
POR15	70 McGee Street (Multi-storey residential building)
POR16	444 Logan Avenue (Multi-storey residential building)
POR17	Planned development – Northwest corner of Mill Street and Bayview Avenue (Multi-storey residential building). Location and height referenced from the West Don Lands Block Plan and Design Guidelines (2006).
POR18	398 Logan Avenue (Residential dwelling)
POR19	449 Logan Avenue (Multi-storey residential building)
POR20	369 Pape Avenue (Multi-storey residential building)
POR22	388 Pape Avenue (Residential dwelling)
POR22B	237 Langley Avenue (Residential dwelling)
POR23	2 Paisley Avenue (Residential dwelling)
POR24	870 Queen Street East (Jimmie Simpson Recreation Centre Building[4])

[4] This receptor has been included within the assessment as a discretionary receptor and is not considered a typical noise or vibration sensitive receptor per the protocol criteria within this assessment.

Figure 1: Representative Sensitive Points of Reception – Don Yard

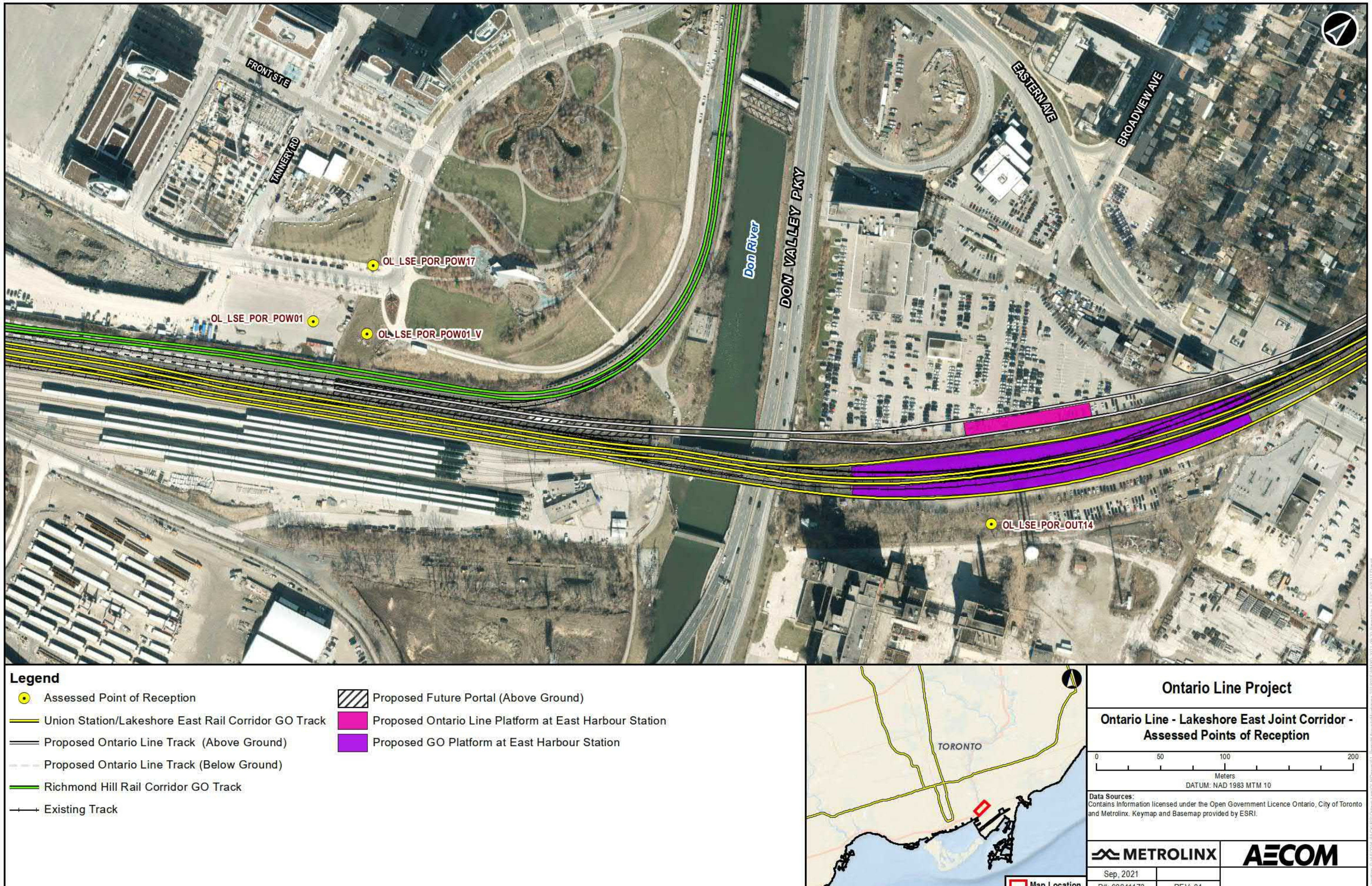


Figure 2: Representative Sensitive Points of Reception – East Harbour to Jimmie Simpson Park

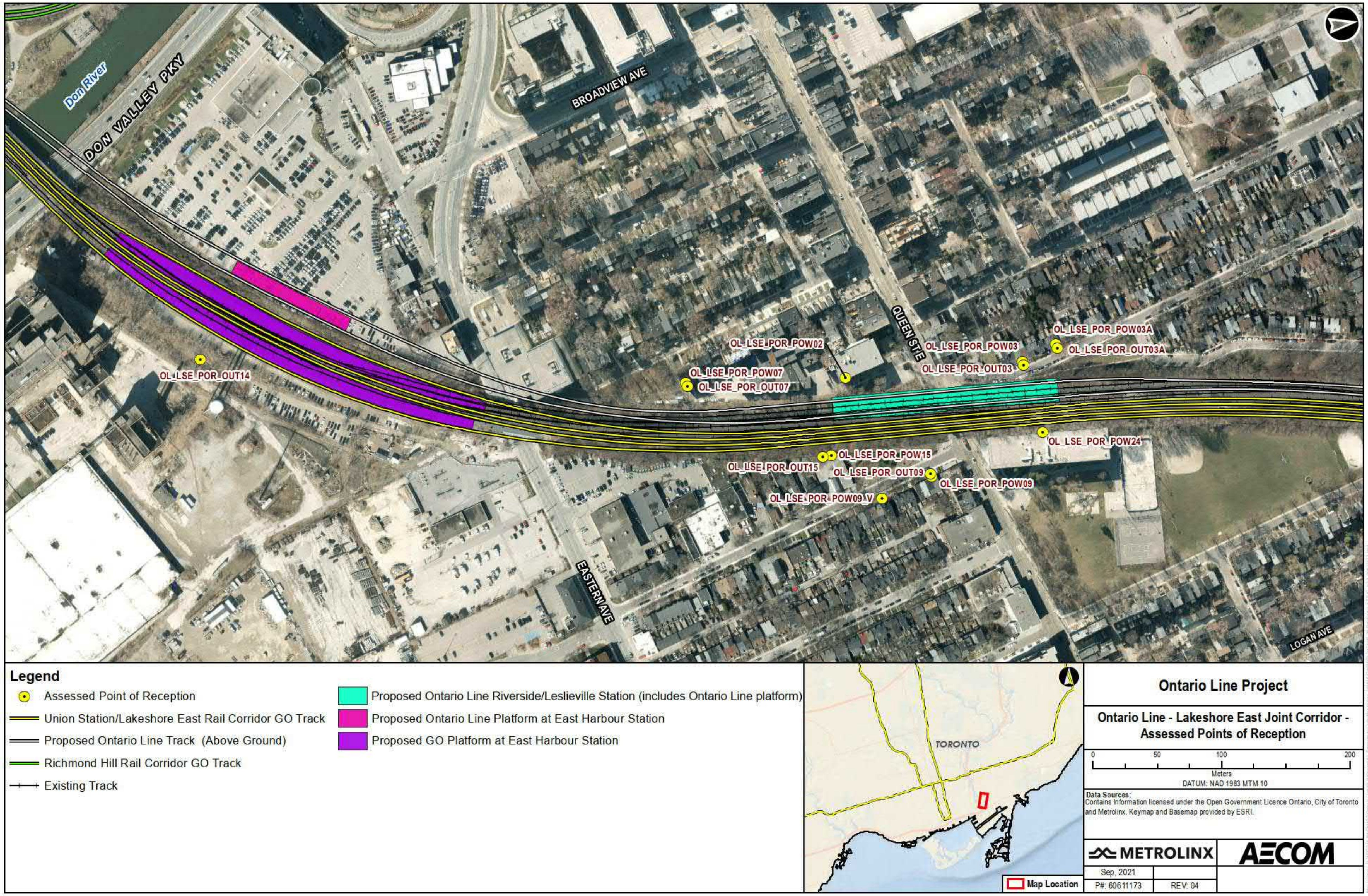
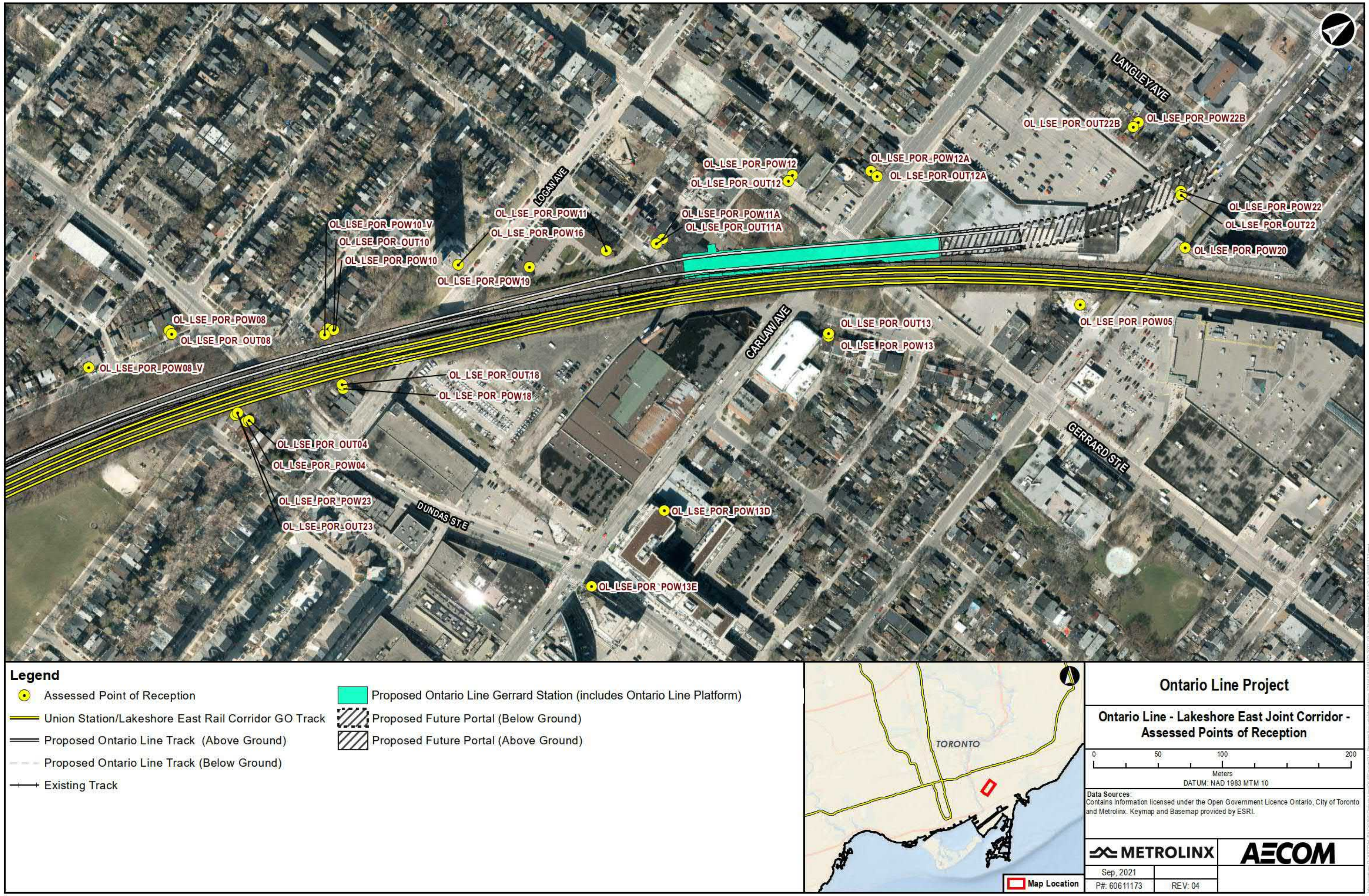


Figure 3: Representative Sensitive Points of Reception – Jimmie Simpson Park to Pape Avenue



3. Operational Noise Assessment

3.1 Criteria

Impacts associated with Project construction will be addressed under separate cover. A number of the Lakeshore East Joint Corridor infrastructure components, including noise barriers investigated in this report, will be constructed as part of the Lakeshore East Joint Corridor early works. Impacts associated with the construction of those components are addressed within the *Noise and Vibration Early Works Report – Ontario Line Lakeshore East Joint Corridor Early Works* document.

This operational noise assessment has been conducted using methods and criteria detailed in the following documents:

- The MOEE[5]/GO Transit Draft Protocol for Noise and Vibration Assessment
- The MOEE/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop

The MOEE/GO Transit *Draft Protocol for Noise and Vibration Assessment* (the MOEE/GO Protocol; MOEE/GO Transit, 1995) provides a framework for noise and vibration assessments of GO Transit rail projects. In accordance with the protocol, noise impacts are evaluated by comparing noise levels from without the project to noise levels with the completed project.

Noise levels without the project are taken to be the higher of the predicted existing ambient noise level, combined with the existing rail noise without the project, or 55 dBA $L_{eq,16hr}$ (daytime) / 50 dBA $L_{eq,8hr}$ (night time). These adjusted daytime and night-time without project levels are considered the “objective” levels for the project. The adjusted noise impact is determined based on the difference between the objective levels and the noise levels with the completed project. In accordance with the Protocol, the feasibility of operational noise mitigation measures is to be reviewed where the predicted noise impact of the project is ‘significant’ (equal to or greater than 5 dB).

The MOEE/TTC *Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop* (the MOEE/TTC Protocol; MOEE/TTC, 1993) sets criteria for noise that have been used for recent assessments of subway projects in Toronto. Similar to the MOEE/GO protocol, mitigation investigation is recommended where the predicted noise impact is equal to or greater than 5 dB based on noise levels with the

[5] Now operating as the Ministry of the Environment, Conservation and Parks (MECP).

project relative to the greater of 55 dBA $L_{eq,16hr}$ (daytime) / 50 dBA $L_{eq,8hr}$ (night time) limits, or the existing ambient noise. The MOEE/TTC Protocol sets an additional pass-by sound level (L_{passby}) criterion limit of 80 dBA for passing trains (applicable to the Ontario Line vehicles).

According to both the MOEE/GO Protocol and MOEE/TTC Protocol, mitigation measures shall be provided to mitigate noise impacts to as close to or lower than the objective levels as is technologically, economically and administratively feasible. Copies of the MOEE/GO and MOEE/TTC Protocols can be found in **Appendix B**.

A summary of both the MOEE/GO and MOEE/TTC protocol criteria is presented in **Table 3-1**.

Table 3-1: Noise Limits by Vehicle Type

Metric	GO Limits[6]	Ontario Line Limits
Daytime Noise Impact [$L_{eq,16hr}$] **(16-hour, 7 a.m. to 11 p.m.)**	5 dB relative to the higher of pre-project sound levels or 55 dBA	5 dB relative to the higher of pre-project sound levels or 55 dBA
Night-time Noise Impact [$L_{eq,8hr}$] **(8-hour, 11 p.m. to 7 a.m.)**	5 dB relative to the higher of pre-project sound levels or 50 dBA	5 dB relative to the higher of pre-project sound levels or 50 dBA
Subway vehicle L_{passby}	Not applicable to non-subway trains.	80 dBA

During the daytime, an outdoor location associated with a residence (labeled as OUT within this report), typically a back or front yard, is taken as the point of reception in the noise assessment. This outdoor assessment location is approximately 3 metres from the unit at a height of 1.5 metres.

During the night-time, the POR is taken at the building façade, which is a location intended to represent a possible bedroom window (labeled as plane of window [POW]). This is also the assessment location selected during the daytime in cases where no outdoor living areas exist, such as an apartment building with no outdoor amenity area. For POW receptors, receptor height is estimated using the number of storeys for the building (e.g. 1.5 metres for 1 storey, 4.5 metres for 2 storeys, and 7.5 metres for 3 storeys). For high-rise buildings, the height of the vertical midpoint of the storey with the highest expected noise levels was used.

[6] GO Limits noted apply to combination of GO, VIA and freight trains operating in rail corridor.

In addition to protocol objectives, Metrolinx is seeking to limit $L_{eq,16hr}$ (daytime) and $L_{eq,8hr}$ (night-time) noise impacts from the project to existing predicted levels at receptors between Eastern and Pape Avenue, where feasible, even for receptors with predicted noise impacts that do not require mitigation investigation per the MOEE/GO Protocol and/or MOEE/TTC Protocol.

For reference in the discussion of noise impacts throughout the report, **Table 3-2** presents the typical impact rating of a change in sound level per the MOEE/GO protocol.

Table 3-2: Impact Rating of Changes in Sound Pressure Level

Impact Level [dB]	Impact Rating
0-2.99	Insignificant
3-4.99	Noticeable
5-9.99	Significant
10+	Very significant

3.2 Methods

In order to assess noise impacts from vehicle operations along the Ontario Line tracks as well as train operations along the GO tracks, the noise assessment method presented in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (the FTA Guide; FTA 2018) has been used, with implementation in the Cadna/A acoustic software package.

Noise models were prepared for both the existing scenario to predict existing railway noise conditions, and future “with project” scenario, which modelled both the noise contributions from the Ontario Line and GO expansion. These noise models were built upon models prepared for the GO Rail Network Electrification project detailed in the *GO Rail Network Electrification Final Environmental Project Report Addendum* report prepared in May 2021.

The future “with project” scenario noise model includes the Ontario Line tracks and portals, additional Lakeshore East GO track (4^{th} track, previously approved as part of the Lakeshore East Don River to Scarborough GO Station Transit Project Assessment Process Environmental Project Report), and the proposed alignment changes to GO tracks in order to accommodate future Ontario Line infrastructure.

The future “with project” scenario model includes the combined railway noise generated by vehicles operating on the Ontario Line tracks and trains operating on the GO tracks.

Future train volumes for trains operating on GO and Ontario Line tracks are presented in **Appendix C**. A complete list of model inputs is presented in **Appendix E**.

3.3 Impact Assessment and Results

Table 3-3 outlines the predicted existing railway noise conditions, predicted future railway noise levels and impacts without any specific noise mitigation measures implemented, whether the greater noise contribution is from the Ontario Line tracks or GO tracks, and whether MOEE/GO and MOEE/TTC criteria are met.

As existing day and night-time noise levels are shown to be greater than the MOEE/GO and MOEE/TTC minimum limits of 55 dBA $L_{eq,16h}$ during the daytime and 50 dBA $L_{eq,8h}$ during the night time, the existing predicted day time and night time levels were adopted as the objective noise levels for the assessment at all locations.

Based on MOEE/GO or MOEE/TTC Protocol requirements, mitigation investigation is recommended for nine noise sensitive locations, located between Eastern Avenue and Pape Avenue. Results with implemented mitigation are presented in **Section 3.4**. At all other (19) noise sensitive locations, noise levels from the Ontario Line tracks and GO tracks were predicted to meet MOEE/GO and MOEE/TTC Protocol criteria. In addition, noise levels are predicted to decrease at eight outdoor receptor locations where the lower elevation at the receptor locations, relative to the tracks and retaining wall, results in a noise screening effect by the retaining wall.

Generally, it was found that receptors adjacent to the south side of the corridor (the side closest to GO tracks) were predicted to have higher noise levels than those to the north of the corridor. The exceptions to this are locations such as POR_12 and POR_22 receptors adjacent to the north side of the corridor (closest to Ontario Line tracks) where existing buildings located in proximity to these receptors are expected to be removed due to construction of the Ontario Line infrastructure on the north side of the corridor. This is expected to result in removal of current noise shielding for these receptors provided by these buildings, leading to higher noise levels.

Further, operations on the GO tracks were predicted to be the dominant source of noise during day and night-time periods at all assessed receptors except POR_OUT03, POR_OUT11A, and POR_OUT12 (outdoor receptors) during the daytime. This can be attributed to the retaining wall providing noise screening to these outdoor receptors located at a lower elevation relative to the GO tracks.

Table 3-3: Predicted Operational Noise Impacts – Without Mitigation

Receptor	Existing Conditions		Future – With Project		Objective Sound Level		Noise Impact, Day [dB]	Noise Impact, Night [dB]	Future – Ontario Line Contributions		Future – GO Train[7] Contributions		Greater Noise Contribution		MOEE/TTC Pass-by Criteria		Meets GO/TTC Protocol Criteria [Y/N]
	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]			Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night	L_{Passby} – Ontario Line [dBA]	Pass-by Exceedance [dBA]	
OL_LSE_POR_POW01	65.9	63.5	68.3	63.8	65.9	63.5	2.4	0.3	52.0	46.5	68.2	63.8	GO	GO	64	0	Y
OL_LSE_POR_POW02	67.1	62.5	70.2	65.0	67.1	62.5	3.1	2.5	62.4	56.8	69.5	64.3	GO	GO	75	0	Y
OL_LSE_POR_POW03	N/A	61.8	N/A	62.9	N/A	61.8	N/A	1.1	N/A	57.3	N/A	61.5	N/A	GO	77	0	Y
OL_LSE_POR_OUT03	65.3	N/A	60.5	N/A	65.3	N/A	-4.8[8]	N/A	57.9	N/A	57.2	N/A	OL	N/A	72	0	
OL_LSE_POR_POW03A	N/A	60.6	N/A	64.2	N/A	60.6	N/A	3.6	N/A	56.1	N/A	63.4	N/A	GO	74	0	Y
OL_LSE_POR_OUT03A	64.4	N/A	62.9	N/A	64.4	N/A	-1.5	N/A	59.7	N/A	60.0	N/A	GO	N/A	74	0	
OL_LSE_POR_POW04	N/A	61.9	N/A	68.4	N/A	61.9	N/A	**6.5**	N/A	54.1	N/A	68.3	N/A	GO	72	0	N
OL_LSE_POR_OUT04	65.8	N/A	69.6	N/A	65.8	N/A	3.8	N/A	49.5	N/A	69.6	N/A	GO	N/A	62	0	
OL_LSE_POR_POW05	70.2	65.5	73.6	68.9	70.2	65.5	3.4	3.4	52.0	46.4	73.6	68.8	GO	GO	64	0	Y
OL_LSE_POR_POW07	N/A	61.5	N/A	64.3	N/A	61.5	N/A	2.8	N/A	54.3	N/A	63.9	N/A	GO	71	0	Y
OL_LSE_POR_OUT07	65.2	N/A	59.1	N/A	65.2	N/A	-6.1	N/A	54.8	N/A	57.0	N/A	GO	N/A	68	0	
OL_LSE_POR_POW08	N/A	59.1	N/A	63.2	N/A	59.1	N/A	4.1	N/A	53.7	N/A	62.7	N/A	GO	72	0	Y
OL_LSE_POR_OUT08	63.6	N/A	66.8	N/A	63.6	N/A	3.2	N/A	59.1	N/A	66.0	N/A	GO	N/A	72	0	

[7] GO Train noise levels above incorporate contributions from GO, VIA and freight services.
[8] Negative values indicate a predicted decrease in noise levels.

Receptor	Existing Conditions		Future – With Project		Objective Sound Level		Noise Impact, Day [dB]	Noise Impact, Night [dB]	Future – Ontario Line Contributions		Future – GO Train[7] Contributions		Greater Noise Contribution		MOEE/TTC Pass-by Criteria		Meets GO/TTC Protocol Criteria [Y/N]
	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]			Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night	L_{Passby} – Ontario Line [dBA]	Pass-by Exceedance [dBA]	
OL_LSE_POR_POW09	N/A	58.6	N/A	62.7	N/A	58.6	N/A	4.1	N/A	46.9	N/A	62.6	N/A	GO	65	0	N
OL_LSE_POR_OUT09	62.6	N/A	67.7	N/A	62.6	N/A	**5.1**	N/A	49.3	N/A	67.7	N/A	GO	N/A	62	0	
OL_LSE_POR_POW10	N/A	63.7	N/A	66.7	N/A	63.7	N/A	3.0	N/A	58.7	N/A	65.9	N/A	GO	77	0	Y
OL_LSE_POR_OUT10	70.2	N/A	65.5	N/A	70.2	N/A	-4.7	N/A	62.4	N/A	62.5	N/A	GO	N/A	77	0	
OL_LSE_POR_POW11	66.1	61.4	70.8	66.1	66.1	61.4	4.7	4.7	63.1	57.6	70.0	65.4	GO	GO	76	0	Y
OL_LSE_POR_POW11A	N/A	58.8	N/A	61.0	N/A	58.8	N/A	2.2	N/A	57.1	N/A	58.8	N/A	GO	76	0	Y
OL_LSE_POR_OUT11A	63.9	N/A	61.0	N/A	63.9	N/A	-2.9	N/A	58.3	N/A	57.7	N/A	OL	N/A	73	0	
OL_LSE_POR_POW12	N/A	56.8	N/A	59.5	N/A	56.8	N/A	2.7	N/A	52.6	N/A	58.5	N/A	GO	71	0	Y
OL_LSE_POR_OUT12	61.2	N/A	60.4	N/A	61.2	N/A	-0.8	N/A	57.6	N/A	57.1	N/A	OL	N/A	71	0	
OL_LSE_POR_POW12A	N/A	53.2	N/A	59.9	N/A	53.2	N/A	**6.7**	N/A	52.3	N/A	59.1	N/A	GO	70	0	N
OL_LSE_POR_OUT12A	57.5	N/A	61.4	N/A	57.5	N/A	3.9	N/A	57.2	N/A	59.4	N/A	GO	N/A	71	0	
OL_LSE_POR_POW13	N/A	61.6	N/A	66.1	N/A	61.6	N/A	4.5	N/A	53.6	N/A	65.9	N/A	GO	72	0	Y
OL_LSE_POR_OUT13	65.8	N/A	70.5	N/A	65.8	N/A	4.7	N/A	58.2	N/A	70.2	N/A	GO	N/A	71	0	
OL_LSE_POR_POW13D	60.0	55.4	64.8	60.0	60.0	55.4	4.8	4.6	53.7	48.1	64.5	59.8	GO	GO	66	0	Y
OL_LSE_POR_POW13E	58.7	54.2	63.6	58.7	58.7	54.2	4.9	4.5	52.5	47	63.2	58.4	GO	GO	65	0	Y
OL_LSE_POR_POW14	65.9	61.9	69.4	63.1	65.9	61.9	3.5	1.2	57.2	51.6	69.1	62.7	GO	GO	69	0	Y

Receptor	Existing Conditions		Future – With Project		Objective Sound Level		Noise Impact, Day [dB]	Noise Impact, Night [dB]	Future – Ontario Line Contributions		Future – GO Train[7] Contributions		Greater Noise Contribution		MOEE/TTC Pass-by Criteria		Meets GO/TTC Protocol Criteria [Y/N]
	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]			Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night	L_{Passby} – Ontario Line [dBA]	Pass-by Exceedance [dBA]	
OL_LSE_POR_POW15	N/A	62.4	N/A	69.0	N/A	62.4	N/A	**6.6**	N/A	53.4	N/A	68.8	N/A	GO	70	0	N
OL_LSE_POR_OUT15	64.1	N/A	66.0	N/A	64.1	N/A	1.9	N/A	46.3	N/A	66.0	N/A	GO	N/A	57	0	
OL_LSE_POR_POW16	65.6	61.0	70.0	65.3	65.6	61.0	4.4	4.3	61.0	55.5	69.4	64.8	GO	GO	73	0	Y
OL_LSE_POR_POW17	63.3	60.8	66.2	61.8	63.3	60.8	2.9	1.0	53.8	48.3	66.0	61.6	GO	GO	66	0	Y
OL_LSE_POR_POW18	N/A	63.1	N/A	70.4	N/A	63.1	N/A	**7.3**	N/A	55.7	N/A	70.2	N/A	GO	73	0	N
OL_LSE_POR_Out18	67.8	N/A	65.5	N/A	67.8	N/A	-2.3	N/A	51.4	N/A	65.3	N/A	GO	N/A	64	0	
OL_LSE_POR_POW19	66.4	61.8	70.7	66.0	66.4	61.8	4.3	4.2	62.8	57.3	69.9	65.3	GO	GO	75	0	Y
OL_LSE_POR_POW20	63.0	58.4	67.3	62.8	63.0	58.4	4.3	4.4	49.9	44.3	67.2	62.7	GO	GO	62	0	Y
OL_LSE_POR_POW22	N/A	55.7	N/A	60.9	N/A	55.7	N/A	**5.2**	N/A	43.3	N/A	60.8	N/A	GO	62	0	N
OL_LSE_POR_Out22	60.1	N/A	65.2	N/A	60.1	N/A	**5.1**	N/A	47.6	N/A	65.1	N/A	GO	N/A	60	0	
OL_LSE_POR_POW22B	N/A	51.8	N/A	58.7	N/A	51.8	N/A	**6.9**	N/A	44.7	N/A	58.5	N/A	GO	62	0	N
OL_LSE_POR_Out22B	56.2	N/A	63.1	N/A	56.2	N/A	**6.9**	N/A	50.4	N/A	62.9	N/A	GO	N/A	63	0	
OL_LSE_POR_POW23	N/A	63.5	N/A	70.6	N/A	63.5	N/A	**7.1**	N/A	52.1	N/A	70.5	N/A	GO	70	0	N
OL_LSE_POR_Out23	67.0	N/A	63.5	N/A	67.0	N/A	-3.5	N/A	49.2	N/A	63.3	N/A	GO	N/A	61	0	
OL_LSE_POR_POW24	68.5	63.7	74.8	69.5	68.5	63.7	**6.3**	**5.8**	55.6	50.1	74.7	69.5	GO	GO	68	0	N

3.4 Noise Barrier Investigation

In order to meet the MOEE/GO and MOEE/TTC Protocol criteria and, further, reduce predicted noise impacts at noise sensitive receptors located along the corridor between Eastern Avenue and Pape Avenue to existing predicted levels, noise barriers were implemented within the noise model. Noise barriers were modelled at varying heights along the corridor, up to a maximum considered height of 7 metres, and included the implementation of Lakeshore East rail corridor Barrier 01 located between east of Pape Avenue and Jones Avenue that was assessed as part of the approved GO Rail Network Electrification EPR Addendum 2021. **Table 3-4** presents the predicted “with barrier” noise levels, as well as the residual impacts (i.e. remaining noise impacts above or below existing levels after implementing noise barriers) with included barriers.

It should be noted that secondary receptors with lesser noise impacts than the worst case ones presented in this report were included in the noise model for the purpose of determining full barrier extents and ensuring barrier heights are predicted to reduce 16-hour daytime L_{eq}, and 8-hour night-time L_{eq} noise levels to or below the predicted existing railway noise levels at all receptors within noise sensitive areas.

As shown in **Table 3-4**, implemented noise barriers are predicted to be effective at reducing noise impacts for the purposes of meeting MOEE/GO and MOEE/TTC criteria at all noise sensitive locations. Implemented noise barriers are predicted to reduce “with project” noise levels by 1 to 14 dB at 22 of 28 assessed noise sensitive locations. A 10 dB decrease is typically considered a “very significant” decrease or half as loud as the “without barrier” project levels.

In addition, implemented noise barriers are predicted to be effective at reducing combined Ontario Line and GO railway 16-hour daytime L_{eq}, and 8-hour night-time L_{eq} noise levels by 0.4 to 10 dB below predicted existing railway noise levels at the majority of assessed receptors between Eastern Avenue and Pape Avenue, and with the exception of elevated floors (approximately above 2-4 storeys) of high-rise buildings POW13D (345 Carlaw Avenue), and POW13E (1189 Dundas Street East and 327 Carlaw Avenue), POW20 (369 Pape Avenue), and POW16 (444 Logan Avenue). A location-specific assessment that incorporated traffic noise has been conducted for these high-rise locations and details are presented in **Section 3.5**.

Noise barriers have been modelled as reflective with an absorption coefficient (alpha) of 0.21. Such barriers can be constructed using transparent materials such as acrylic panels. The locations, extents, heights, and additional details of modelled noise barriers are presented in **Appendix D.** Noise contour maps are provided in **Appendix F**, for day-time receptors at a height of 1.5 metres (representing ground level at an outdoor receptor), and night-time receptors at a height of 4.5 metres (representing the plane of window for a 2nd storey window), for both existing and “with barrier” future scenarios. It should be kept in mind that while contours are presented at “general” heights, the results presented within this report were for receptor heights accounting for the number of storeys at the specific respective locations.

Table 3-4: Predicted "With Barrier" Noise Impacts

Receptors	Existing Conditions		Future – With Project		Objective Sound Level		Impact [dB]		Future – With Barriers		Residual Impact [dB]		Mitigated Ontario Line L_{Passby} [dBA]	Meets GO/TTC Protocol Criteria [Y/N]
	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night		
OL_LSE_POR_POW01	65.9	63.5	68.3	63.8	65.9	63.5	2.4	0.3	68.3	63.8	2.4	0.3	64	Y
OL_LSE_POR_POW02	67.1	62.5	70.2	65	67.1	62.5	3.1	2.5	64.9	59.5	-2.2	-3	65	Y
OL_LSE_POR_POW03	N/A	61.8	N/A	62.9	N/A	61.8	N/A	1.1	N/A	52	N/A	-9.8	62	Y
OL_LSE_POR_OUT03	65.3	N/A	60.5	N/A	65.3	N/A	-4.8[9]	N/A	56.9	N/A	-8.4	N/A	63	
OL_LSE_POR_POW03A	N/A	60.6	N/A	64.2	N/A	60.6	N/A	3.6	N/A	56.9	N/A	-3.7	63	Y
OL_LSE_POR_OUT03A	64.4	N/A	62.9	N/A	64.4	N/A	-1.5	N/A	55.7	N/A	-8.7	N/A	60	
OL_LSE_POR_POW04	N/A	61.9	N/A	68.4	N/A	61.9	N/A	6.5	N/A	55.4	N/A	-6.5	60	Y
OL_LSE_POR_OUT04	65.8	N/A	69.6	N/A	65.8	N/A	3.8	N/A	59.5	N/A	-6.3	N/A	60	
OL_LSE_POR_POW05	70.2	65.5	73.6	68.9	70.2	65.5	3.4	3.4	69.8	64.9	-0.4	-0.6	63	Y
OL_LSE_POR_POW07	N/A	61.5	N/A	64.3	N/A	61.5	N/A	2.8	N/A	56.6	N/A	-4.9	60	Y
OL_LSE_POR_OUT07	65.2	N/A	59.1	N/A	65.2	N/A	-6.1	N/A	56.5	N/A	-8.7	N/A	58	
OL_LSE_POR_POW08	N/A	59.1	N/A	63.2	N/A	59.1	N/A	4.1	N/A	55	N/A	-4.1	60	Y
OL_LSE_POR_OUT08	63.6	N/A	66.8	N/A	63.6	N/A	3.2	N/A	57	N/A	-6.6	N/A	58	
OL_LSE_POR_POW09	N/A	58.6	N/A	62.7	N/A	58.6	N/A	4.1	N/A	51.2	N/A	-7.4	58	Y
OL_LSE_POR_OUT09	62.6	N/A	67.7	N/A	62.6	N/A	5.1	N/A	56.1	N/A	-6.5	N/A	58	
OL_LSE_POR_POW10	N/A	63.7	N/A	66.7	N/A	63.7	N/A	3	N/A	54.8	N/A	-8.9	64	Y
OL_LSE_POR_OUT10	70.2	N/A	65.5	N/A	70.2	N/A	-4.7	N/A	59.9	N/A	-10.3	N/A	66	
OL_LSE_POR_POW11	66.1	61.4	70.8	66.1	66.1	61.4	4.7	4.7	65.2	60.2	-0.9	-1.2	64	Y
OL_LSE_POR_POW11A	N/A	58.8	N/A	61	N/A	58.8	N/A	2.2	N/A	52.7	N/A	-6.1	62	Y
OL_LSE_POR_OUT11A	63.9	N/A	61	N/A	63.9	N/A	-2.9	N/A	57.6	N/A	-6.3	N/A	62	
OL_LSE_POR_POW12	N/A	56.8	N/A	59.5	N/A	56.8	N/A	2.7	N/A	50.1	N/A	-6.7	57	Y
OL_LSE_POR_OUT12	61.2	N/A	60.4	N/A	61.2	N/A	-0.8	N/A	55.5	N/A	-5.7	N/A	58	

[9] Negative values indicate a predicted decrease in noise levels.

Receptors	Existing Conditions		Future – With Project		Objective Sound Level		Impact [dB]		Future – With Barriers		Residual Impact [dB]		Mitigated Ontario Line L_{Passby} [dBA]	Meets GO/TTC Protocol Criteria [Y/N]
	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day	Night		
OL_LSE_POR_POW12A	N/A	53.2	N/A	59.9	N/A	53.2	N/A	6.7	N/A	50.4	N/A	-2.8	58	Y
OL_LSE_POR_OUT12A	57.5	N/A	61.4	N/A	57.5	N/A	3.9	N/A	56.1	N/A	-1.4	N/A	58	
OL_LSE_POR_POW13	N/A	61.6	N/A	66.1	N/A	61.6	N/A	4.5	N/A	60.3	N/A	-1.3	71	Y
OL_LSE_POR_OUT13	65.8	N/A	70.5	N/A	65.8	N/A	4.7	N/A	57.8	N/A	-8	N/A	60	
OL_LSE_POR_POW13D	60	55.4	64.8	60	60	55.4	4.8	4.6	64.8	59.8	4.8	4.4	68	Y
OL_LSE_POR_POW13E	58.7	54.2	63.6	58.7	58.7	54.2	4.9	4.5	63.5	58.6	4.8	4.4	66	Y
OL_LSE_POR_POW14	65.9	61.9	69.4	63.1	65.9	61.9	3.5	1.2	69.5	63.1	3.6	1.2	69	Y
OL_LSE_POR_POW15	N/A	62.4	N/A	69	N/A	62.4	N/A	6.6	N/A	55.5	N/A	-6.9	58	Y
OL_LSE_POR_OUT15	64.1	N/A	66	N/A	64.1	N/A	1.9	N/A	59.5	N/A	-4.6	N/A	57	
OL_LSE_POR_POW16	65.6	61	70	65.3	65.6	61	4.4	4.3	70.2	65.5	4.6	4.5	68	Y
OL_LSE_POR_POW17	63.3	60.8	66.2	61.8	63.3	60.8	2.9	1	66.3	61.8	3	1	66	Y
OL_LSE_POR_POW18	N/A	63.1	N/A	70.4	N/A	63.1	N/A	7.3	N/A	57.8	N/A	-5.3	61	Y
OL_LSE_POR_Out18	67.8	N/A	65.5	N/A	67.8	N/A	-2.3	N/A	61.9	N/A	-5.9	N/A	61	
OL_LSE_POR_POW19	66.4	61.8	70.7	66	66.4	61.8	4.3	4.2	66	61	-0.4	-0.8	67	Y
OL_LSE_POR_POW20	63	58.4	67.3	62.8	63	58.4	4.3	4.4	66.8	61.8	3.8	3.4	64	Y
OL_LSE_POR_POW22	N/A	55.7	N/A	60.9	N/A	55.7	N/A	5.2	N/A	52.6	N/A	-3.1	58	Y
OL_LSE_POR_Out22	60.1	N/A	65.2	N/A	60.1	N/A	5.1	N/A	56.5	N/A	-3.6	N/A	57	
OL_LSE_POR_POW22B	N/A	51.8	N/A	58.7	N/A	51.8	N/A	6.9	N/A	50	N/A	-1.8	53	Y
OL_LSE_POR_Out22B	56.2	N/A	63.1	N/A	56.2	N/A	6.9	N/A	53.9	N/A	-2.3	N/A	51	
OL_LSE_POR_POW23	N/A	63.5	N/A	70.6	N/A	63.5	N/A	7.1	N/A	57.3	N/A	-6.2	61	Y
OL_LSE_POR_Out23	67	N/A	63.5	N/A	67	N/A	-3.5	N/A	61.8	N/A	-5.2	N/A	61	
OL_LSE_POR_POW24	68.5	63.7	74.8	69.5	68.5	63.7	6.3	5.8	61.1	55.7	-7.4	-8	60	Y

3.5 Road Traffic Noise Assessment

The assessment described in previous sections of this report considered the differences between predicted changes in rail noise between existing and future (with project) conditions. Ambient noise sources were not included in the noise modelling. Therefore, the assessment is considered conservative because the baseline level used to determine noise impacts will be lower than if ambient sources were included. In practice, however, there is some influence on the overall noise levels from ambient noise sources including road traffic, particularly at receptors situated in close proximity to roadways such as several existing high-rise buildings along the corridor.

At the high-rise locations POW16 (444 Logan Avenue), POW13D (345 Carlaw Avenue), POW13E (1189 Dundas Street East and 327 Carlaw Avenue), and POW20 (369 Pape Avenue) described in **Section 3.4** that are located approximately between Eastern Avenue and Pape Avenue, and where future noise levels were not predicted to be reduced to existing levels at elevated storeys of the high-rise buildings, an additional analysis of road traffic noise was performed in order to predict location-specific residual noise impacts due to the project.

As is standard for traffic noise assessments in Ontario, the *Ontario Road Noise Analysis Method for Environment and Transportation* (ORNAMENT) was used to assess existing road traffic noise levels at the locations in question.

Traffic volumes were obtained from publicly available data from the City of Toronto for the following intersections:

- Carlaw Avenue and Dundas Street East;
- Logan Avenue and Dundas Street East;
- Pape Avenue and Riverdale Avenue;

A detailed description of methods used to complete the traffic assessment is available in **Appendix E**. Traffic calculation inputs are presented in **Appendix G**. **Table 3-5** presents the results of the road traffic noise assessment at POW16, POW13D, POW13E, and POW20, as well as a numerical comparison with day and night-time predicted existing and future railway noise levels.

Table 3-5: Comparison of Predicted Rail Noise and Road Noise at Receptors Representing High-Rise Buildings

Receptors	Existing Conditions (Rail)		Future - with Barriers (Rail)		Existing Road Traffic Noise	
	Day($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]
POW16	65.6	61.0	70.2	65.5	55.3	48.7
POW13D	60.0	55.4	64.8	59.8	60.8	54.3
POW13E	58.7	54.2	63.5	58.6	63.6	57.1
POW20	63.0	58.4	66.8	61.8	52.8	46.3

Table 3-6 below presents the predicted existing and future “with barrier” day and night time noise levels at locations POW16, POW13D, POW13E, and POW20, with predicted existing road traffic noise added to both scenarios in order to determine residual noise impacts.

Table 3-6: Predicted Rail + Road Noise and Residual Impacts At Receptors Representing High-Rise Buildings

Receptors	Existing Conditions + Road Noise		Future - with Barriers + Road Noise		Residual Impact + Road Noise	
	Day ($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day ($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day ($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]
POW16	66.0	61.2	70.3	65.6	4.4	4.3
POW13D	63.4	57.9	66.3	60.9	2.8	3.0
POW13E	64.8	58.9	66.6	60.9	1.7	2.0
POW20	63.4	58.7	67.0	61.9	3.6	3.3

As can be seen in **Table 3-6,** existing road traffic noise at POW16 and POW20 is more than 10 dB lower than future predicted rail noise, and is therefore not expected to be a significant noise contributor at these locations. As a result, future predicted noise impacts at these locations may be noticeable.

At receptors POW13D and POW13E near Dundas Street East and Carlaw Avenue, traffic noise is predicted to be a significant noise source in addition to rail noise, and residual impacts are expected to be within the 2-3 dB range. Consequently, noise impacts at these receptors are predicted to be insignificant as a 3 dB impact is typically considered to be “just perceptible” by the human ear.

3.6 Discussion and Recommendations

Noise barriers implemented along both sides of the corridor are predicted to be effective in satisfying the goal of reducing 16-hour Day-time L_{eq}, and 8-hour Night-time L_{eq} noise levels to predicted existing railway noise levels at assessed worst case receptor locations facing the corridor between Eastern and Pape Avenue with the exception of five high-rise buildings POW13D (345 Carlaw Avenue), POW13E (1189 Dundas Street East and 327 Carlaw Avenue), POW20 (369 Pape Avenue), and POW16 (444 Logan Avenue). The upper floors of these receptors are predicted to have residual impacts in the 'insignificant' to 'noticeable' range, and thus do not require additional mitigation as per the MOEE/TTC and MOEE/GO Protocol. At all other assessed receptors, noise barriers are predicted to achieve reductions of 0.4 to 10 dB below the predicted existing noise levels.

It should be noted that any potential future developments south of Langley Street may provide additional shielding to the POW20 receptor location and others in the vicinity, depending on the extent and height of the structure(s). At the future planned developments outside of Eastern Avenue to Pape Avenue portion, such as planned/under construction development buildings north of Mill Street (POW01 and POW17), and the potential high-rise building at East Harbour (POW14), predicted noise impacts are expected to comply with MOEE/GO and TTC/GO protocol criteria.

Implemented noise barriers are shown in **Appendix D**, ranging in height from 2.5 to 6.5 metres.

Metrolinx will install noise barriers with a minimum height of 5 metres, in alignment with the noise barrier implementation approach planned to be undertaken by GO Expansion. Installing noise barriers with a minimum height of 5 metres will provide additional mitigation. To facilitate this and barrier detailed design development, refinements to the noise model and recommended barrier design presented in this report will be performed, and changes to barrier height, extent and surface types will be implemented where required. These refinements may also include removal of barriers from the GO and Ontario Line bridges as well as refinements to the barrier height and extent at the future Ontario Line stations (Riverside/Leslieville and Gerrard). However, barriers will still be designed to meet the MOEE/GO and MOEE/TTC protocol criteria along the entire Lakeshore East Joint Corridor, and to reduce day ($L_{eq,16h}$) and night time ($L_{eq,8h}$) levels to predicted existing levels where feasible between Eastern Avenue and Pape Avenue.

4. Operational Vibration Assessment

4.1 Criteria

As noted above, this Report documents the operational noise and vibration assessment of Ontario Line vehicles and GO trains within the Lakeshore East Joint Corridor. A number of the Lakeshore East Joint Corridor infrastructure components, including realigned GO tracks and the new fourth track as well as associated vibration mitigation investigated in this report, will be installed as part of the Lakeshore East Joint Corridor early works. Impacts associated with the construction of those components are addressed within the *Noise and Vibration Early Works Report – Ontario Line Lakeshore East Joint Corridor Early Works* document.

The vibration impacts from the Ontario Line vehicles were evaluated by comparing the predicted vibration levels following the completion of the Project at each identified receptor location in accordance with the MOEE/TTC protocol. The MOEE/TTC protocol is applicable for light commuter rail vehicles such as those associated with the Ontario Line Project. The feasibility of operational vibration mitigation measures is required to be investigated if the predicted Root-Mean-Square (RMS) vibration velocity from the Ontario Line exceeds 0.1 mm/s at a receptor location.

The vibration impacts from GO vehicle operations were evaluated by comparing the predicted vibration levels with the completed project and without the project (i.e., existing) at each identified receptor location in accordance with the MOEE/GO Protocol. The MOEE/GO Protocol is applicable to heavy rail vehicles such as VIA and GO trains. The feasibility of operational vibration mitigation measures is required to be investigated where the predicted impact is 25% or more above the existing RMS vibration velocity level or 0.14 mm/s RMS vibration velocity during a train pass-by, whichever is higher.

A summary of both the MOEE/GO and MOEE/TTC protocol criteria is presented in **Table 4-1**.

Table 4-1: Vibration Protocol Criteria

Metric	GO Train Limits[10]	Ontario Line Vehicle Limits
RMS Vibration Velocity	Increase of 25% above the higher of existing vibration levels, or 0.14 mm/s.	0.1 mm/s

4.2 Methods

As with the noise assessment, vibration levels were predicted at receptor locations selected to represent the most exposed or potentially impacted within a sensitive area (i.e., the location typically closest to the tracks). Vibration sensitive receptors are generally located in the same position as POW receptors established for the noise assessment but at ground level. Vibration levels have been predicted in accordance with the General Vibration Assessment procedures described in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (FTA 2018).

Predicted vibration levels in accordance with the US FTA methods are based on reference vibration curves derived from measurements of ground-borne vibration at representative North American transit systems. The FTA method includes various adjustments such as train speed, distance from tracks based on the existing and proposed track alignments, special track work (e.g., crossovers or switches) and elevated transit structures (bridges and elevated guideways).

For vibration calculations, Ontario Line vehicle speeds have been set to the operational speeds provided in **Appendix E**. For the GO track operations, train speeds have been set to the track speed limit of 145 km/h. This represents a predictable worst-case pass-by scenario for trains operating on both sets of tracks.

4.3 Impact Assessment and Results

Table 4-2 outlines the predicted RMS vibration velocity levels from the existing and future operations on the Lakeshore East Joint Corridor. Where vibration levels were predicted to exceed either the applicable MOEE/GO or MOEE/TTC Protocol vibration criteria, the required vibration reduction has been presented.

As shown in **Table 4-2**, vibration mitigation investigation is predicted to be required at nine receptor locations (POW01_V, POW04, POW09, POW10_V, POW14, POW15,

[10] GO Train Limits noted apply to GO, VIA and freight trains operating in rail corridor.

POW18, POW23, and POW24). Mitigation was required to be investigated for GO tracks at 8 of these 9 locations – all except POW10_V. In the case of POW10_V, where mitigation was required to be investigated for Ontario Line tracks, the vibration limit exceedance can be attributed to the Ontario Line track proximity to this receptor. The greater extent of mitigation required for GO tracks can be expected because heavy rail trains generate higher overall vibration levels due to the higher weight of the trains and higher assessed speeds.

Appendix D presents the track segments requiring vibration mitigation, mitigation extents, and potential transition zone extents for the areas represented by the receptor locations where mitigation investigation is predicted to be required. The transition zones are segments of track beyond the vibration reduction zones where treatment of lower resilience (i.e., less springy or elastic than the vibration mitigation section of track, but still more elastic than standard track) may be provided to reduce the change in track structure flexibility between the isolated system and the standard track system. This transition zone results in less rapid track degradation, extending the life-span of the track system.

In accordance with the MOEE/GO and MOEE/TTC protocols, vibration impacts are determined based on individual train pass-by events. In the occurrence of additive vibration, such as during a simultaneous GO train and Ontario Line vehicle pass-by, sample calculations indicate that overall vibration levels would not be significantly higher than that of the dominant individual source. Therefore, the results within this report are based on the worst case single pass-bys of trains operating on GO or Ontario Line tracks.

A sample calculation for a receptor requiring mitigation investigation has been provided in **Appendix G**.

Table 4-2: Vibration Assessment Results and Required Vibration Reduction

Receptor ID	Predicted RMS Velocity (mm/s)			Objective RMS Velocity (mm/s)		% Above Objective [GO][1]	Mitigation Investigation Requirement (Y/N)		Vibration Reduction Required (dB)	
	Existing GO	Future GO	Future OL	Future GO	Future OL		GO	OL	GO	OL
POW01_V	0.18	0.23	0.07	0.18	0.10	30%	**Y**	N	**2**	0
POW02	0.45	0.31	0.07	0.45	0.10	-33%	N	N	0	0
POW03	0.50	0.31	0.09	0.50	0.10	-38%	N	N	0	0
POW04	0.45	0.81	0.05	0.45	0.10	81%	**Y**	N	**5**	0
POW05	0.69	0.79	0.02	0.69	0.10	14%	N	N	0	0
POW07	0.38	0.29	0.05	0.38	0.10	-23%	N	N	0	0
POW08_V	0.24	0.20	0.04	0.24	0.10	-18%	N	N	0	0
POW09_V	0.17	0.23	0.02	0.17	0.10	35%	**Y**	N	**3**	0

Receptor ID	Predicted RMS Velocity (mm/s)			Objective RMS Velocity (mm/s)		% Above Objective [GO][1]	Mitigation Investigation Requirement (Y/N)		Vibration Reduction Required (dB)	
	Existing GO	Future GO	Future OL	Future GO	Future OL		GO	OL	GO	OL
POW10_V	0.75	0.54	0.16	0.75	0.10	-28%	N	**Y**	0	**4**
POW11	0.35	0.30	0.08	0.35	0.10	-14%	N	N	0	0
POW12	0.13	0.13	0.01	0.14	0.10	-8%	N	N	0	0
POW13	0.26	0.29	0.01	0.26	0.10	12%	N	N	0	0
POW14	0.31	0.51	0.02	0.31	0.10	62%	**Y**	N	**4**	0
POW15	0.50	1.13	0.04	0.50	0.10	128%	**Y**	N	**7**	0
POW16	0.26	0.21	0.05	0.26	0.10	-22%	N	N	0	0
POW17	0.03	0.04	0.01	0.14	0.10	-72%	N	N	0	0
POW18	0.53	1.18	0.06	0.53	0.10	123%	**Y**	N	**7**	0

Receptor ID	Predicted RMS Velocity (mm/s)			Objective RMS Velocity (mm/s)		% Above Objective [GO][1]	Mitigation Investigation Requirement (Y/N)		Vibration Reduction Required (dB)	
	Existing GO	Future GO	Future OL	Future GO	Future OL		GO	OL	GO	OL
POW19	0.37	0.31	0.08	0.37	0.10	-18%	N	N	0	0
POW23	0.75	1.64	0.06	0.75	0.10	119%	**Y**	N	**7**	0
POW24	0.72	1.49	0.06	0.72	0.07	109%	**Y**	N	**6**	0

Notes:

1. Negative predicted vibration impact occurs when the planned future track alignment is further from the most affected receptor than current positioning or future vibration level is below the objective vibration level.
2. The _V notation indicates a vibration specific receptor (e.g. where the façade of a building may have been different than the worst case location for a receptor within the noise assessment, such as the corner of a building vs. a 3rd storey window).
3. As vibration calculations were based on the façade at ground level at a given receptor location, receptors included within the noise assessment for the purposes of assessment at higher storeys or floors may not be included within the vibration receptor list.

4.4 Discussion and Recommendations

Vibration from the future Ontario Line and GO track operations is predicted to exceed the MOEE/GO or MOEE/TTC Protocol mitigation thresholds at locations POW01_V, POW04, POW09, POW14, POW15, POW18, POW23, POW24 (exceedances due to GO track operations), and POW_10V (exceedance due to Ontario Line track operations).

As the required vibration reductions presented in **Table 4-2** range between 2 to 8 dB, the predicted vibration levels are anticipated to be reduced to below required criteria using conventional mitigation measures. Typical vibration mitigation measures and expected vibration reduction applicable to both GO and Ontario Line tracks include, but are not limited to:

- Resilient rail fasteners – 4 to 8 dB reduction
- Resilient supported sleepers/ties – approximately 10 dB reduction
- Booted sleepers/ties – approximately 10 dB reduction

In addition, the following are applicable for GO tracks only, with a ballast trackbed:

- Ballast mats – 10 to 15 dB reduction
- Tire-derived aggregates – 8 to 14 dB reduction

A detailed vibration analysis, including vibration propagation testing to consider local ground conditions, will be conducted in the detailed design stage in order to refine mitigation requirements.

5. Summary and Conclusions

5.1 Operational Noise Assessment

In accordance with the MOEE/GO and MOEE/TTC protocol criteria, noise impacts from the Lakeshore East Joint Corridor operations are predicted to require noise mitigation investigation at nine noise sensitive locations between Eastern Avenue and Pape Avenue. However, Metrolinx is seeking to limit $L_{eq,16hr}$ (daytime) and $L_{eq,8hr}$ (night-time) noise impacts from the project to existing predicted levels at receptors between Eastern Avenue and Pape Avenue, where feasible, even for receptors with predicted noise impacts that do not require mitigation investigation per the MOEE/GO Protocol and/or MOEE/TTC Protocol. Barriers have been modelled along both sides of the corridor in order to satisfy the goal of reducing 16-hour Day-time L_{eq}, and 8-hour Night-time L_{eq} noise levels to predicted existing railway noise levels at assessed worst case receptor locations facing the corridor between Eastern Avenue and Pape Avenue.

Noise barriers implemented along both sides of the corridor are predicted to be effective in satisfying the goal of reducing 16-hour Day-time L_{eq}, and 8-hour Night-time L_{eq} noise levels to predicted existing railway noise levels at assessed worst case receptor locations facing the corridor between Eastern Avenue and Pape Avenue with the exception of five high-rise buildings POW13D (345 Carlaw Avenue), POW13E (1189 Dundas Street East and 327 Carlaw Avenue), POW20 (369 Pape Avenue), and POW16 (444 Logan Avenue). The upper floors of these receptors are predicted to have residual impacts in the ‘insignificant’ to ‘noticeable’ range, and thus do not require additional mitigation as per the MOEE/TTC and MOEE/GO Protocol. At all other assessed receptors, noise barriers are predicted to achieve reductions of 0.4 to 10 dB, resulting in $L_{eq,16hr}$ (daytime) and $L_{eq,8hr}$ (night-time) noise levels below the predicted existing noise levels.

The locations, extents, heights, and additional details of modelled noise barriers are presented in **Appendix D**.

While modelled barriers shown in Appendix D range in height from 2.5 metres to 6.5 metres, Metrolinx will install noise barriers with a minimum height of 5 metres, in alignment with the noise barrier implementation approach planned to be undertaken by GO Expansion. Installing noise barriers with a minimum height of 5 metres will provide additional mitigation. To facilitate this and barrier detailed design development, refinements to the noise model and recommended barrier design presented in this report will be performed, and changes to barrier height, extent and surface types will be implemented where required. These refinements may also include removal of barriers from the GO and Ontario Line bridges as well as refinements to the barrier height and extent at the Ontario Line stations (Leslieville and Gerrard). However, barriers will still be designed to meet the MOEE/GO and MOEE/TTC protocol criteria along the entire Lakeshore East Joint Corridor, and to reduce day ($L_{eq,16h}$) and night time ($L_{eq,8h}$) levels to predicted existing levels where feasible between Eastern Avenue and Pape Avenue.

5.2 Operational Vibration Assessment

Vibration mitigation investigation is predicted to be required at nine receptor locations. As the required vibration reductions presented in **Table 4-2** range from 2 to 8 dB, the predicted vibration levels are anticipated to be reduced to below required criteria using conventional mitigation measures. Results and mitigation requirements are detailed in **Section 4.3**. The locations and extents of areas requiring vibration reduction are presented in **Appendix D**.

A detailed vibration analysis, including vibration propagation testing to consider local ground conditions, will be conducted in the detailed design stage in order to refine mitigation requirements for these locations.

6. References

United States Federal Transit Administration, 2018:
Transit Noise and Vibration Impact Assessment Manual (FTA Report No. 0123).

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MOEE/GO Transit Draft Noise and Vibration Protocol.

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Appendix A

Glossary

Term	Definition
Sound	Pressure wave travelling through a medium, such as air.
Noise	Unwanted sound.
Acoustics	The science of sound propagation and transmission.
Vibration	Oscillation of a parameter that defines the motion of a mechanical system.
Decibel, dB	A logarithmic ratio, not strictly a unit, used to describe sound levels. For sound pressure, the reference level is 20 micro pascals (threshold of hearing).
Frequency	The rate at which an event is repeated. Measured in Hertz (Hz), where 1 Hz = 1 oscillation/sec. Normal human hearing extends over a range of frequencies from about 20 Hz to about 20 kHz.
Octave Band	A band of frequencies where the upper limiting frequency is twice the lower limiting frequency. Octave bands are identified by their centre-frequencies. The octave bands standardized for acoustic measurements include those centred at 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.
A-Weighting Network, dBA	A frequency weighting network intended to represent the variation in the ear's ability to hear different frequencies. Overall sound levels calculated or measured using the A-weighting network are indicated by dBA rather than dB.
Sound Pressure Level (SPL, L_p)	A measurement of instantaneous sound pressure and equal to 10 times the logarithm (base 10) of the ratio of the instantaneous sound pressure of a sound divided by the reference sound pressure of 20 μPa (0 dB). Reported and measured in decibels (dB or dBA).
L_{eq} - "Equivalent sound level"	Value of a constant sound pressure level which would result in the same total sound energy as would the measured time-varying sound pressure level over equivalent time duration. The $L_{eq,\ 1hr,}$ for example, describes the equivalent continuous sound level over a 1-hour period.
L_{Passby}	The passby sound level, defined as the A-weighted equivalent sound level, Leq, over the passby time interval given by the total length and speed of the vehicle.
Absorption Coefficient	The coefficient used to evaluate the sound absorption efficiency of materials. It is the ratio of absorbed energy to incident sound energy represented by alpha (α).
Peak Particle Velocity (PPV)	The peak signal value of an oscillating vibration velocity waveform. Can be expressed in mm/s.
Root Mean Square Velocity (RMSV)	The square root of the mean-square value of an oscillating vibration velocity waveform, where the mean-square value is obtained by squaring the value of amplitudes at each instant in time and then averaging these values over the sample time.

Appendix B

Noise and Vibration Protocols

MOEE / GO TRANSIT
DRAFT PROTOCOL FOR NOISE AND VIBRATION ASSESSMENT

1.0 PURPOSE

GO Transit and the Ministry of Environment and Energy (MOEE) recognize that commuter rail transit facilities produce noise and vibration which may affect neighbouring properties. This document identifies the framework within which criteria will be used to assess noise and vibration from proposed GO Transit rail projects. The framework in this document is to be applied for planning purposes in order to address the requirements of the Environmental Assessment Act and is to be utilized during implementation of the project.

The purpose of this document can be summarized by the following:

- assist GO Transit in the preparation of Environmental Assessments;
- streamline the MOEE's noise impact review of Environmental Assessments; and
- make available to the public a consistent approach for Environmental Assessments.

This Protocol does not apply to existing GO Transit operations, nor does it apply to projects undertaken by other non-GO Transit rail operators.

2.0 SCOPE

- Establish noise and vibration objectives for GO Transit rail projects.
- Establish methods of assessment - measurement and prediction.
- Enable the comparison of alternatives.
- Establish the framework for the assessment of mitigation where impacts are identified.

3.0 DEFINITIONS

Adjusted Noise Impact:

Noise impact is the incremental increase in the pre-project equivalent sound level resulting from the introduction of a GO Transit project. The Adjusted

Noise Impact is calculated by adjusting the value of the noise impact to indicate greater impact at higher pre-project sound levels.

Ambient Noise (Ambient Sound Level):

The ambient noise (ambient sound level) is the sound existing at a point of reception in the absence of all noise from the GO Transit rail project. In this Protocol, the ambient is taken to be the noise from road traffic and existing industry. The ambient specifically excludes transient noise from aircraft and railways.

Day-time Equivalent Sound Level:

$L_{eq,16}$ is the day-time equivalent sound level. The definition of equivalent sound level is given in Reference 2. The applicable time period is from 07:00 to 23:00 hours.

GO Transit Rail Project:

GO Transit rail project means a project to add or expand rail service and/or a layover site that requires approval under the Environmental Assessment Act be obtained by carrying out an environmental assessment.

Layover Site:

Layover site means a GO Transit facility dedicated to overnight storage of GO trains.

Night-time Equivalent Sound Level:

$L_{eq,8}$ is the night-time equivalent sound level. The definition of equivalent sound level is given in Reference 2. The applicable time period is from 23:00 to 07:00 hours.

Point of Reception:

Day-time: 07:00 to 23:00 hours

Day-time point of reception is any outdoor location on the property of a sensitive land use where sound originating from the Project is received and which is no less than 15m from the nearest track's centre line. For at-grade sensitive land uses, e.g., low density residential development, this point is normally 3m from the unit in the front or back yard whichever is most exposed to the noise source at a height of 1.5m. For residential uses such as apartment units, this is normally the plane of the apartment bedroom or living room window.

Nighttime: 23:00 to 07:00 hours

Night-time point of reception is the plane of a bedroom window where sound originating from the Project is received and which is no less than 15m from the nearest track's centre line. At the planning stage, this is usually assessed at the nearest facade.

Point of Vibration Assessment:

Point of Vibration Assessment is the location 5m to 10m away from the building foundation in a direction parallel to the tracks or adjusted as required to accommodate site conditions.

Rail Service:

Rail Service means the operation of GO trains along transit corridors (including GO Transit commuter stations) and access routes between GO facilities and these corridors. Layover sites are not part of the Rail Service and are therefore assessed separately.

Sensitive Land Use:

Sensitive land use means a residential dwelling or place where people ordinarily sleep or a commercial/industrial operation that is exceptionally sensitive to noise or vibration. Noise and vibration impacts will be assessed for lands which have been committed for sensitive land uses. Committed uses include uses such as: existing development, approved site plans, approved condominium plans or draft approved plans of subdivision.

Vibration Velocity:

Vibration shall be assessed using the running average RMS (Root-Mean-Square) vibration velocity (mm/sec).

4.0 NOISE

4.1 Rail Service

For the purposes of assessment, rail service is considered to include the operation of trains on the rail line and the operation of trains inside commuter stations. Idling of trains inside commuter stations is considered part of the operation. Noise produced by layover sites is not considered part of the rail service and is assessed separately, see Section 4.2.

4.1.1 Objective

The desirable objective is that the day-time (16 hour) L_{eq} produced by the rail service operation of the GO Transit project does not exceed the higher of the ambient sound level, combined with the sound level from existing rail activity, or 55 dB L_{eq}. Furthermore, that the night-time (8 hour) L_{eq} produced by the rail service operation of the GO Transit project does not exceed the higher of the ambient sound level, combined with the sound level from existing rail service, or 50 dB L_{eq}.

4.1.2 Impact Assessment Method

The noise impact of GO Transit rail projects shall be assessed using prediction methods acceptable to the MOEE (see Reference 1). The noise impact from rail service shall be assessed on a 16 hour (day-time) basis using L_{eq},16, and 8 hour (night-time) basis using L_{eq},8. The impact assessment method should base its assessment on future GO Transit train volume projections, from the commencement of operations to a maximum of twenty years (typical GO Transit planning horizon).

4.1.3 Impact Assessment Criteria

The impact at a point of reception shall be expressed in terms of the Adjusted Noise Impact. The Adjusted Noise Impact shall be based on the difference between:

- pre-project noise, which is the combination of the ambient noise and the rail noise; and

- post-project noise, which is the combination of the ambient noise and the post-project rail noise.

Where the pre-project noise is less than 55 dB L_{eq} during the daytime or 50 dB L_{eq} during the nighttime, the pre-project noise shall be taken as 55 dB L_{eq} daytime or 50 dB L_{eq} nighttime.

The impact shall be rated with respect to the objectives as follows:

Adjusted Impact Level	Impact Rating
0-2.99 dB	Insignificant
3-4.99 dB	Noticeable
5-9.99 dB	Significant
10 +dB	Very Significant

Where a GO Transit rail project may produce road traffic noise impact, these noise impacts shall be assessed in accordance with the methods approved for the Environmental Assessment of roadway projects, e.g., Class EA.

4.1.4 Mitigation

When a 'significant or greater' impact is predicted, the potential to mitigate will be evaluated based on administrative, operational, economic and technical feasibility. If deemed feasible, the mitigation measures shall ensure that the predicted sound level from the GO Transit rail project is as close to, or lower than, the rail service objective.

4.2 Layover Sites

For the purposes of assessment, a layover is considered to include the idling of trains in an area off the mainline track that is designated for such use. Due to operational constraints, GO Transit will usually generate layover alternatives that closely parallel mainline tracks.

4.2.1 Objective

The desirable objective is that the L_{eq} in any hour produced by the operation of the layover site does not exceed the higher of the ambient sound level, including the sound level from existing industry, or 55 dB L_{eq}.

4.2.2 Impact Assessment Method

The noise impact of GO Transit layover sites should be evaluated on a case-by-case basis , by predicting the one hour L_{eq} at a point of reception, using prediction methods acceptable to the MOEE. The noise impact assessment should incorporate all noise sources associated with the layover operation.

4.2.3 Impact Assessment Criteria

For the purposes of site selection, the noise impact shall be assessed utilizing the rating method of Section 4.1.3, with the exception that the minimum pre-project L_{eq} shall be 45 dB L_{eq}.

4.2.4 Mitigation

When a 'noticeable or greater' impact is predicted, the potential to mitigate will initially be evaluated based on administrative, operational, economic and technical feasibility. In addition, the feasibility shall consider the effectiveness of mitigation with respect to site specific conditions and other sources of noise not included in the original impact assessment. If deemed feasible, the mitigation measures shall ensure that the predicted sound level from the GO Transit rail project is as close to, or lower than, the layover objective.

4.3 Construction

Noise and vibration impacts from the construction of a project shall be examined. For the purposes of impact assessment and identifying the need for mitigation, the guidelines in Reference 5 apply.

5.0 VIBRATION

The assessment of ground-borne vibration shall be confined to that produced by the operation on the line and shall exclude vibration due to maintenance and/or construction activities.

5.1 Objective

The desirable objective is that the vibration velocity produced by the GO Transit project does not exceed 0.14 mm/s at a point of vibration assessment. Where the vibration from existing operation exceeds 0.14 mm/s, the desirable objective is to not exceed the existing vibration level.

5.2 Assessment Method

The vibration impact of a GO Transit rail project shall be assessed using field measurements of vibration velocities. Where applicable, the assessment shall include vibration generated by non-GO Transit rail traffic.

5.3 Impact Assessment Criteria

The impact at a point of vibration assessment will fall into one of the following categories:

- existing and future vibration velocity remains less than 0.14 mm/s ;
- existing vibration velocity is less than 0.14 mm/s, future vibration is expected to exceed 0.14 mm/s;
- existing vibration velocity is greater than 0.14 mm/s, future vibration is not expected to exceed this value; and
- existing vibration is greater than 0.14 mm/sec, future vibration is expected to exceed this figure.

GO Transit will not increase vibration velocity to a level that will cause structural damage.

5.4 Mitigation

When the vibration velocity at a point of vibration assessment exceeds the objective by 25%, the requirement to mitigate will be evaluated based on administrative, operational, economic and technical feasibility.

6.0 REFERENCES

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[2] NPC-101 - Technical Definitions, part of Reference 5.

[3] NPC-102 - Instrumentation, part of Reference 5.

[4] NPC-103 - Procedures, part of Reference 5.

[5] Model Municipal Noise Control By-law, Final Report, August 1978, Ontario Ministry of the Environment.

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MOEE/TTC
PROTOCOL FOR NOISE AND VIBRATION ASSESSMENT FOR THE PROPOSED YONGE-SPADINA SUBWAY LOOP

JUNE 16, 1993

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RCEP Profile #1411

PROTOCOL FOR NOISE AND VIBRATION ASSESSMENT

PART A. PURPOSE

The Toronto Transit Commission (TTC) and the Ministry of the Environment and Energy (MOEE) recognize that transit facilities produce noise and vibration which may affect neighbouring properties within urbanized areas. This document identifies the framework within which criteria will be applied for limiting wayside air-borne noise, ground-borne noise and vibration from the TTC's proposed Yonge-Spadina Subway Loop Line (the "Line"). The framework presented in this document is to be applied for planning purposes in order to address the requirements of the Environmental Assessment Act and is to be utilized during implementation of the Line.

The passby sound levels and vibration velocities in this protocol have been developed specifically for the Line and this protocol is not to be applied retroactively to existing TTC transit lines, routes or facilities nor to transit authorities other than TTC. Further, the criteria specified for this project are not precedent setting for future projects.

Prediction and measurement methods are being developed by the TTC. This will be done in consultation with MOEE and the Ministry of Transportation (MTO). Studies pertaining to noise and vibration levels are also being conducted by TTC. Upon completion of these studies, the TTC may revisit the assessment criteria and methods in this protocol to modify them as required in consultation with MOEE and the Ministry of Transportation (MTO).

PART B. GENERAL

During design of the Line, predicted wayside sound levels and vibration velocities are to be compared to criteria given in this protocol. This will permit an impact assessment and help determine the type or extent of mitigation measures to reduce that impact. Sound levels and vibration velocities will be predicted from sound levels and velocities of TTC's existing rail technologies.

The criteria presented in this document are based on good operating conditions and the impact assessment assumes this condition. Good operating conditions exist when well maintained vehicles operate on well maintained continuous welded rail without significant rail corrugation. It is recognised that wheel flats or rail corrugations will inevitably occur and will temporarily increase sound and vibration levels until they are corrected. Levels in this protocol do not reflect these occasional events, nor do they apply to maintenance activities on the Line. TTC recognizes that wheel rail squeal is a potential source of noise which may pose a concern to the community. TTC is investigating and will continue to investigate measures to mitigate wheel rail squeal and will endeavour to mitigate this noise source. TTC endeavours to minimize the noise and vibration impacts associated with its transit operations and is committed to providing good operating conditions to the extent technologically, economically and administratively feasible.

It is recognised that levels of sound and vibration at special trackwork, such as at crossovers and turnouts, are inevitably higher than along tangent track. Also, there is a limit to the degree of mitigation that is feasible at special trackwork areas. This is to be taken into account in predicting sound and vibration levels near these features and in applying the levels in this protocol. Special trackwork, such as at crossovers and turnouts, is encompassed within the framework of this document.

This protocol applies to existing and proposed residential development having municipal approval on the date of this protocol. The protocol also applies to existing and municipally approved proposed nursing homes, group homes, hospitals and other such institutional land uses where people reside. This protocol does not apply to commercial and industrial land uses.

This protocol does not apply closer than 15 m to the centreline of the nearest track. Any such cases shall be assessed on a case by case basis.

Part D of this document deals with air-borne noise from the Line and its construction. Part E deals with ground-borne noise and vibration from the Line.

PART C. DEFINITIONS

The following definitions apply to both parts D and E of this document.

Ancillary Facilities:

Subsidiary locations associated with either the housing of personnel or equipment engaged in TTC activities or associated with mainline revenue operations. Examples of ancillary facilities include, but are not limited to, subway stations, bus terminals, emergency services buildings, fans, fan and vent shafts, substations, mechanical equipment plants, maintenance and storage facilities, and vehicle storage and maintenance facilities.

Passby Time Interval:

The passby time interval of a vehicle or train is given by its total length and its speed. The start of the pass-by is defined as that point in time when the leading wheels pass a reference point. The end of the pass-by is defined as that point in time when the last wheels of the vehicle or train pass the same reference point. The reference point is to be chosen to give the highest level at the point of reception or point of assessment, i.e. usually at the point of closest approach. From a signal processing perspective, the passby time interval will be defined in the prediction and measurement methods being developed.

PART D. AIR-BORNE NOISE

1.0 DEFINITIONS

The following definitions are to be used only within the context of Part D of this document.

Ambient:

The ambient is the sound existing at the point of reception in the absence of all noise from the Line. In this protocol the ambient is taken to be the noise from road traffic and existing industry. The ambient specifically excludes transient noise from aircraft and railways, except for pre-existing TTC rail operations.

Daytime Equivalent Sound Level:

$L_{eq,15h}$ is the daytime equivalent sound level. The definition of equivalent sound level is provided in Reference 2. The applicable time period is from 07:00 to 23:00 hours.

Nighttime Equivalent Sound Level:

$L_{eq,8h}$ is the nighttime equivalent sound level. The applicable time period is from 23:00 to 07:00 hours.

Point of Reception:

Daytime: 07:00 - 23:00 hours

Any outdoor point on residential property, 15 m or more from the nearest track's centreline, where sound originating from the Line is received.

Nighttime: 23:00 - 07:00 hours

The plane of any bedroom window, 15 m or more from the nearest track's centreline, where sound originating from the Line is received. At the planning stage, this is usually assessed at the nearest facade of the premises.

Passby Sound Level, L_{passby} :

Within the context of this document, the passby sound level is defined as the A-weighted equivalent sound level, L_{eq} [Reference 2] over the passby time interval.

2.0 RAIL TRANSIT

In the assessment of noise impact, rail transit is considered to include the movement of trains between stations, the movement and idling of trains inside stations as well as the movement of trains between the mainline and ancillary facilities. Ancillary facilities are not considered part of the rail transit and are assessed as stationary sources. Trains idling in maintenance yards and storage facilities are part of the stationary source.

The assessment of noise impact resulting from Line is to be performed in terms of the following sound level descriptors:

1) Daytime equivalent sound level, $L_{eq,16h}$,
2) Nighttime equivalent sound level, $L_{eq,8h}$,
3) Passby Sound Level, L_{passby}.

The predicted daytime and nighttime equivalent sound levels include the effects of both passby sound level and frequency of operation and are used to assess the noise impact of the Line. The Passby Sound Level criterion is used to assess the sound levels received during a single train passby. The criteria and methods to be used are discussed in Sections 2.1 and 2.2.

2.1 Criteria

Noise impact shall be predicted and assessed during design of the Line using the following sound level criteria:

DAYTIME EQUIVALENT SOUND LEVEL:

The limit at a point of reception for the predicted daytime equivalent sound levels for rail transit operating alone (excluding contributions from the ambient) is 55 dBA or the ambient $L_{eq,16h}$, whichever is higher.

NIGHTTIME EQUIVALENT SOUND LEVEL:

The limit at a point of reception for the predicted nighttime equivalent sound levels for rail transit operating alone (excluding contributions from the ambient) is 50 dBA or the ambient $L_{eq,8h}$, whichever is higher.

PASSBY SOUND LEVEL:

The limit at a point of reception for predicted L_{passby} for a single train operating alone and excluding contributions from other sources is 80 dBA. This limit is based on vehicles operating on tangent track. It does not apply within 100m of special trackwork and excludes wheel rail squeal.

Mitigating measures will be incorporated in the design of the Line when predictions show that any of the above limits are exceeded by more than 5 dB. All mitigating measures shall ensure that the predicted sound levels are as close to, or lower than, the respective limits as is technologically, economically, and administratively feasible.

2.2 Prediction

In most cases, a reasonable estimate of the ambient sound level can be made using a road traffic noise prediction method such as that described in Reference 9, and the minimum sound levels in Table 106-2 of Reference 6. Prediction of road traffic L_{eq} is preferred to individual measurements in establishing the ambient. Prediction techniques for the L_{eq} from road traffic and the L_{eq} or L_{passby} from transit shall be compatible with one another. Any impact assessment following this protocol shall include a description of the prediction method and the assumptions and sound level data inherent in it. Prediction and measurement methods compatible with MOEE guidelines and procedures are being developed by the TTC at the date of this protocol in consultation with MTO and MOEE.

3.0 ANCILLARY FACILITIES

Predicted noise impacts from ancillary facilities shall be assessed during the design of the Line in accordance with the stationary source guidelines detailed in Reference 5. The predictions used shall be compatible with and at least as accurate as CSA Standard Z107.55.

4.0 BUSES IN MIXED TRAFFIC

Where buses are part of the road traffic there are no additional criteria requirements beyond those presented in the Ministry of Transportation of Ontario Protocol for dealing with noise concerns during the preparation, review and evaluation of Provincial Highways Environmental Assessments (Reference 1). Buses should be considered as medium trucks in the traffic noise prediction models.

5.0 CONSTRUCTION

Noise impacts from the construction of the Line are to be examined. For the purposes of impact assessment and identifying the need for mitigation, the Ministry of the Environment and Energy guidelines for construction presented in Reference 7 are to be referred to.

PART E. GROUND-BORNE VIBRATION

The assessment of ground-borne vibration impact is confined to the vibration that is produced by the operation of the Line and excludes vibration due to maintenance activities.

In recognition of the fact that the actual vibration response of a building is affected by its own structural characteristics, this document deals with the assessment of ground-borne vibration only on the outside premises. Structural characteristics of buildings are beyond the scope of this protocol and beyond the control of the TTC.

It is recognised that ground-borne vibration can produce air-borne noise inside a structure and there is a direct correlation between the two. The TTC can only control ground-borne noise by controlling ground-borne vibration. Accordingly, ground-borne noise will be predicted and assessed in terms of vibration measured at a point of assessment using the limit in Section 2.0, Vibration Assessment.

1.0 DEFINITIONS

The following definitions are to be used only within the context of Part E of this document.

Point of Assessment:

A point of assessment is any outdoor point on residential property, 15 m or more from the nearest track's centreline, where vibration originating from the Line is received.

Vibration Velocity:

Vibration Velocity is the root-mean-square (rms) vibration velocity assessed during a train pass-by. The unit of measure is metres per second (m/s) or millimetres per second (mm/s). For the purposes of this protocol only vertical vibration is assessed. The vertical component of transit vibration is usually higher than the horizontal. Human sensitivity to horizontal vibration at the frequencies of interest is significantly less than the sensitivity to vertical vibration.

2.0 VIBRATION ASSESSMENT

Vibration velocities at points of assessment shall be predicted during design of the Line. If the predicted rms vertical vibration velocity from the Line exceeds 0.1 mm/sec, mitigation methods shall be applied during the detailed design to meet this criterion to the extent technologically, economically, and administratively feasible. Where it is suitable, a double tie system or its equivalent will be the mitigation method of choice. This is a state of the art vibration isolation system developed by TTC and used where vibration isolation is required on new underground lines (see Reference 8).

Any impact assessment following this protocol shall include a description of the prediction method and the assumptions and data inherent in it. Prediction and measurement methods are being developed by the TTC at the date of this protocol in cooperation with MTO and MOEE.

References

1)**A Protocol for Dealing With Noise Concerns During the Preparation, Review and Evaluation of Provincial Highways Environmental Assessments**, Ministry of Transportation, February 1986.

2)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-101 Technical Definitions**, Ministry of the Environment, August 1978.

3)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-103 Procedures**, Ministry of the Environment, August 1978.

4)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-104 Sound Level Adjustments**, Ministry of the Environment, August 1978.

5)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-105 Stationary Sources**, Ministry of the Environment, August 1978.

6)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-106 Sound Levels of Road Traffic**, Ministry of the Environment, August 1978.

7)**Noise Control Guideline For Class Environmental Assessment of Undertakings**, February 1980, Ministry of the Environment.

8)**Toronto Subway System Track Vibration Isolation System (Double Tie) - Technical Report**, TTC Engineering Department, June 1982.

9)**STAMSON 4.1**, Ontario Ministry of the Environment Road and Rail Noise Prediction Software

Appendix C

Future Ontario Line and GO Track Volumes

LSE OnCorr Tracks

	East Harbor to Danforth - Combined Table							
	Track 1 (Local)		Track 2 (Express)		Track 3 (Express)		Track 4 (Local)	
	Day	Night	Day	Night	Day	Night	Day	Night
D1L6 (rev and non rev)	5	-	21	5	19	3	5	-
D2L12 (rev and non rev)	1	-	31	5	37	3	2	-
E1L6 (rev and non rev)	46	6	1	0	1	-	47	9
E2L12 (rev and non rev)	18	7	1	0	1	-	19	4
Freight	0	0	3	1	4	0	0	0
Via	0	0	16	1	18	0	0	0
D1L6 STF	6	-	1	-	1	-	6	-
E1L6 STF	129	29	2	2	4	-	128	32
E2L12 STF	-	1	3	2	5	-	-	-

	East Harbor to US - Combined Table							
	Track 1 (Local)		Track 2 (Express)		Track 3 (Express)		Track 4 (Local)	
	Day	Night	Day	Night	Day	Night	Day	Night
D1L6 (rev and non rev)	5	-	21	5	19	3	5	-
D2L12 (rev and non rev)	1	-	31	5	37	3	2	-
E1L6 (rev and non rev)	46	6	1	0	1	-	47	9
E2L12 (rev and non rev)	18	7	1	0	1	-	19	4
Freight	0	0	3	1	4	0	0	0
Via	0	0	16	1	18	0	0	0
D1L6 STF	6	-	1	-	1	-	6	-
E1L6 STF	129	29	2	2	4	-	128	32
E2L12 STF	-	1	3	2	5	-	-	-

Station	Route	D1L6		D2L12		E1L6		E2L12	
		DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
REVENUE									
Danforth to East Harbour	GO Eastbound Revenue Local	5	-	2	-	47	9	19	4
	GO Eastbound Revenue Express 1	9	2	15	1	-	-	-	-
	GO Eastbound Revenue Express 2	2	-	11	1	-	-	-	-
	GO Westbound Revenue Local	5	-	1	-	46	6	18	7
	GO Westbound Revenue Express 1	14	1	9	4	-	-	-	-
	GO Westbound Revenue Express 2	2	-	10	1	-	-	-	-
East Harbour to Union	GO Eastbound Revenue Local	5	-	2	-	47	9	19	4
	GO Eastbound Revenue Express 1	9	2	15	1	-	-	-	-
	GO Eastbound Revenue Express 2	2	-	11	1	-	-	-	-
	GO Westbound Revenue Local	5	-	1	-	46	6	18	7
	GO Westbound Revenue Express 1	14	1	9	4	-	-	-	-
	GO Westbound Revenue Express 2	2	-	10	1	-	-	-	-
Whitby RMF to Union Station	GO Eastbound Non-Revenue	1	1	-	-	-	-	-	-
	GO Westbound Non-Revenue	1	4	-	-	-	-	-	-
Midland Layover to Union Station	GO Eastbound Non-Revenue	1	-	7	-	-	-	-	-
	GO Westbound Non-Revenue	-	-	6	-	-	-	-	-
Don Yard to Union Station	GO Eastbound Non-Revenue	6	-	4	1	1	-	1	-
	GO Westbound Non-Revenue	4	-	6	-	1	-	1	-
Danforth to East Harbour	GO Northbound Local	6	-	-	-	128	32	-	-
	GO Northbound Express	1	-	-	-	4	-	5	-
	GO Southbound Local	6	-	-	-	129	29	-	1
	GO Southbound Express	1	-	-	-	2	2	3	2

Richmond Hill Future Tracks

	Track 1 (WB/SB)		Track 2 (EB/NB)	
	Day	Night	Day	Night
D1L6 rev+non rev	7	3	11	-
D2L12 rev+non rev	11	1	12	-
E2L12 rev+non rev	-	-	-	-

Station	Route	D1L6		D2L12		E2L12	
		DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
REVENUE							
Oriole to Union	GO Southbound	7	3	8	1	-	-
	GO Northbound	11	-	9	-	-	-
NON-REVENUE							
Belleville Don Branch Layover to Union	GO Southbound	-	-	3	-	-	-
	GO Northbound	-	-	3	-	-	-

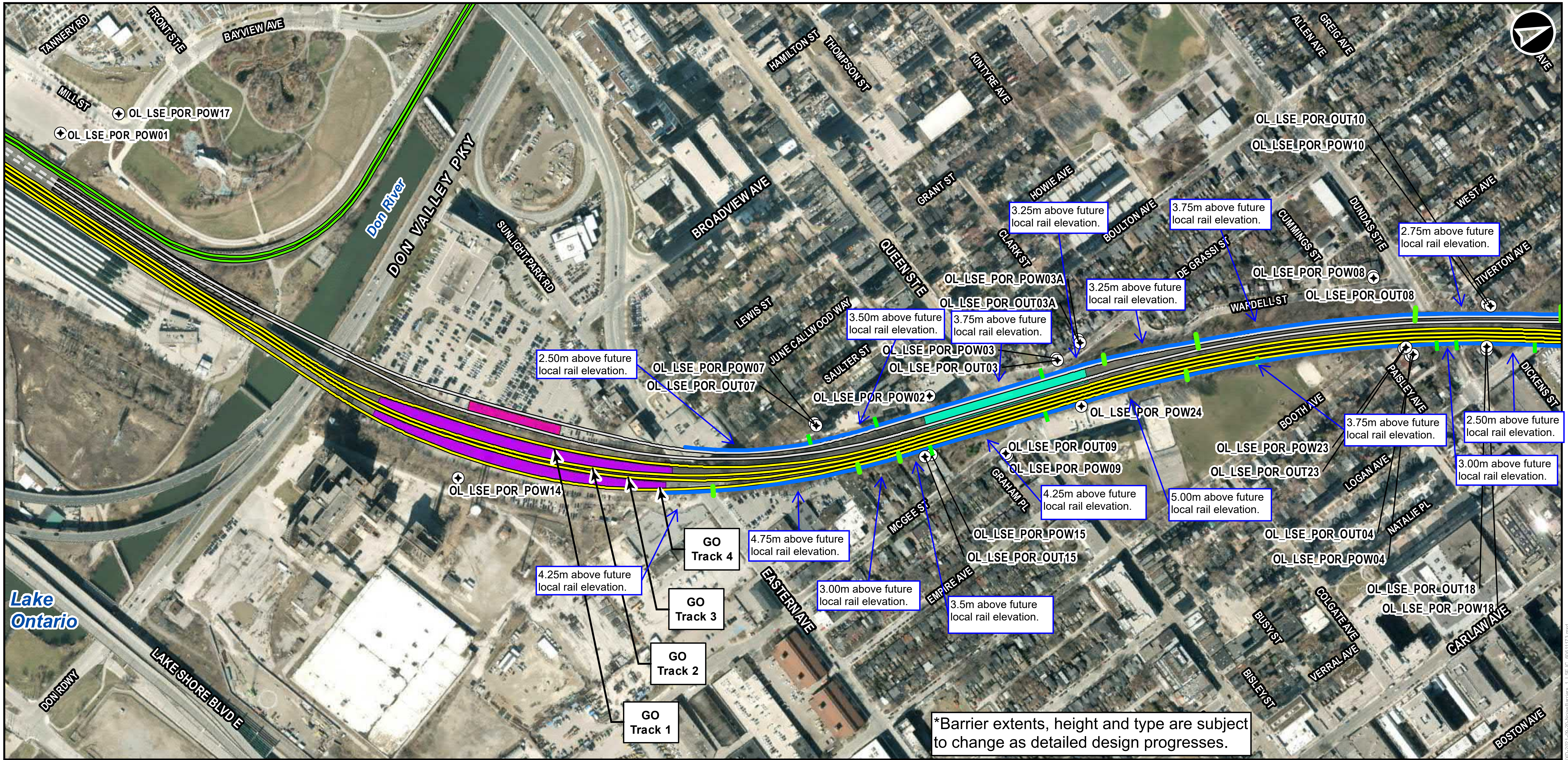
Ontario Line Volumes

Name of Period	Period		Trains per Hour	No. Hours in Period	No. Trains per Period	
	Start	End	2060-2080 Data		2060-2080 Data	
Weekday 1	6:00	7:00	18	1	18	Night
Weekday 2	7:00	10:00	40	3	120	Day
Weekday 3	10:00	15:00	24	5	120	Day
Weekday 4	15:00	19:00	40	4	160	Day
Weekday 5	19:00	22:00	24	3	72	Day
Weekday 6	22:00	0:00	24	2	48	1/2 Day, 1/2 Night
Weekday 7	0:00	1:30	18	1.5	27	Night
			TOTAL		565	
			Day	07:00 to 23:00	496	
			Night	23:00 to 07:00	69	

Note: Trains per period are per track (i.e. in each direction on the corridor).

Appendix D

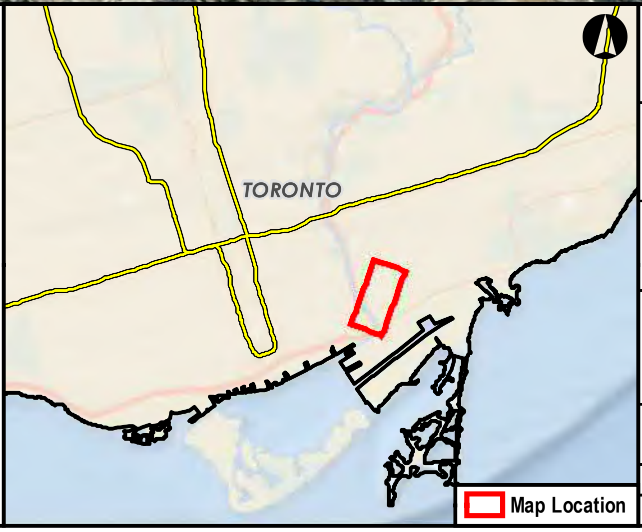
Noise and Vibration Mitigation Figures



*Barrier extents, height and type are subject to change as detailed design progresses.

Legend

- Noise Receptors
- Union Station/Lakeshore East Rail Corridor GO Track
- Proposed Ontario Line Track (Above Ground)
- Proposed Ontario Line Track (Below Ground)
- Richmond Hill Rail Corridor GO Track
- Existing Tracks
- Noise Barrier
- Noise Barrier Segment Marker (delineates segments of different height)
- Proposed Ontario Line Riverside/Leslieville Station (includes Ontario Line platform)
- Proposed Future Portal (Above Ground)
- Proposed Ontario Line Platform at East Harbour Station
- Proposed GO Platform at East Harbour Station



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Investigated Noise Barriers

0 50 100 200 300
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
Contains Information licensed under the Open Government Licence Ontario, City of Toronto and Metrolinx. Keymap and Basemap provided by ESRI.

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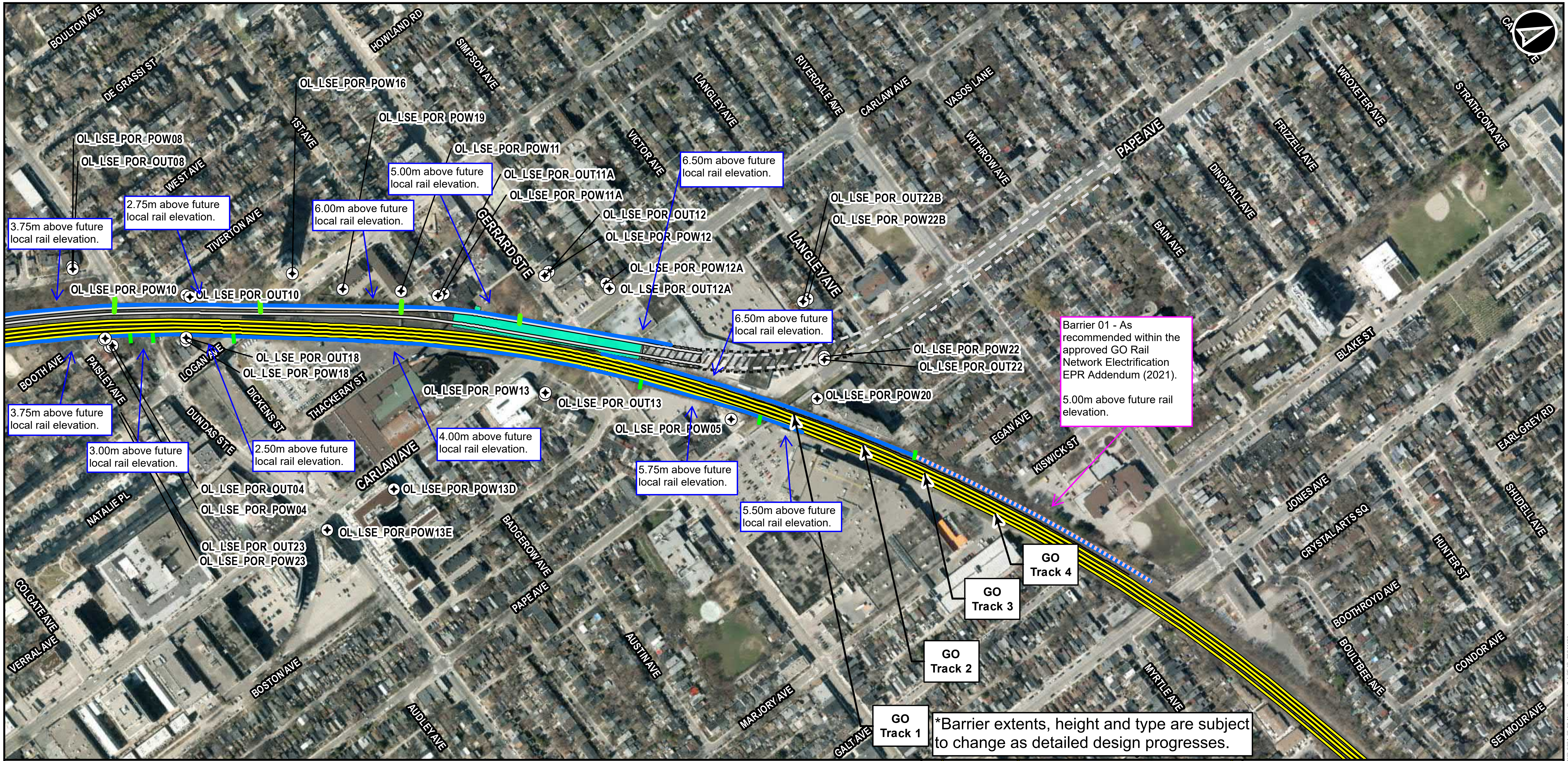
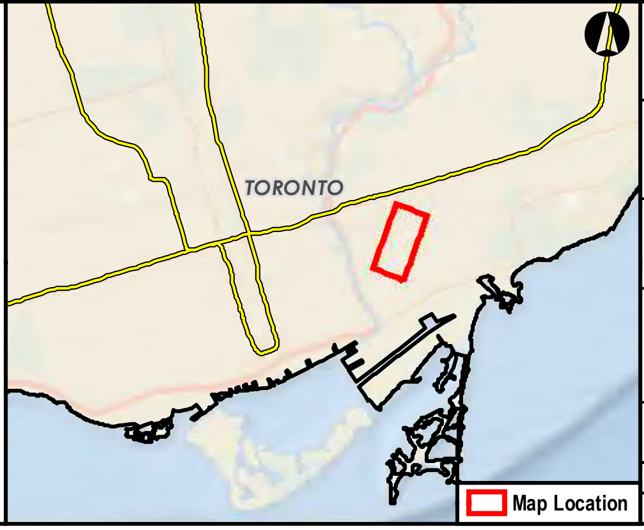


Legend

- Noise Receptors
- Union Station/Lakeshore East Rail Corridor GO Track
- Proposed Ontario Line Track (Above Ground)
- Proposed Ontario Line Track (Below Ground)
- Existing Tracks
- Noise Barrier
- Noise Barrier Segment Marker (delineates segments of different height)
- Proposed Ontario Line Gerrard Station (includes Ontario Line Platform)
- Proposed Future Portal (Below Ground)
- Proposed Future Portal (Above Ground)



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Investigated Noise Barriers

0 50 100 200 300
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
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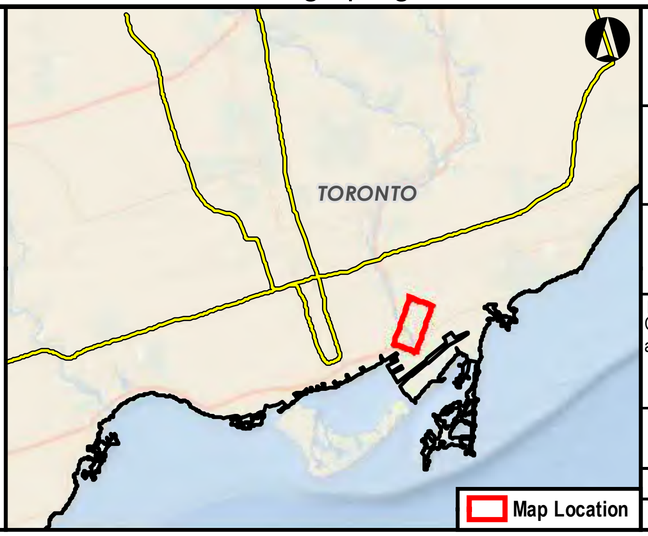
* Potential vibration mitigation extents/locations subject to refinement as detailed design progresses.

Legend

- Vibration Receptor
- Union Station/Lakeshore East Rail Corridor GO Track
- Proposed Ontario Line Track (Above Ground)
- Proposed Ontario Line Track (Below Ground)
- Richmond Hill Rail Corridor GO Track

Vibration Mitigation Extents

- Mitigation Extents - where vibration mitigation is required.
- Mitigation Transition - intermediate treatment to connect mitigated and untreated track segments.



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Vibration Mitigation Extents

0 50 100 200 300
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
Contains Information licensed under the Open Government Licence Ontario, City of Toronto and Metrolinx. Keymap and Basemap provided by ESRI.

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Sep, 2021	
P#: 60611173	REV: 04

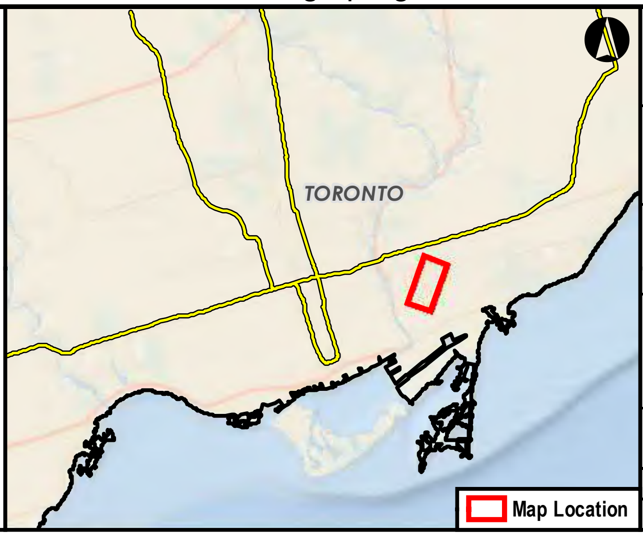
* Potential vibration mitigation extents/locations subject to refinement as detailed design progresses.

Legend

- Vibration Receptor
- Union Station/Lakeshore East Rail Corridor GO Track
- Proposed Ontario Line Track (Above Ground)
- Proposed Ontario Line Track (Below Ground)

Vibration Mitigation Extents

- Mitigation Extents - where vibration mitigation is required.
- Mitigation Transition - intermediate treatment to connect mitigated and untreated track segments.



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Vibration Mitigation Extents

0 50 100 200 300
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
Contains Information licensed under the Open Government Licence Ontario, City of Toronto and Metrolinx. Keymap and Basemap provided by ESRI.

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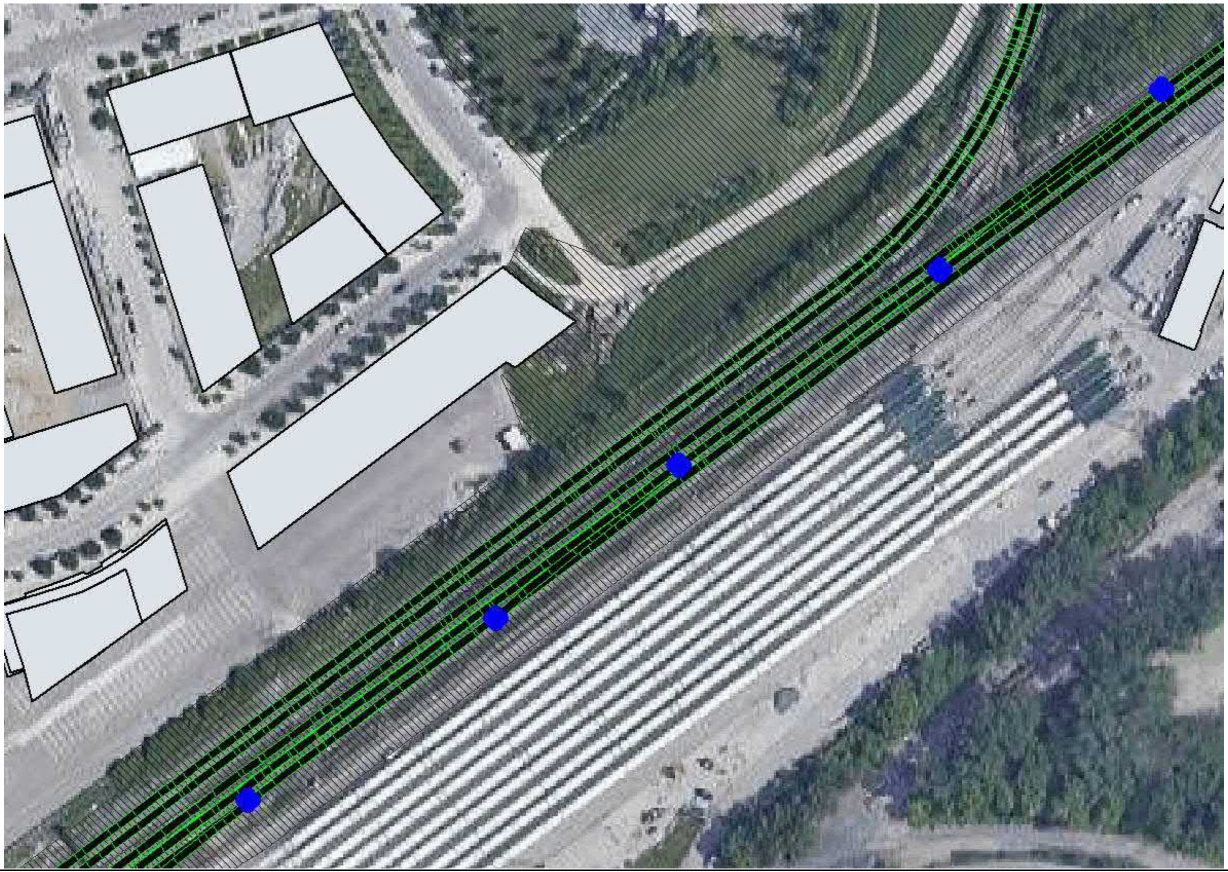
Appendix E

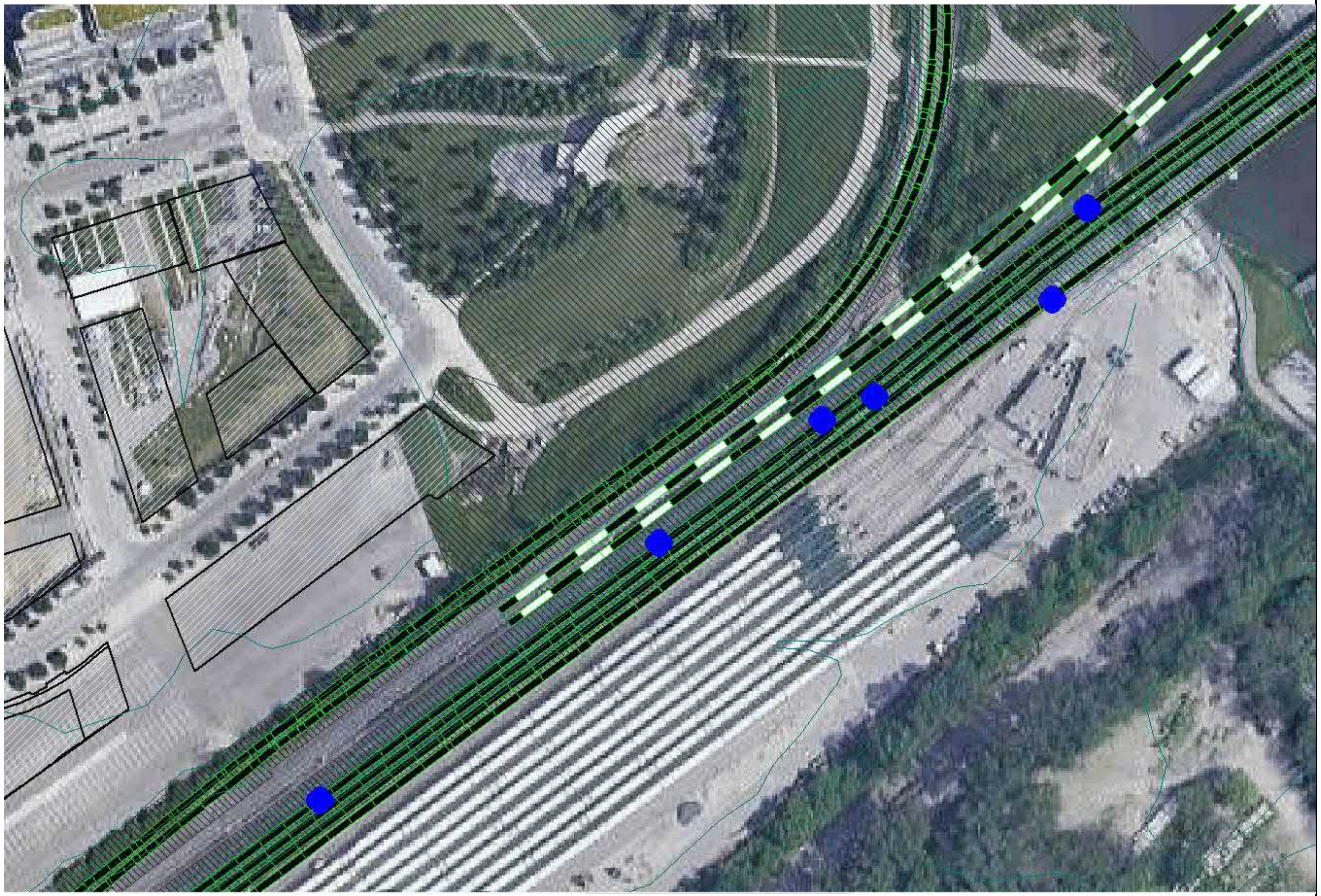
Summary of Model Inputs

Item #	Item	Description
1	Existing and Future Conditions	Building geometry adopted from the GO Rail Network Electrification Final Environmental Project Report Addendum noise model or estimated using street view or drawings of planned buildings.
2	Existing and Future Conditions	Noise from trains crossing over switches and crossovers was accounted for by applying a +5 dB adjustment to tracks connected to and within 300 feet of a crossover/switch, per the FTA Guide (FTA, 2018).
3	Existing and Future Conditions	16 hour day (7 AM to 11 PM) and 8 hour night (11 PM to 7 AM) time periods.
4	Existing and Future Conditions	Buildings modelled as reflective, having an absorption coefficient of alpha=0.21.
5	Existing and Future Conditions	Global ground absorption of 0.20, with a ground absorption of 0.66 in ballasted track or vegetated/grassed areas. A higher ground absorption coefficient provides a greater loss in sound energy when reflected off of the ground surface.
6	Existing and Future Conditions	A maximum order of reflection of 2 (i.e. reflection of sound on up to 2 consecutive sources is considered).

Item #	Item	Description
7	Existing Conditions	Crossover locations for existing model based on aerial photography and provided noise model for the GO Rail Network Electrification Final Environmental Project Report Addendum. Note: No crossovers located east of the Don River. 
8	Existing Conditions	Sound level data for Lakeshore East GO, Richmond Hill GO, VIA, referenced from the Federal Transit Administration's (FTA) Transit Noise and Vibration Impact Assessment Manual.

Item #	Item	Description
9	Existing Conditions	Existing track alignment geometry used.
10	Existing Conditions	Existing train volumes as presented in the GO Rail Network Electrification Final Environmental Project Report Addendum noise model.
11	Existing Conditions	Ground terrain elevation data was adopted from the GO Rail Network Electrification Final Environmental Project Report Addendum noise model.
12	Existing Conditions	Existing trains modelled with an assumed railheight of 0.3 metres above grade (in addition to source heights for trains), as applied for the GO Rail Network Electrification Final Environmental Project Report Addendum.
13	Existing Conditions	Local train services were assumed to operate on their respective outside eastbound and westbound service tracks, while express train services were assumed to operate on the inside track as per the GO Rail Network Electrification Final Environmental Project Report Addendum.
14	Existing Conditions	Non-revenue, VIA and freight trains were assumed to operate on the inside track, similar to express trains as per the GO Rail Network Electrification Final Environmental Project Report Addendum).
15	Existing Conditions	Train speeds and throttle settings have been based on the provided noise models and throttle profile charts from the GO Rail Network Electrification Final Environmental Project Report Addendum).
16	Future Conditions	Sound level data for Lakeshore East GO, Richmond Hill GO, VIA, referenced from the Federal Transit Administration’s (FTA) Transit Noise and Vibration Impact Assessment Manual; All future diesel locomotives will have an exhaust silencer installed which will reduce the base sound level by 3 dB.
17	Future Conditions	Ontario Line train modelled as FTA rail car vehicle type with 80.4 dBA sound exposure level at 15 m, 80 m reference length, 80 km/h reference speed and source height of 0.6 m.
18	Future	A +3 dB adjustment is included for slab track at grade and a +5dB adjustment is included for

Item #	Item	Description
	Conditions	elevated guideway sections.
19	Future Conditions	The new proposed track alignments and elevations for both the Ontario Line and GO tracks and Lakeshore East corridor.
20	Future Conditions	Ontario Line service volumes as outlined in **Appendix D.** Weekday data for the year 2021 was used in the noise model, for each track direction.
21	Future Conditions	Future GO track volumes for the year 2037. Detailed train volume data can be found in **Appendix D**.
22	Future Conditions	Future GO train speeds and throttle settings have been based on the provided GO Lakeshore East model for the GO Rail Network Electrification Final Environmental Project Report Addendum noise model;

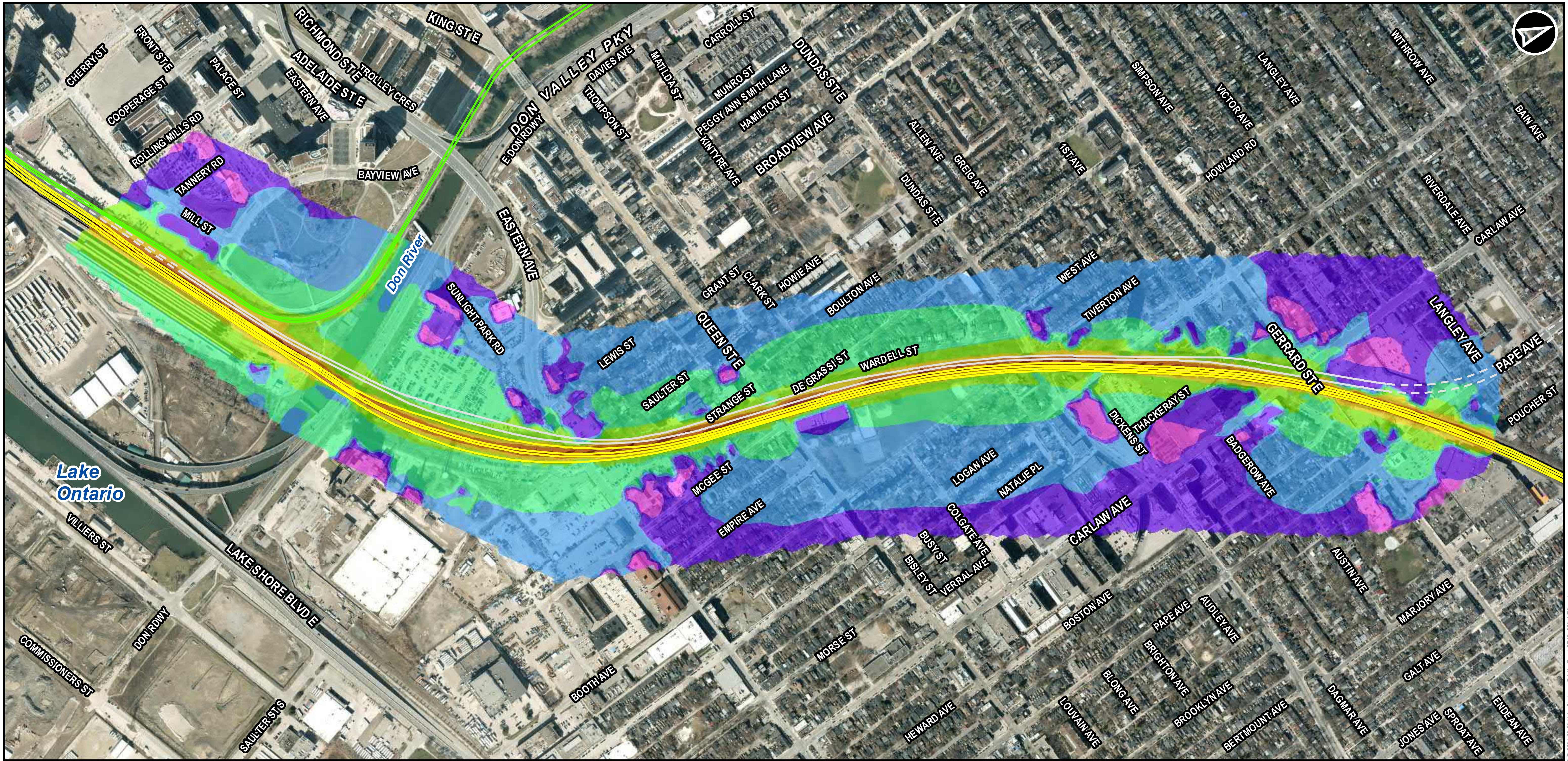
Item #	Item	Description
23	Future Conditions	Crossover locations for future model conservatively based on existing crossover locations and where future track alignment is predicted to cross over over existing tracks. Note: No crossovers are expected to be located east of the Don River. 

Item #	Item	Description
24	Future Conditions	Ground elevation data as previously modelled for the GO Rail Network Electrification Final Environmental Project Report Addendum in combination with provided design elevation data for the Ontario Line and GO tracks;
25	Future Conditions	Idling train locations at the expected future East Harbour GO Station have been based on the provided GO Rail Network Electrification Final Environmental Project Report Addendum noise model.
26	Future Conditions	Local train services were assumed to operate on their respective outside northbound and southbound service tracks, while express train services assumed to operate on their respective inside northbound and southbound tracks as per the GO Rail Network Electrification Final Environmental Project Report Addendum);
27	Future Conditions	Non-revenue, VIA and freight train volumes were assumed to operate on their respective inside northbound and southbound tracks, similar to express trains as per the GO Rail Network Electrification Final Environmental Project Report Addendum
28	Future Conditions	Idling reference sound power levels for electric and diesel trains were taken from the provided GO Rail Network Electrification Final Environmental Project Report Addendum noise model . Idling noise considered the amount of expected electric and diesel train volumes on each track.
29	Future Conditions	Portal-radiated reverberant train noise from the Ontario Line tunnel portals was calculated in accordance with *Prediction of Sound radiated from Tunnel Openings', Wolfgang Probst, Noise Control Engineering Journal, Vol. 58, No.2, 2010*;

Item #	Item	Description
30	Future Conditions	Ontario Line trains assumed to operate at the speeds outlined in the following table: <table><tr><th>Subway Line Segments</th><th>East Bound Subway Line Operational Train Speed (km/h)</th><th>West Bound Subway Line Operational Train Speed (km/h)</th></tr><tr><td>**Corktown to East Harbour**</td><td>71.5</td><td>75.5</td></tr><tr><td>**East Harbour to Leslieville**</td><td>52.0</td><td>53.0</td></tr><tr><td>**Leslieville to Gerrard**</td><td>74.0</td><td>75.5</td></tr><tr><td>**Gerrard to Pape**</td><td>75.0</td><td>75.5</td></tr></table>
31	Traffic Noise	Traffic volumes (including bus and truck counts) taken from turning movement counts provided as open data at Toronto.ca. Peak hour data from the data sets was multiplied by a factor of 10 to obtain annual average daily traffic (AADT) data.
32	Traffic Noise	Traffic speeds obtained from posted speed limits for streets included in the assessment.
33	Traffic Noise	Buses assumed to be similar to “medium trucks” within ORNAMENT calculations.
34	Traffic Noise	Trucks set as “heavy trucks” within ORNAMENT calculations.
35	Traffic Noise	Road grade estimated using elevation profile data within Google Earth.
36	Traffic Noise	AADT traffic volumes split as 90% day, and 10% night, as recommended within ORNAMENT for regional roads.

Appendix F

Noise Contour Figures



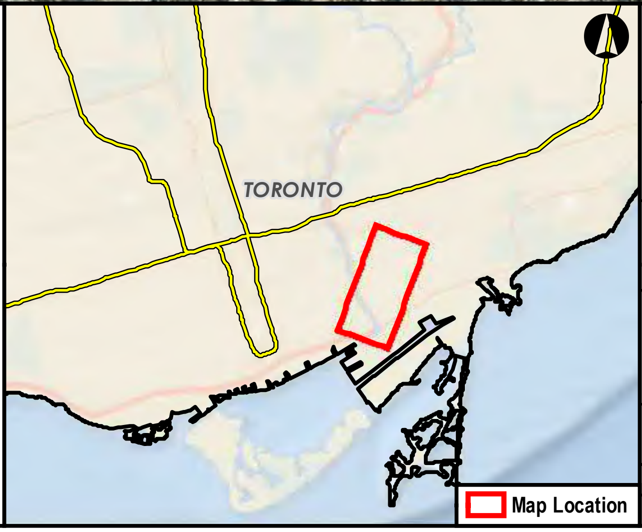
Legend

- Existing Tracks
- Proposed Ontario Line Track (Underground)
- Proposed Ontario Line Track (Above Ground)
- Union Station/Lakeshore East Rail Corridor GO Track
- Richmond Hill Rail Corridor GO Track

Existing - Day (dBA)

- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Existing Day-time Noise Contours - 1.5m Height

0 50 100 200 300 400 500
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
Contains Information licensed under the Open Government Licence Ontario, City of Toronto and Metrolinx. Keymap and Basemap provided by ESRI.

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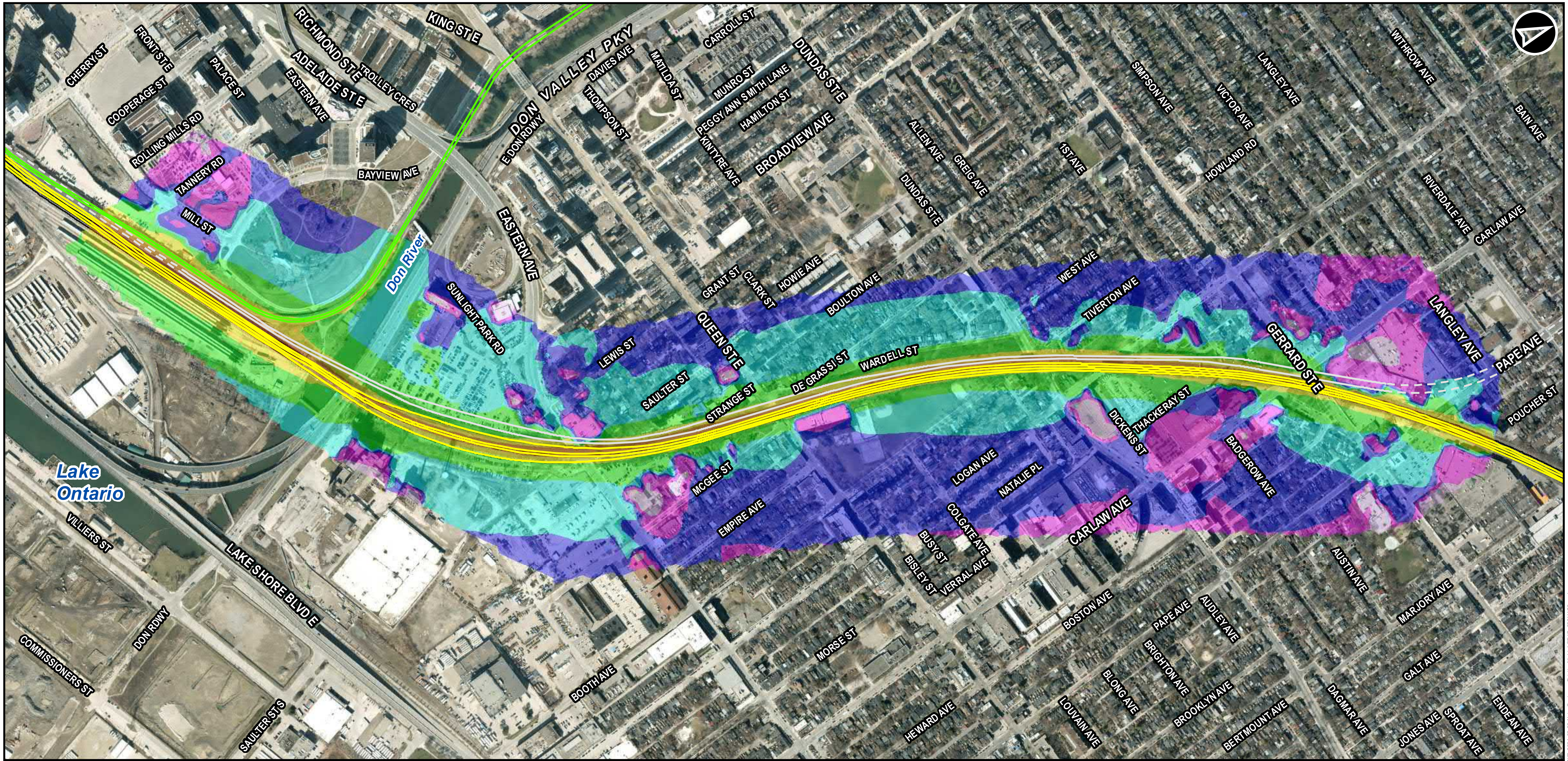
P#: 60611173	REV: 04



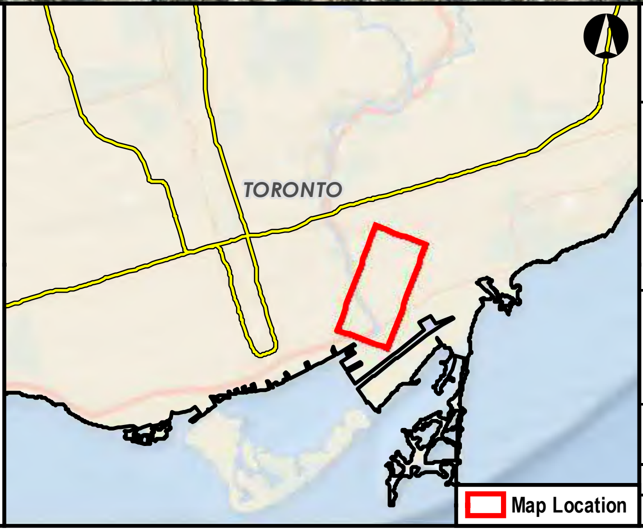
Legend

- Existing Tracks
- Proposed Ontario Line Track (Underground)
- Proposed Ontario Line Track (Above Ground)
- Union Station/Lakeshore East Rail Corridor GO Track
- Richmond Hill Rail Corridor GO Track

Existing - Night (dBA)

- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Existing Night-time Noise Contours - 4.5m Height

0 50 100 200 300 400 500
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
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Sep, 2021

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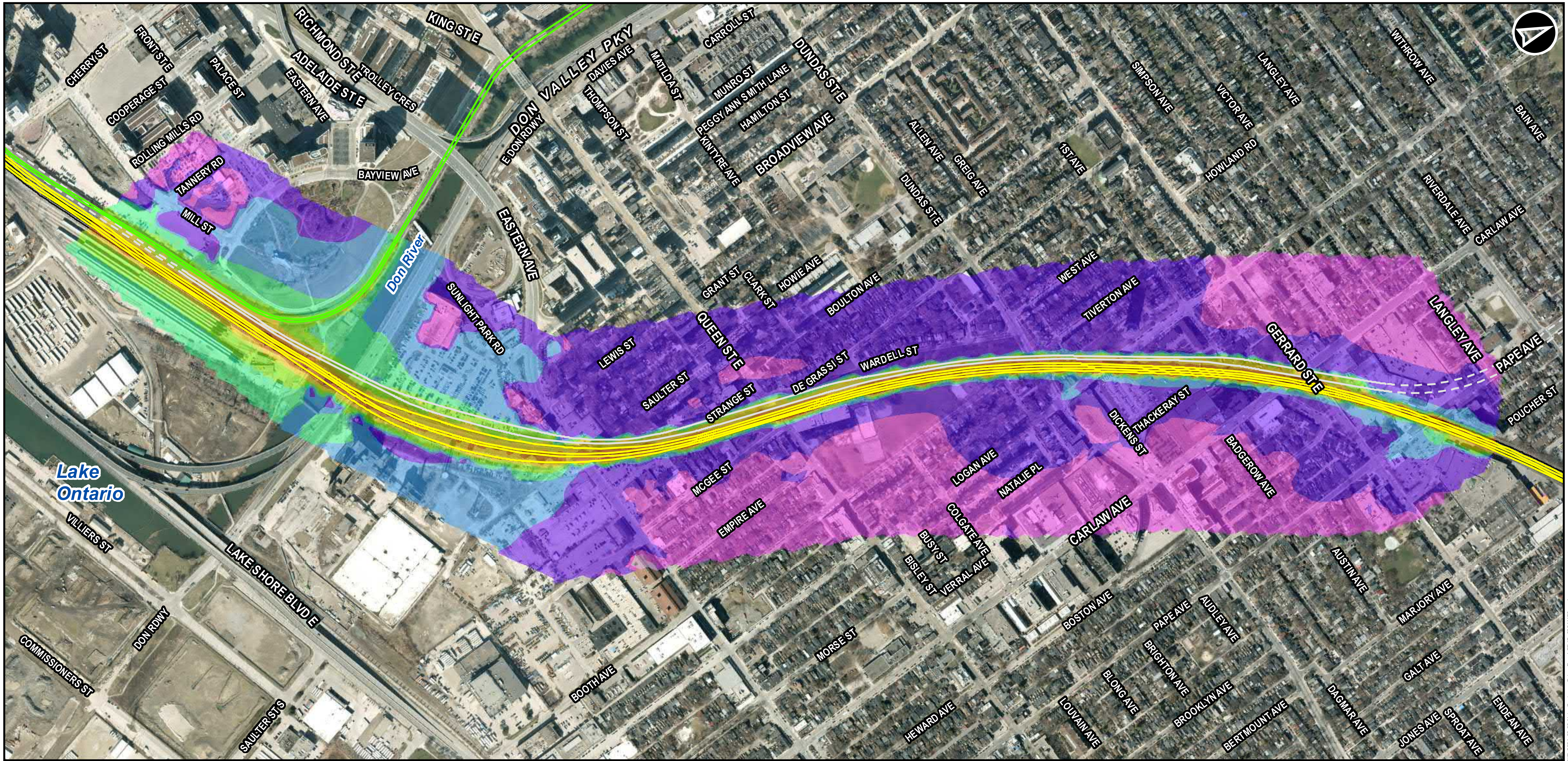


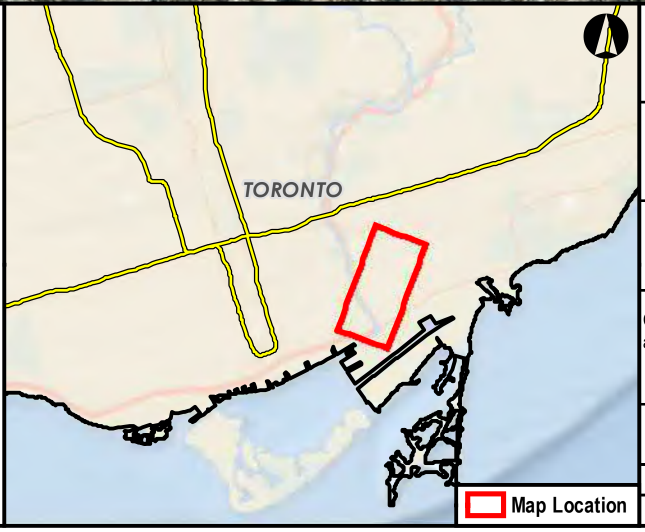
Legend

- Existing Tracks
- Proposed Ontario Line Track (Underground)
- Proposed Ontario Line Track (Above Ground)
- Union Station/Lakeshore East Rail Corridor GO Track
- Richmond Hill Rail Corridor GO Track

Future - Day - with Barrier (dBA)

- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Future Day-time Noise Contours - 1.5m Height

0 50 100 200 300 400 500
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
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P#: 60611173
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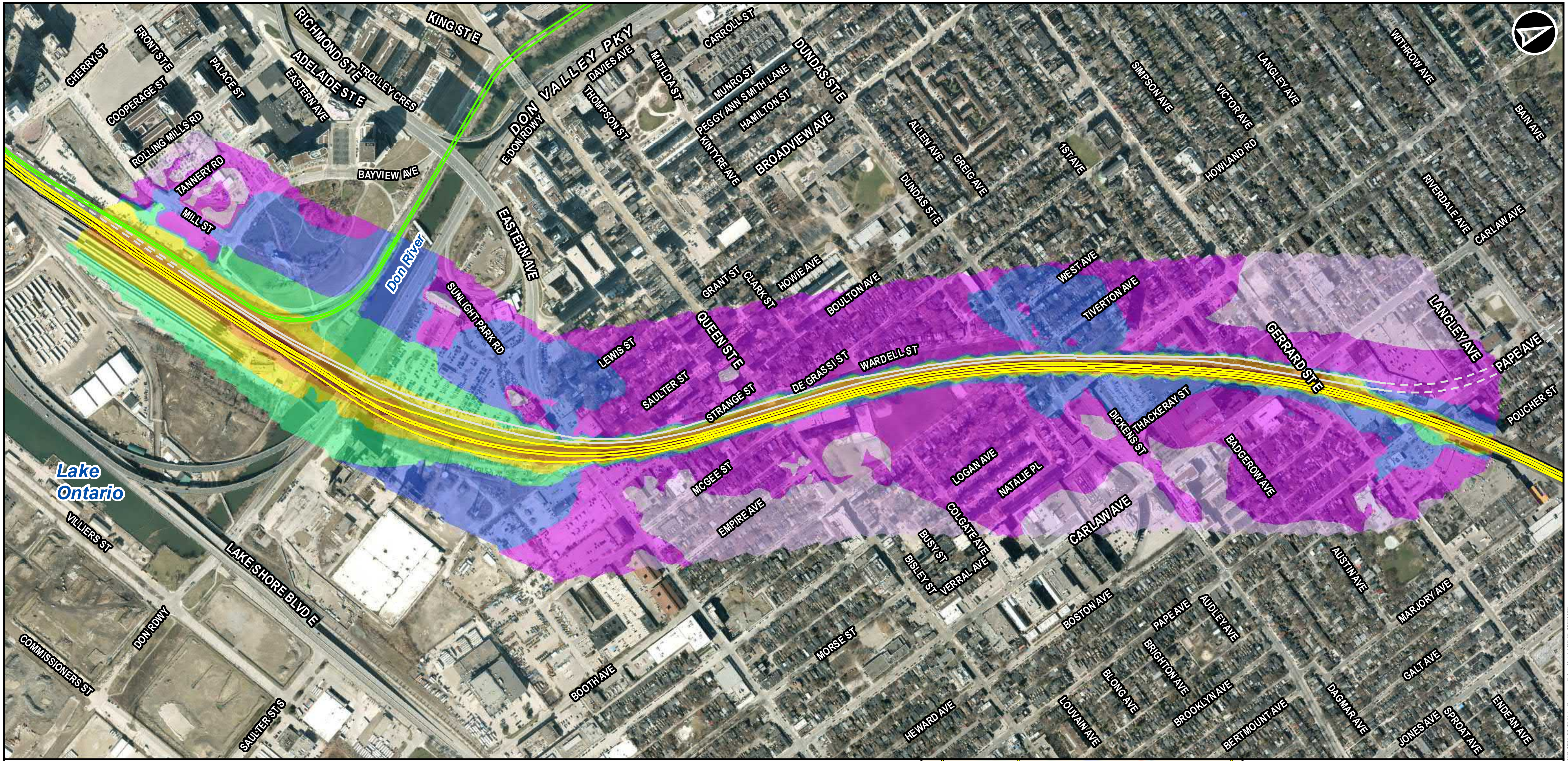


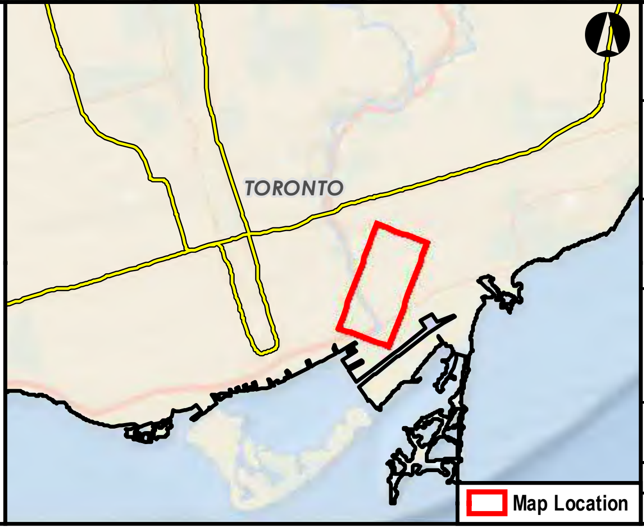
Legend

- Existing Tracks
- Proposed Ontario Line Track (Underground)
- Proposed Ontario Line Track (Above Ground)
- Union Station/Lakeshore East Rail Corridor GO Track
- Richmond Hill Rail Corridor GO Track

Future - Night - with Barrier (dBA)

- 45 - 50
- 50 - 55
- 55 - 60
- 61 - 65
- 66 - 70
- 71 - 75
- 76 - 80

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.



Ontario Line Project

Ontario Line - Lakeshore East Joint Corridor - Future Night-time Noise Contours - 4.5m Height

0 50 100 200 300 400 500
Meters
DATUM: NAD 1983 MTM 10

Data Sources:
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Sep, 2021
P#: 60611173 REV: 04

Appendix G

Sample Calculations

Traffic Noise Calculations - ORNAMENT/STAMSON Inputs and Results

		No Project																			
RECEIVER	SOURCE	θ1	θ2	TOPO	WOODS	No. Rows	@ Density	Ground Surface Type	Receiver Height (r) (m)	Source Receiver Dist (m)	Barr θ1	Barr θ2	Barrier Height (m)	Barrier Receiver Distance (m)	Elevation Change (e) (m)	Source Ground Elevation (m)	Distance	Receiver Ground Elevation (m)	Base of Barrier Elevation (m)	Leq (16hr) (dBA)	Leq (Night) (dBA)
POW16	Logan Avenue	-90	90	1	-	-	-	2	22.5	19	-	-	-	-	0	-	-	-	-	**55.3**	**48.7**
POW13D	Carlaw Avenue - Dundas to Gerrard	-90	90	1	-	-	-	2	22.5	10	-	-	-	-	0	-	-	-	-	60.6	54.1
	Dundas Street - Carlaw to Logan	0	60	1	-	-	-	2	22.5	63	-	-	-	-	0	-	-	-	-	47.9	41.3
																		Total		**60.8**	**54.3**
POW13E	Carlaw Avenue - Queen to Dundas	-90	45	1	-	-	-	2	22.5	11	-	-	-	-	0	-	-	-	-	59.4	52.9
	Carlaw Avenue - Dundas to Gerrard	45	90	1	-	-	-	2	22.5	11	-	-	-	-	0	-	-	-	-	54.2	47.6
	Dundas Street - Carlaw to Jones	-45	90	1	-	-	-	2	22.5	12	-	-	-	-	0	-	-	-	-	59.9	53.3
	Dundas Street - Carlaw to Logan	-90	-45	1	-	-	-	2	22.5	15	-	-	-	-	0	-	-	-	-	52.8	46.3
																		Total		**63.6**	**57.1**
POW20	Pape - Bridge to Riverdale	0	90	1	-	-	-	2	22.5	17	-	-	-	-	0	-	-	-	-	**52.8**	**46.3**

Note: Manual volume and distance adjustments applied where distances where source-receiver distances were less than 15 metres and traffic volumes were less than 4000 AADT on a road due to restrictions within STAMSON.

U.S. Federal Transit Administration
Transit Noise and Vibration Impact Assessment
"FTA General Vibration Assessment 2018"

Project No.	60611173
Project Name	Ontario Line

Case	POW23
	Future -GO/VIA

Note: All distances are in ft and All vibration levels in dB are VdB re: 1 min/s

1. Factors Affecting Vibration Source (Source Factor)

1.1. Train/Vehicle Type and Speed

				Resulting Adjustments
Train Type	F	(F) reight, (L)RT/Rapid Transit, (B)us		
Train Speed	90	mph		5.1

1.2. Train/Vehicle Type and Parameters (not additive, apply greatest value only)

Stiff Suspension?	n	(y/n, usually n) yes when vertical resonance frequency greater than 15 Hz	0	
Resilient Wheels?	n	No effect on vibration, included to match standard (y/n)	0	0.0
Worn wheels or wheels with flats?	n	(y/n, No for new or well maintained system)	0	
		If both the wheels and the track are worn, only one adjustment should be used.		

1.3. Track Conditions (not additive, apply greatest value only)

Worn or Corrugated track?	n	Worn track (y/n, usually n for new or well maintained system)	0	
Special Trackwork? If "Y", Distance?	n	ft Crossovers, diamonds, frogs, etc. (y/n)	0	0.0
Jointed Track or Uneven Road Surfaces?	CWR	Jointed Track (J), Continuous Welded Rail (CWR), or Rough Road	0	

1.4. Track Treatments (not additive, apply greatest value only)

Floating slab trackbed?	n	Concrete floating slab on spring isolators (y/n)	0	
Ballast mats?	n	Rubber mat placed over concrete, under the ballast (y/n)	0	0
High Resilience Fasterners?	n	Used with concrete track slabs (y/n)	0	
Resiliently Supported Ties?	n	Concrete ties on rubber blocks, with resilient fasteners (y/n)	0	

2. Factors Affecting Vibration Path (Path Factor)

2.1. Track Configuration (not additive, apply greatest value only)

2.1.1. Type of Transit Stucture

Relative to at-grade tie & ballast:

Elevated Structure?	n	Elevated structure (y/n)	0	
In open cut?	n	No effect on vibration, included to match standard (y/n)	0	

Mutually
May also both be "n"

Relative to bored subway tunnel in soil:

Station	n	0	
Cut and Cover	n	0	0
Rock-Based	n	0	

2.2. Ground-Borne Propagation Effects

2.2.1. Geologic Condition that Promote Efficient Vibration Propagation

Efficient propagation in soil

Efficient propagation in soil?	n	Accounts for clay soils or other mediums with efficient propagation (y/n)	Mutually	0	
Propagation in Rock Layer?	n	Accounts for lower attenuation with distance in rock versus soil (y/n)	exclusive		0
If y, Distance (50 ft, 100 ft, 150 ft, 200 ft)=	200	ft	choices	0	
			May also both be "n"		

Base Vibration Level at 10 ft	94.5	VdB, FTA base curve levels at 10 ft from track
Total Adjustments	5.1	VdB
Adjusted Vibration Level at 10 ft	**99.6**	VdB, including train type and track type adjustements above.
	2.427	mm/sec (RMS)

2.3. Distance to Meet Guideline Limits

ISO 2631-2 Guidelines for Whole Body Vibration in Buidlings

Space	Limit VdB
Industrial / Workshop	90.0
Office	84.0
Residential Day	78.0
Residential Night, Operating Rooms	72.0

Provides the distance past which the guideline limits are met.
The limits are inside the building levels

2.4. Vibration Level at Given Receptor (outside)

Source-Receiver distance	**20.9**	ft, from track to receptor (DISTANCE should be less than 300 ft)	-3.4
Total distance and path adjustments	-3.4	VdB	
Vibration Level at distance	**96.2**	VdB **1.639** mm/s r.m.s.	

Noise and Vibration Operations Report – Ontario Line and GO Lakeshore West Joint Corridor, February 2022, AECOM

Metrolinx

Noise and Vibration Operations Report

Ontario Line and GO Lakeshore West Joint Corridor

Prepared by:

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Date: February 2022

Project #: 60611173

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- represents AECOM’s professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
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Senior Environmental Planner

Executive Summary

ES.1 Ontario Line and GO Lakeshore West Joint Corridor Operations

Metrolinx, an agency of the Province of Ontario, is proceeding with the planning and development of four priority transit projects under the Transit Plan for the Greater Toronto Area (GTA), one of which is the Ontario Line, extending from Exhibition/Ontario Place to the Ontario Science Centre in the City of Toronto. AECOM Canada Limited (AECOM) was retained by Metrolinx and Infrastructure Ontario (IO) to complete this Joint Corridor Operational Noise and Vibration Impact Assessment Report for the portion of the proposed Ontario Line Project (the Project) which will operate in the GO Lakeshore West rail corridor between Dufferin Street and Strachan Avenue.

The Project is proposed to be a new approximately 16-kilometre subway line with connections to Line 1 (Yonge-University) subway service at Osgoode and Queen Stations, Line 2 (Bloor-Danforth) subway service at Pape Station, and Line 5 (Eglinton Crosstown) Light Rail Transit (LRT) service at the future Science Centre Station. Fifteen stations are proposed, with additional connections to three GO Transit lines (Lakeshore East, Lakeshore West and Stouffville), and the Queen, King, Bathurst, Spadina, Harbourfront and Gerrard/Carlton streetcar routes. The Project will reduce crowding on Line 1 and provide connections to new high-order rapid transit neighbourhoods.

The Project will be constructed in a dedicated right-of-way with a combination of elevated (i.e., above existing rail corridor/roadway), tunneled (i.e., underground), and at-grade (i.e., at grade with existing rail corridor/roadway) segments at various locations.

This Joint Corridor Operational Noise and Vibration Impact Assessment Report has been completed in accordance with Section 15 of *Ontario Regulation 341/20: Ontario Line Project* under the *Environmental Assessment Act.* Ontario Regulation 341/20 is a proponent-driven, self-assessment process that provides a defined framework for the proponent to follow. Ontario Regulation 341/20 includes provisions for consultation with the public, agencies and Indigenous communities in addition to Environmental Conditions, Early Works and Environmental Impact Assessment reporting requirements.

In addition to the planned Ontario Line, the Lakeshore West rail corridor is planned to be expanded as part of the regional GO Expansion program. The planned expansion includes alignment changes and additional train volumes.

For clarity, tracks not used by Ontario Line vehicles will be referred to as GO tracks in this report.

The purpose of this Report is to:

- Document the assessment of the combined noise impacts and the combined vibration impacts associated with both the operation of vehicles on the Ontario Line tracks and the operation of trains on the GO tracks within the Lakeshore West Joint Corridor; and,
- Provide noise and vibration mitigation recommendations to be developed and refined during detailed design.

This Report supports the Ontario Line Environmental Impact Assessment Report prepared in accordance with Ontario Regulation 341/20: Ontario Line Project.

A glossary of terminology is provided in **Appendix A**.

ES.2 Assessed Points of Reception

The Study Area encompasses the Lakeshore West rail corridor and surrounding noise and vibration sensitive areas. The west boundary of the Study Area is Dufferin Street. The east boundary of the Study Area is at the planned tunnel portal just west of Pirandello Street, located west of Strachan Avenue. In addition, based on United States (US) Federal Transit Administration (FTA) guidelines and direction from Metrolinx, noise and vibration was assessed up to 300 m from each side of the railway.

Assessed points of reception were selected to represent noise and vibration sensitive receptors within the Study Area. These assessed points of reception (PORs) are at the closest sensitive properties to the rail corridor within each sensitive land use area. Assessed PORs for both noise and vibration analysis are shown in **Figure 1**.

ES.3 Operational Noise Assessment

This Report documents the operational noise and vibration assessment of Ontario Line and GO trains within the Lakeshore West Joint Corridor. Impacts associated with Project construction are addressed under separate cover. Details of the noise assessment methods are provided in **Section 3**.

The noise impact from train operations was assessed using the noise assessment method presented in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (the FTA Guide; FTA 2018), with implementation in the Cadna/A acoustic software package. Noise models were prepared for both the existing and future "with project" scenarios. Noise impacts were evaluated with respect to the MOEE[1]/GO Transit *Draft Protocol for Noise and Vibration Assessment* (the MOEE/GO Protocol; MOEE/GO

[1] Now operating as the Ministry of the Environment, Conservation and Parks (MECP).

Transit, 1995) and the MOEE/TTC *Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop* (the MOEE/TTC Protocol; MOEE/TTC, 1993).

The results indicated that noise impacts from the Ontario Line and GO joint corridor are predicted to be below the threshold for noise mitigation investigation based on MOEE/GO and MOEE/TTC protocol criteria at every assessed receptor location.

ES.4 Operational Vibration Assessment

As noted above, this Report documents the operational noise and vibration assessment of Ontario Line and GO trains within the Lakeshore West Joint Corridor. Details of the vibration assessment methods are provided in **Section 4**.

Vibration levels were predicted at receptor locations selected to represent the most exposed or impacted within a sensitive area. Vibration levels have been predicted in accordance with the General Vibration Assessment procedures described in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (FTA, 2018). The vibration impacts from GO train operations were evaluated in accordance with the MOEE/GO Protocol, while the vibration impacts from the Ontario Line trains were evaluated in accordance with the MOEE/TTC protocol.

Vibration impacts from the future Ontario Line and GO train operations are predicted to be below the MOEE/GO or MOEE/TTC Protocol mitigation thresholds at every assessed receptor location.

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Appendices

1. Introduction

Metrolinx, an agency of the Province of Ontario, is proceeding with the planning and development of four priority transit projects under the Transit Plan for the Greater Toronto Area (GTA), one of which is the Ontario Line, extending from Exhibition/Ontario Place to the Ontario Science Centre in the City of Toronto. AECOM Canada Limited (AECOM) was retained by Metrolinx and Infrastructure Ontario (IO) to complete this Operational Noise and Vibration Impact Assessment Report for the portion of the proposed Ontario Line Project (the Project) which will operate in the GO Lakeshore West rail corridor between Dufferin Street and Strachan Avenue.

The Project will be a new approximately 16-kilometre subway line with connections to Line 1 (Yonge-University) subway service at Osgoode and Queen Stations, Line 2 (Bloor-Danforth) subway service at Pape Station, and Line 5 (Eglinton Crosstown) Light Rail Transit (LRT) service at the future Science Centre Station. Fifteen stations are proposed, with additional connections to three GO transit lines (Lakeshore East, Lakeshore West and Stouffville), and the Queen, King, Bathurst, Spadina, Harbourfront and Gerrard/Carlton streetcar routes. The Project will reduce crowding on Line 1 and provide connections to the new high-order rapid transit neighbourhoods.

The Project will be constructed in a dedicated right-of-way with a combination of elevated (i.e., above existing rail corridor/roadway), tunneled (i.e., underground), and at-grade (i.e., at grade with existing rail corridor/roadway) segments at various locations.

This Operational Noise and Vibration Impact Assessment Report has been completed in accordance with Section 15 of Ontario Regulation 341/20: Ontario Line Project under the *Environmental Assessment Act.* Ontario Regulation 341/20 is a proponent-driven, self-assessment process that provides a defined framework for the proponent to follow. Ontario Regulation 341/20 includes provisions for consultation with the public, agencies and Indigenous communities in addition to Environmental Conditions, Early Works and Environmental Impact Assessment reporting requirements.

In addition to the planned Ontario Line, the Lakeshore West rail corridor is planned to be expanded as part of the regional GO Expansion program. The planned expansion includes alignment changes and additional train volumes.

For clarity, tracks not used by Ontario Line vehicles will be referred to as GO tracks in this report.

The purpose of this report is to document the noise and vibration impact assessment of the proposed above ground operations of the Project and GO tracks within the GO Lakeshore West rail corridor segment between Dufferin Street and Strachan Avenue, in Toronto, Ontario. The relevant assessment guidelines, methodologies and assumptions are outlined in this report, along with predicted noise and vibration impacts and a discussion on requirements for mitigation.

A glossary of terminology is provided in **Appendix A**.

2. Study Area and Assessed Points of Reception

The operational noise and vibration assessment Study Area encompasses the Lakeshore West rail corridor and surrounding noise and vibration sensitive areas. The west boundary of the Study Area is at Dufferin Street. The east boundary of the Study Area is at the planned tunnel portal just west of Pirandello Street, located west of Strachan Avenue (see **Figure 1**). In addition, based on United States (US) Federal Transit Administration (FTA) guidelines and direction from Metrolinx, noise and vibration was assessed up to 300 m from each side of the railway.

The predominant land uses within the Study Area include:

- Residential;
- Mixed use areas; and
- General employment areas.

As defined in the MOEE/GO Transit Draft Protocol for Noise and Vibration Assessment, a sensitive land use is defined as a residential dwelling, a place where people ordinarily sleep, or a commercial/industrial operation that is exceptionally sensitive to noise or vibration.

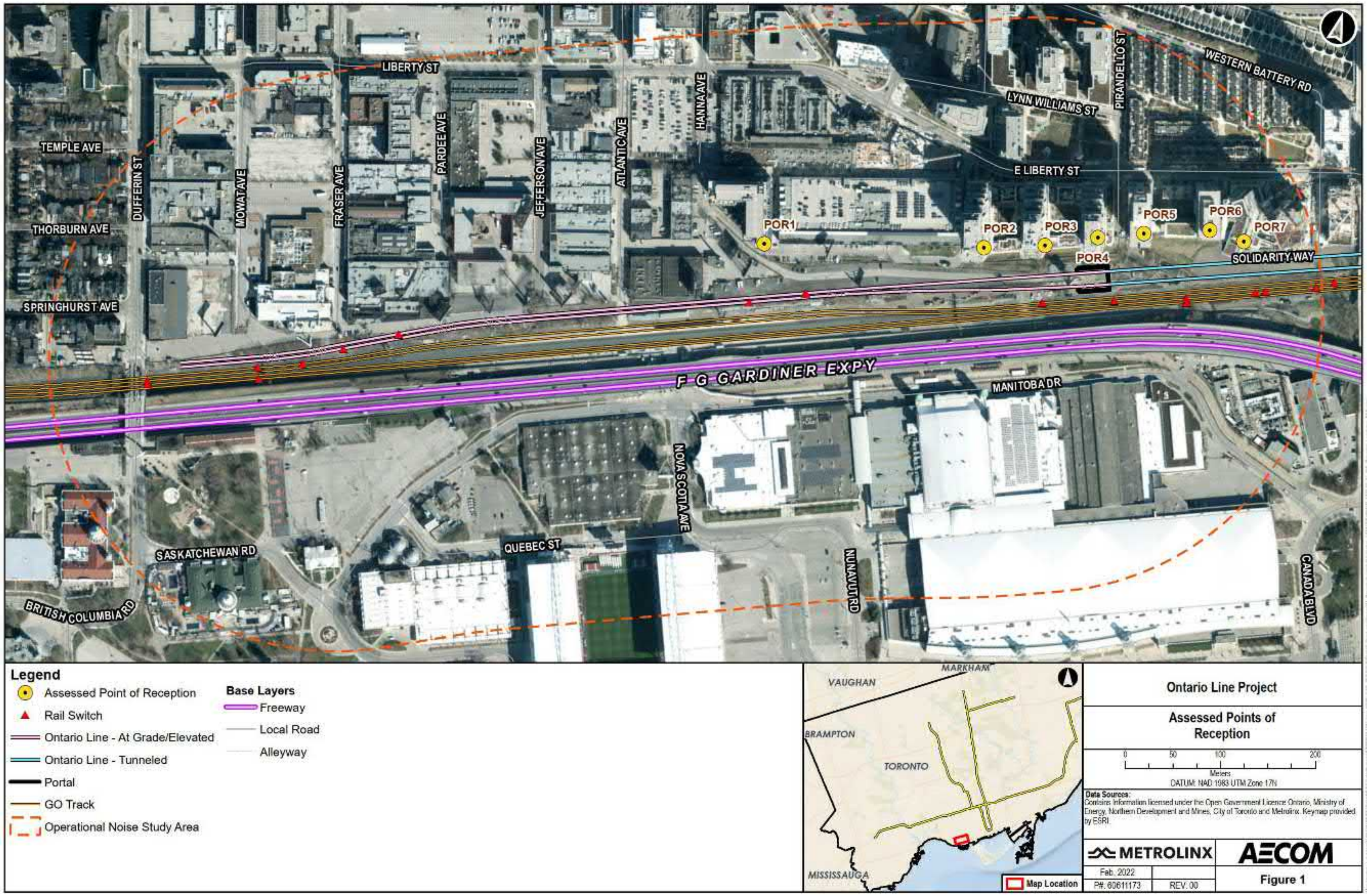
Within the Study Area, noise and vibration sensitive points of reception (PORs), or sensitive receptors, include residences, schools, worship spaces, hospitals and retirement homes. Sensitive receptors have been visually identified using aerial and street photography. Within each sensitive land use area (i.e., an area with several noise and/or vibration sensitive receptors in close proximity to each other), a sample receptor has been selected to represent the worst case receptor, which is the receptor in a given sensitive land use area that is typically in closest proximity to the project and with the highest expected project related noise and/or vibration levels. Planned and approved developments have also been considered by reviewing block plans and development applications available during the time of the assessment. **Table 2-1** below presents the representative PORs to be assessed, which are also presented in **Figure 1**.

Table 2-1: Representative Sensitive Points of Reception

Receptor ID	Location
POR1	#5 Hanna Avenue (Multi-storey residential building)
POR2	#85 East Liberty Street (Multi-storey residential building)

Receptor ID	Location
POR3	#75 East Liberty Street (Multi-storey residential building)
POR4	#65 East Liberty Street / #6 Pirandello Street (Multi-storey residential building)
POR5	#59 East Liberty Street (Multi-storey residential building)
POR6	#55 East Liberty Street (Multi-storey residential building)
POR7	#51 East Liberty Street (Multi-storey residential building)

Figure 1: Representative Sensitive Points of Reception



3. Operational Noise Assessment

3.1 Criteria

This operational noise assessment has been conducted using methods and criteria detailed in the following documents:

- The MOEE[2]/GO Transit Draft Protocol for Noise and Vibration Assessment
- The MOEE/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop

The MOEE/GO Transit *Draft Protocol for Noise and Vibration Assessment* (the MOEE/GO Protocol; MOEE/GO Transit, 1995) provides a framework for noise and vibration assessments of GO Transit rail projects. In accordance with the protocol, noise impacts are evaluated by comparing noise levels from without the project to noise levels with the completed project.

Noise levels without the project are taken to be the higher of the predicted existing ambient noise level, combined with the existing rail noise without the project, or 55 dBA $L_{eq,16hr}$ (daytime) / 50 dBA $L_{eq,8hr}$ (night time). These adjusted daytime and night-time without project levels are considered the "objective" levels for the project. The adjusted noise impact is determined based on the difference between the objective levels and the noise levels with the completed project. In accordance with the Protocol, the feasibility of operational noise mitigation measures is to be reviewed where the predicted noise impact of the project is 'significant' (equal to or greater than 5 dB).

The MOEE/TTC *Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop* (the MOEE/TTC Protocol; MOEE/TTC, 1993) sets criteria for noise that have been used for recent assessments of subway projects in Toronto. Similar to the MOEE/GO protocol, mitigation investigation is recommended where the predicted noise impact is equal to or greater than 5 dB based on noise levels with the project relative to the greater of 55 dBA $L_{eq,16hr}$ (daytime) / 50 dBA $L_{eq,8hr}$ (night time) limits, or the existing ambient noise. The MOEE/TTC Protocol sets an additional pass-by sound level (L_{passby}) criterion limit of 80 dBA for passing trains (applicable to the Ontario Line trains).

According to both the MOEE/GO Protocol and MOEE/TTC Protocol, mitigation measures shall be provided to mitigate noise impacts to as close to or lower than the

[2] Now operating as the Ministry of the Environment, Conservation and Parks (MECP).

objective levels as is technologically, economically and administratively feasible. Copies of the MOEE/GO and MOEE/GO TTC Protocols can be found in **Appendix B**.

A summary of both the MOEE/GO and MOEE/TTC protocol criteria is presented in **Table 3-1**.

Table 3-1: Noise Limits by Vehicle Type

Metric	GO Limits[3]	Ontario Line Limits
Daytime Noise Impact [$L_{eq,16hr}$] (16-hour, 7 a.m. to 11 p.m.)	5 dB relative to the higher of pre-project sound levels or 55 dBA	5 dB relative to the higher of pre-project sound levels or 55 dBA
Night-time Noise Impact [$L_{eq,8hr}$] (8-hour, 11 p.m. to 7 a.m.)	5 dB relative to the higher of pre-project sound levels or 50 dBA	5 dB relative to the higher of pre-project sound levels or 50 dBA
Subway vehicle L_{passby}	Not applicable to non-subway trains.	80 dBA

During the daytime, an outdoor location associated with a residence (labeled as OUT within this report), typically a back or front yard, is taken as the point of reception in the noise assessment. This outdoor assessment location is approximately 3 metres from the unit at a height of 1.5 metres.

During the night-time, the POR is taken at the building façade, which is a location intended to represent a possible bedroom window (labeled as plane of window [POW]). This is also the assessment location selected during the daytime in cases where no outdoor living areas exist, such as an apartment building with no outdoor amenity area. For POW receptors, receptor height is estimated using the number of storeys for the building (e.g. 1.5 metres for 1 storey, 4.5 metres for 2 storeys, and 7.5 metres for 3 storeys). For high-rise buildings, the height of the vertical midpoint of the storey with the highest expected noise levels was used.

For reference in the discussion of noise impacts throughout the report, **Table 3-2** presents the typical impact rating of a change in sound level per the MOEE/GO protocol.

[3] GO Limits noted apply to combination of GO, VIA and freight trains operating in rail corridor.

Table 3-2: Impact Rating of Changes in Sound Pressure Level

Impact Level [dB]	Impact Rating
0-2.99	Insignificant
3-4.99	Noticeable
5-9.99	Significant
10+	Very significant

3.2 Methods

In order to assess noise impacts from vehicle operations along the Ontario Line tracks as well as train operations along the GO tracks, the noise assessment method presented in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (the FTA Guide; FTA 2018) has been used, with implementation in the Cadna/A acoustic software package.

Noise models were prepared for both the existing scenario to predict existing conditions, and future “with project” scenario, which modelled both the noise contributions from the Ontario Line and the GO expansion. These noise models were built upon models provided by RWDI prepared for the 2017 GO Rail Network Electrification Transit Project Assessment Process (the Electrification TPAP) and the GO Expansion project currently under assessment.

Future train volumes for trains operating on GO and Ontario Line tracks are presented in **Appendix C**.

The existing scenario noise model incorporates the following assumptions and parameters:

- FTA reference sound level data for Lakeshore West GO, VIA, and freight trains;
- Existing track alignment geometry provided by Metrolinx;
- Existing train volumes as presented in the Electrification TPAP Report (RWDI, 2017);
- Ground elevation data as previously modelled for the Electrification TPAP;
- Railway sources with an assumed height of 0.3 metres above grade (in addition to source heights for trains), as applied for the Electrification TPAP;

- Building geometry was taken from the Electrification TPAP model or estimated;
- Local train services were assumed to operate on their respective outside northbound and southbound service tracks, while express train services were assumed to operate on the inside track as per the Electrification TPAP Report (RWDI, 2017);
- Non-revenue, VIA and freight trains were assumed to operate on the inside track, similar to express trains as per the Electrification TPAP Report (RWDI, 2017);
- Existing speeds and throttle settings have been based on the provided Electrification TPAP models and throttle profile charts from the Electrification TPAP Reports (RWDI, 2017);
- Noise from impacts at special trackwork (such as switches and crossovers) was accounted for by applying a 5 dB penalty for tracks connected to and within 300 feet of a crossover, per the FTA Guide (FTA, 2018);
- 16 hour day (7 AM to 11 PM) and 8 hour night (11 PM to 7 AM) time periods;
- Buildings modelled as reflective;
- Global ground absorption of 0.20, with a ground absorption of 0.66 in ballasted track or vegetated/grassed areas; and
- A maximum order of reflection of 2.

The future “with project” scenario noise model implements the additional GO Lakeshore West track, future GO alignment, and Ontario Line tracks and portal geometry. This model incorporates the following assumptions and parameters:

- FTA reference sound level data for Lakeshore West GO, VIA and freight trains. The reference level for future GO train diesel locomotives has been reduced by 3 dB, as new, quieter vehicles are planned for future use;
- Ontario Line train modelled as FTA rail car vehicle type with 80.4 dBA sound exposure level at 15 m, 80 m reference length, 80 km/h reference speed and source height of 0.6 m;
- A +3 dB adjustment is included for slab track at grade and a +5dB adjustment is included for elevated guideway sections.
- The new proposed track alignments and elevations for both the Ontario Line and GO tracks and Lakeshore West corridor provided by Metrolinx;
- Ontario Line service volumes provided by Metrolinx. Weekday data for the year 2077 was used in the noise model, for each track direction. Detailed train volume data can be found in **Appendix C**;
- Future GO track volumes provided by Metrolinx for the year 2037. Detailed train volume data can be found in **Appendix C**;
- Ontario Line trains assumed to operate at 75 km/h eastbound and 75.5 km/h westbound in the Exhibition to Bathurst segment as provided by Metrolinx;
- Future GO train speeds and throttle settings have been based on the provided GO model;

- Ground elevation data as previously modelled for the Electrification TPAP in combination with provided design elevation data for the Ontario Line and GO tracks;
- Idling train locations have been based on the provided GO model.
- GO railway sources assumed to have a height of 0.3 metres above grade (in addition to source heights for trains), as applied in the provided GO model;
- Building geometry was taken from the Electrification TPAP model or estimated;
- Local train services were assumed to operate on their respective outside northbound and southbound service tracks, while express train services assumed to operate on their respective inside northbound and southbound tracks as per the Electrification TPAP Report (RWDI, 2017);
- Non-revenue, VIA and freight train volumes were assumed to operate on their respective inside northbound and southbound tracks, similar to express trains as per the Electrification TPAP Report (RWDI, 2017);
- Idling reference sound power levels for electric and diesel trains were taken from the provided GO noise model. Idling noise was adjusted for the expected day and night train volumes on each track;
- Portal-radiated reverberant train noise from the tunnel portals was calculated in accordance with *Prediction of Sound radiated from Tunnel Openings', Wolfgang Probst, Noise Control Engineering Journal, Vol. 58, No.2, 2010*;
- Noise from impacts at special trackwork (such as switches and crossovers) was accounted for by applying a 5 dB penalty for tracks connected to and within 300 feet of a crossover, per the FTA Guide (FTA, 2018);
- 16 hour day (7 AM to 11 PM) and 8 hour night (11 PM to 7 AM) time periods;
- Buildings modelled as reflective;
- Global ground absorption of 0.2, with a ground absorption of 0.66 in ballasted track or vegetated/grassed areas; and
- A maximum order of reflection of 2.

3.3 Impact Assessment and Results

Table 3-3 outlines the predicted noise levels and impacts without any specific noise mitigation measures implemented and presents whether the greater noise contribution is from the Ontario Line or GO trains. Where impacts of 5 dB or more are predicted, mitigation investigation is required. The predicted noise levels and impacts have been plotted as noise contours in the figures presented in **Appendix D**.

As existing day and night-time noise levels are shown to be greater than the MOEE/GO and MOEE/TTC minimum limits of 55 dBA $L_{eq,16h}$ during the daytime and 50 dBA $L_{eq,8h}$ during the night time, the existing predicted day time and night time levels were adopted as the objective noise levels for the assessment at all locations.

As shown in **Table 3-3**, unmitigated noise impacts are predicted to be below the MOEE/GO and MOEE/TTC protocol criteria at every assessed receptor.

Table 3-3: Predicted Operational Noise Impacts

Receptor	Existing Conditions		Future – With Project		Objective Sound Level		Adjusted Noise Impact		Future – Ontario Line Contributions		Future – GO Train[4] Contributions		Greater Noise Contribution		L_{Passby} – Ontario Line [dBA]	Passby Exceedance [dB]	Mitigation Investigation Requirement [Y/N]
	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8hr}$) [dBA]	Day ($L_{eq,16hr}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day ($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day [dB]	Night [dB]	Day ($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day ($L_{eq,16h}$) [dBA]	Night ($L_{eq,8h}$) [dBA]	Day	Night			
OL_LSW_POR_POW01	65.3	61.0	65.8	61.6	65.3	61.0	0.5	0.6	61.5	55.9	63.8	60.3	GO	GO	75	0	N
OL_LSW_POR_POW02	66.9	62.5	68.8	64.8	66.9	62.5	1.9	2.3	59.5	53.4	68.2	64.5	GO	GO	73	0	N
OL_LSW_POR_POW03	67.5	63.4	69.2	65.4	67.5	63.4	1.7	2.0	57.6	52.1	68.9	65.2	GO	GO	72	0	N
OL_LSW_POR_POW04	68.4	64.1	69.6	65.4	68.4	64.1	1.2	1.3	58.9	51.2	69.2	65.2	GO	GO	71	0	N
OL_LSW_POR_POW05	68.6	64.3	68.9	64.7	68.6	64.3	0.3	0.4	53.2	45.0	68.8	64.6	GO	GO	68	0	N
OL_LSW_POR_POW06	69.8	65.5	69.3	64.5	69.8	65.5	-0.5 [5]	-1.0	54.4	48.6	69.2	64.4	GO	GO	68	0	N
OL_LSW_POR_POW07	69.3	65.7	68.4	64.0	69.3	65.7	-0.9	-1.7	52.1	46.6	68.3	63.9	GO	GO	65	0	N

[4] GO Train noise levels in table incorporate contributions from GO, VIA and freight services.
[5] Negative values indicate a predicted decrease in noise levels.

4. Operational Vibration Assessment

4.1 Criteria

As noted above, this Report documents the operational noise and vibration assessment of Ontario Line vehicles and GO trains within the Lakeshore West Joint Corridor. The assessment of vibration was completed under separate criteria for the GO and Ontario Line vehicles.

The vibration impacts from the Ontario Line trains were evaluated by comparing the predicted vibration levels following the completion of the Project at each identified receptor location in accordance with the MOEE/TTC protocol. The MOEE/TTC protocol is applicable for light commuter rail vehicles such as those associated with the Ontario Line Project. The feasibility of operational vibration mitigation measures is required to be investigated if the predicted RMS vibration velocity from the Ontario Line exceeds 0.1 mm/s at a receptor location.

The vibration impacts from GO vehicle operations were evaluated by comparing the predicted vibration levels with the completed project and without the project (i.e., existing) at each identified receptor location in accordance with the MOEE/GO Protocol. The MOEE/GO Protocol is applicable to heavy rail vehicles such as VIA and GO trains. The feasibility of operational vibration mitigation measures is required to be investigated where the predicted impact is 25% or more above the existing RMS vibration level or 0.14 mm/s RMS vibration velocity during a train pass-by, whichever is higher.

A summary of both the MOEE/GO and MOEE/TTC protocol criteria is presented in **Table 4-1**.

Table 4-1: Vibration Protocol Criteria

Metric	GO Train Limits[6]	Ontario Line Vehicle Limits
RMS Vibration Velocity	Increase of 25% above the higher of existing vibration levels, or 0.14 mm/s.	0.1 mm/s

[6] GO Train Limits noted apply to GO, VIA and freight trains operating in rail corridor.

4.2 Methods

As with the noise assessment, vibration levels were predicted at receptor locations selected to represent the most exposed or impacted within a sensitive area. Vibration sensitive receptors are located in the same position as POW receptors established for the noise assessment but at ground level. Vibration levels have been predicted in accordance with the General Vibration Assessment procedures described in the US FTA *Transit Noise and Vibration Impact Assessment Manual* (FTA, 2018).

Predicted vibration levels in accordance with the US FTA methods are based on reference vibration curves derived from measurements of ground-borne vibration at representative North American transit systems. The FTA method includes various adjustments such as train speed, distance from tracks based on the existing and proposed track alignments, special track work (e.g., crossovers or switches) and elevated transit structures (bridges and elevated guideways).

For vibration calculations, Ontario Line train speeds have been set to 76 km/h throughout. For the GO operations, train speeds have been set to the track speed limit of 145 km/h. This represents a predictable worst-case pass-by scenario for trains operating on both sets of tracks.

4.3 Impact Assessment and Results

Table 4-2 outlines the predicted RMS vibration velocity levels from the existing and future operations on the Lakeshore West rail corridor. Where vibration levels were predicted to exceed either the applicable MOEE/GO or MOEE/TTC Protocol vibration criteria, the required vibration reduction has been presented.

As shown in **Table 4-2** vibration mitigation investigation is predicted to not be required at all assessed receptor locations.

Table 4-2: Vibration Assessment Results and Required Vibration Reduction

Receptor ID	Predicted RMS Velocity (mm/s)			Objective (RMSV, mm/s)		% Above Objective [GO][1]	Mitigation Investigation Requirement (Y/N)		Vibration Reduction Required (dB)	
	Existing GO	Future GO	Future OL	Future GO	Future OL		GO	OL	GO	OL
OL_LSW_POR_POW01	0.09	0.13	0.05	0.14	0.1	-7%	N	N	0	0
OL_LSW_POR_POW02	0.16	0.16	0.05	0.16	0.1	1%	N	N	0	0
OL_LSW_POR_POW03	0.29	0.29	0.05	0.29	0.1	1%	N	N	0	0
OL_LSW_POR_POW04	0.17	0.17	0.05	0.17	0.1	2%	N	N	0	0

Note:

1. Negative predicted vibration impact occurs when the planned future track alignment is further from the most affected receptor or future vibration level is below the lower level limit.

5. Summary and Conclusions

Potential impacts of the noise and vibration associated with the operation of the Ontario Line and GO Lakeshore West Joint Corridor have been assessed. Noise and vibration impacts are predicted to be well below the thresholds for mitigation investigation at all assessed points of reception. No further noise and vibration assessments for the planned train operations in this segment of joint corridor are anticipated to be required.

6. References

United States Federal Transit Administration, 2018:
Transit Noise and Vibration Impact Assessment Manual (FTA Report No. 0123).

Ministry of the Environment and Energy (MOEE) and GO Transit, 1995:
MOEE/GO Transit Draft Noise and Vibration Protocol.

Ministry of the Environment and Energy (MOEE) and Toronto Transit Commission (TTC), 1993:
MOEE/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop.

RWDI, 2017:
GO Rail Network Electrification TPAP – Final Noise/Vibration Impact Assessment Report – Lakeshore West Rail Corridor.

Appendix A

Glossary

Appendix A. Terminology

Term	Definition
Sound	Pressure wave travelling through a medium, such as air.
Noise	Unwanted sound.
Acoustics	The science of sound propagation and transmission.
Vibration	Oscillation of a parameter that defines the motion of a mechanical system.
Decibel, dB	A logarithmic ratio, not strictly a unit, used to describe sound levels. For sound pressure, the reference level is 20 micro pascals (threshold of hearing).
Frequency	The rate at which an event is repeated. Measured in Hertz (Hz), where 1 Hz = 1 oscillation/sec. Normal human hearing extends over a range of frequencies from about 20 Hz to about 20 kHz.
Octave Band	A band of frequencies where the upper limiting frequency is twice the lower limiting frequency. Octave bands are identified by their centre-frequencies. The octave bands standardized for acoustic measurements include those centred at 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.
A-Weighting Network, dBA	A frequency weighting network intended to represent the variation in the ear's ability to hear different frequencies. Overall sound levels calculated or measured using the A-weighting network are indicated by dBA rather than dB.
Sound Pressure Level (SPL, L_p)	A measurement of instantaneous sound pressure and equal to 10 times the logarithm (base 10) of the ratio of the instantaneous sound pressure of a sound divided by the reference sound pressure of 20 μPa (0 dB). Reported and measured in decibels (dB or dBA).
L_{eq} - "Equivalent sound level"	Value of a constant sound pressure level which would result in the same total sound energy as would the measured time-varying sound pressure level over equivalent time duration. The $L_{eq, 1hr}$, for example, describes the equivalent continuous sound level over a 1-hour period.
Peak Particle Velocity (PPV)	The peak signal value of an oscillating vibration velocity waveform. Can be expressed in mm/s.
Root Mean Square Velocity (RMSV)	The square root of the mean-square value of an oscillating vibration velocity waveform, where the mean-square value is obtained by squaring the value of amplitudes at each instant in time and then averaging these values over the sample time.
Vibration Decibel, VdB	A logarithmic ratio, not strictly a unit, used to describe felt vibration.

Appendix B

Noise and Vibration Protocols

MOEE / GO TRANSIT
DRAFT PROTOCOL FOR NOISE AND VIBRATION ASSESSMENT

1.0 PURPOSE

GO Transit and the Ministry of Environment and Energy (MOEE) recognize that commuter rail transit facilities produce noise and vibration which may affect neighbouring properties. This document identifies the framework within which criteria will be used to assess noise and vibration from proposed GO Transit rail projects. The framework in this document is to be applied for planning purposes in order to address the requirements of the Environmental Assessment Act and is to be utilized during implementation of the project.

The purpose of this document can be summarized by the following:

- assist GO Transit in the preparation of Environmental Assessments;
- streamline the MOEE's noise impact review of Environmental Assessments; and
- make available to the public a consistent approach for Environmental Assessments.

This Protocol does not apply to existing GO Transit operations, nor does it apply to projects undertaken by other non-GO Transit rail operators.

2.0 SCOPE

- Establish noise and vibration objectives for GO Transit rail projects.
- Establish methods of assessment - measurement and prediction.
- Enable the comparison of alternatives.
- Establish the framework for the assessment of mitigation where impacts are identified.

3.0 DEFINITIONS

Adjusted Noise Impact:

Noise impact is the incremental increase in the pre-project equivalent sound level resulting from the introduction of a GO Transit project. The Adjusted

Noise Impact is calculated by adjusting the value of the noise impact to indicate greater impact at higher pre-project sound levels.

Ambient Noise (Ambient Sound Level):

The ambient noise (ambient sound level) is the sound existing at a point of reception in the absence of all noise from the GO Transit rail project. In this Protocol, the ambient is taken to be the noise from road traffic and existing industry. The ambient specifically excludes transient noise from aircraft and railways.

Day-time Equivalent Sound Level:

$L_{eq,16}$ is the day-time equivalent sound level. The definition of equivalent sound level is given in Reference 2. The applicable time period is from 07:00 to 23:00 hours.

GO Transit Rail Project:

GO Transit rail project means a project to add or expand rail service and/or a layover site that requires approval under the Environmental Assessment Act be obtained by carrying out an environmental assessment.

Layover Site:

Layover site means a GO Transit facility dedicated to overnight storage of GO trains.

Night-time Equivalent Sound Level:

$L_{eq,8}$ is the night-time equivalent sound level. The definition of equivalent sound level is given in Reference 2. The applicable time period is from 23:00 to 07:00 hours.

Point of Reception:

<u>Day-time:</u> 07:00 to 23:00 hours

Day-time point of reception is any outdoor location on the property of a sensitive land use where sound originating from the Project is received and which is no less than 15m from the nearest track's centre line. For at-grade sensitive land uses, e.g., low density residential development, this point is normally 3m from the unit in the front or back yard whichever is most exposed to the noise source at a height of 1.5m. For residential uses such as apartment units, this is normally the plane of the apartment bedroom or living room window.

Nighttime: 23:00 to 07:00 hours

Night-time point of reception is the plane of a bedroom window where sound originating from the Project is received and which is no less than 15m from the nearest track's centre line. At the planning stage, this is usually assessed at the nearest facade.

Point of Vibration Assessment:

Point of Vibration Assessment is the location 5m to 10m away from the building foundation in a direction parallel to the tracks or adjusted as required to accommodate site conditions.

Rail Service:

Rail Service means the operation of GO trains along transit corridors (including GO Transit commuter stations) and access routes between GO facilities and these corridors. Layover sites are not part of the Rail Service and are therefore assessed separately.

Sensitive Land Use:

Sensitive land use means a residential dwelling or place where people ordinarily sleep or a commercial/industrial operation that is exceptionally sensitive to noise or vibration. Noise and vibration impacts will be assessed for lands which have been committed for sensitive land uses. Committed uses include uses such as: existing development, approved site plans, approved condominium plans or draft approved plans of subdivision.

Vibration Velocity:

Vibration shall be assessed using the running average RMS (Root-Mean-Square) vibration velocity (mm/sec).

4.0 NOISE

4.1 Rail Service

For the purposes of assessment, rail service is considered to include the operation of trains on the rail line and the operation of trains inside commuter stations. Idling of trains inside commuter stations is considered part of the operation. Noise produced by layover sites is not considered part of the rail service and is assessed separately, see Section 4.2.

4.1.1 Objective

The desirable objective is that the day-time (16 hour) L_{eq} produced by the rail service operation of the GO Transit project does not exceed the higher of the ambient sound level, combined with the sound level from existing rail activity, or 55 dB L_{eq}. Furthermore, that the night-time (8 hour) L_{eq} produced by the rail service operation of the GO Transit project does not exceed the higher of the ambient sound level, combined with the sound level from existing rail service, or 50 dB L_{eq}.

4.1.2 Impact Assessment Method

The noise impact of GO Transit rail projects shall be assessed using prediction methods acceptable to the MOEE (see Reference 1). The noise impact from rail service shall be assessed on a 16 hour (day-time) basis using L_{eq},16, and 8 hour (night-time) basis using L_{eq},8. The impact assessment method should base its assessment on future GO Transit train volume projections, from the commencement of operations to a maximum of twenty years (typical GO Transit planning horizon).

4.1.3 Impact Assessment Criteria

The impact at a point of reception shall be expressed in terms of the Adjusted Noise Impact. The Adjusted Noise Impact shall be based on the difference between:

- pre-project noise, which is the combination of the ambient noise and the rail noise; and
- post-project noise, which is the combination of the ambient noise and the post-project rail noise.

Where the pre-project noise is less than 55 dB L_{eq} during the daytime or 50 dB L_{eq} during the nighttime, the pre-project noise shall be taken as 55 dB L_{eq} daytime or 50 dB L_{eq} nighttime.

The impact shall be rated with respect to the objectives as follows:

Adjusted Impact Level	Impact Rating
0-2.99 dB	Insignificant
3-4.99 dB	Noticeable
5-9.99 dB	Significant
10 +dB	Very Significant

Where a GO Transit rail project may produce road traffic noise impact, these noise impacts shall be assessed in accordance with the methods approved for the Environmental Assessment of roadway projects, e.g., Class EA.

4.1.4 Mitigation

When a 'significant or greater' impact is predicted, the potential to mitigate will be evaluated based on administrative, operational, economic and technical feasibility. If deemed feasible, the mitigation measures shall ensure that the predicted sound level from the GO Transit rail project is as close to, or lower than, the rail service objective.

4.2 Layover Sites

For the purposes of assessment, a layover is considered to include the idling of trains in an area off the mainline track that is designated for such use. Due to operational constraints, GO Transit will usually generate layover alternatives that closely parallel mainline tracks.

4.2.1 Objective

The desirable objective is that the L_{eq} in any hour produced by the operation of the layover site does not exceed the higher of the ambient sound level, including the sound level from existing industry, or 55 dB L_{eq}.

4.2.2 Impact Assessment Method

The noise impact of GO Transit layover sites should be evaluated on a case-by-case basis , by predicting the one hour L_{eq} at a point of reception, using prediction methods acceptable to the MOEE. The noise impact assessment should incorporate all noise sources associated with the layover operation.

4.2.3 Impact Assessment Criteria

For the purposes of site selection, the noise impact shall be assessed utilizing the rating method of Section 4.1.3, with the exception that the minimum pre-project L_{eq} shall be 45 dB L_{eq}.

4.2.4 Mitigation

When a 'noticeable or greater' impact is predicted, the potential to mitigate will initially be evaluated based on administrative, operational, economic and technical feasibility. In addition, the feasibility shall consider the effectiveness of mitigation with respect to site specific conditions and other sources of noise not included in the original impact assessment. If deemed feasible, the mitigation measures shall ensure that the predicted sound level from the GO Transit rail project is as close to, or lower than, the layover objective.

4.3 Construction

Noise and vibration impacts from the construction of a project shall be examined. For the purposes of impact assessment and identifying the need for mitigation, the guidelines in Reference 5 apply.

5.0 VIBRATION

The assessment of ground-borne vibration shall be confined to that produced by the operation on the line and shall exclude vibration due to maintenance and/or construction activities.

5.1 Objective

The desirable objective is that the vibration velocity produced by the GO Transit project does not exceed 0.14 mm/s at a point of vibration assessment. Where the vibration from existing operation exceeds 0.14 mm/s, the desirable objective is to not exceed the existing vibration level.

5.2 Assessment Method

The vibration impact of a GO Transit rail project shall be assessed using field measurements of vibration velocities. Where applicable, the assessment shall include vibration generated by non-GO Transit rail traffic.

5.3 Impact Assessment Criteria

The impact at a point of vibration assessment will fall into one of the following categories:

- existing and future vibration velocity remains less than 0.14 mm/s ;
- existing vibration velocity is less than 0.14 mm/s, future vibration is expected to exceed 0.14 mm/s;
- existing vibration velocity is greater than 0.14 mm/s, future vibration is not expected to exceed this value; and
- existing vibration is greater than 0.14 mm/sec, future vibration is expected to exceed this figure.

GO Transit will not increase vibration velocity to a level that will cause structural damage.

5.4 Mitigation

When the vibration velocity at a point of vibration assessment exceeds the objective by 25%, the requirement to mitigate will be evaluated based on administrative, operational, economic and technical feasibility.

6.0 REFERENCES

[1] STEAM, Sound from Trains Environmental Analysis Method, Ontario Ministry of the Environment, ISBN 0-7729-6376-2 (1990).

[2] NPC-101 - Technical Definitions, part of Reference 5.

[3] NPC-102 - Instrumentation, part of Reference 5.

[4] NPC-103 - Procedures, part of Reference 5.

[5] Model Municipal Noise Control By-law, Final Report, August 1978, Ontario Ministry of the Environment.

[6] Noise Control Guideline for Class Environmental Undertakings, February 1980, Ontario Ministry of the Environment.

MOEE/TTC
PROTOCOL FOR NOISE AND VIBRATION ASSESSMENT FOR THE PROPOSED YONGE-SPADINA SUBWAY LOOP

JUNE 16, 1993

TABLE OF CONTENTS

RCEP Profile #1411

PROTOCOL FOR NOISE AND VIBRATION ASSESSMENT

PART A. PURPOSE

The Toronto Transit Commission (TTC) and the Ministry of the Environment and Energy (MOEE) recognize that transit facilities produce noise and vibration which may affect neighbouring properties within urbanized areas. This document identifies the framework within which criteria will be applied for limiting wayside air-borne noise, ground-borne noise and vibration from the TTC's proposed Yonge-Spadina Subway Loop Line (the "Line"). The framework presented in this document is to be applied for planning purposes in order to address the requirements of the Environmental Assessment Act and is to be utilized during implementation of the Line.

The passby sound levels and vibration velocities in this protocol have been developed specifically for the Line and this protocol is not to be applied retroactively to existing TTC transit lines, routes or facilities nor to transit authorities other than TTC. Further, the criteria specified for this project are not precedent setting for future projects.

Prediction and measurement methods are being developed by the TTC. This will be done in consultation with MOEE and the Ministry of Transportation (MTO). Studies pertaining to noise and vibration levels are also being conducted by TTC. Upon completion of these studies, the TTC may revisit the assessment criteria and methods in this protocol to modify them as required in consultation with MOEE and the Ministry of Transportation (MTO).

PART B. GENERAL

During design of the Line, predicted wayside sound levels and vibration velocities are to be compared to criteria given in this protocol. This will permit an impact assessment and help determine the type or extent of mitigation measures to reduce that impact. Sound levels and vibration velocities will be predicted from sound levels and velocities of TTC's existing rail technologies.

The criteria presented in this document are based on good operating conditions and the impact assessment assumes this condition. Good operating conditions exist when well maintained vehicles operate on well maintained continuous welded rail without significant rail corrugation. It is recognised that wheel flats or rail corrugations will inevitably occur and will temporarily increase sound and vibration levels until they are corrected. Levels in this protocol do not reflect these occasional events, nor do they apply to maintenance activities on the Line. TTC recognizes that wheel rail squeal is a potential source of noise which may pose a concern to the community. TTC is investigating and will continue to investigate measures to mitigate wheel rail squeal and will endeavour to mitigate this noise source. TTC endeavours to minimize the noise and vibration impacts associated with its transit operations and is committed to providing good operating conditions to the extent technologically, economically and administratively feasible.

It is recognised that levels of sound and vibration at special trackwork, such as at crossovers and turnouts, are inevitably higher than along tangent track. Also, there is a limit to the degree of mitigation that is feasible at special trackwork areas. This is to be taken into account in predicting sound and vibration levels near these features and in applying the levels in this protocol. Special trackwork, such as at crossovers and turnouts, is encompassed within the framework of this document.

This protocol applies to existing and proposed residential development having municipal approval on the date of this protocol. The protocol also applies to existing and municipally approved proposed nursing homes, group homes, hospitals and other such institutional land uses where people reside. This protocol does not apply to commercial and industrial land uses.

This protocol does not apply closer than 15 m to the centreline of the nearest track. Any such cases shall be assessed on a case by case basis.

Part D of this document deals with air-borne noise from the Line and its construction. Part E deals with ground-borne noise and vibration from the Line.

PART C. DEFINITIONS

The following definitions apply to both parts D and E of this document.

Ancillary Facilities:

Subsidiary locations associated with either the housing of personnel or equipment engaged in TTC activities or associated with mainline revenue operations. Examples of ancillary facilities include, but are not limited to, subway stations, bus terminals, emergency services buildings, fans, fan and vent shafts, substations, mechanical equipment plants, maintenance and storage facilities, and vehicle storage and maintenance facilities.

Passby Time Interval:

The passby time interval of a vehicle or train is given by its total length and its speed. The start of the pass-by is defined as that point in time when the leading wheels pass a reference point. The end of the pass-by is defined as that point in time when the last wheels of the vehicle or train pass the same reference point. The reference point is to be chosen to give the highest level at the point of reception or point of assessment, i.e. usually at the point of closest approach. From a signal processing perspective, the passby time interval will be defined in the prediction and measurement methods being developed.

PART D. AIR-BORNE NOISE

1.0 DEFINITIONS

The following definitions are to be used only within the context of Part D of this document.

Ambient:

The ambient is the sound existing at the point of reception in the absence of all noise from the Line. In this protocol the ambient is taken to be the noise from road traffic and existing industry. The ambient specifically excludes transient noise from aircraft and railways, except for pre-existing TTC rail operations.

Daytime Equivalent Sound Level:

$L_{eq,15h}$ is the daytime equivalent sound level. The definition of equivalent sound level is provided in Reference 2. The applicable time period is from 07:00 to 23:00 hours.

Nighttime Equivalent Sound Level:

$L_{eq,8h}$ is the nighttime equivalent sound level. The applicable time period is from 23:00 to 07:00 hours.

Point of Reception:

Daytime: 07:00 - 23:00 hours

Any outdoor point on residential property, 15 m or more from the nearest track's centreline, where sound originating from the Line is received.

Nighttime: 23:00 - 07:00 hours

The plane of any bedroom window, 15 m or more from the nearest track's centreline, where sound originating from the Line is received. At the planning stage, this is usually assessed at the nearest facade of the premises.

Passby Sound Level, L_{passby} :

Within the context of this document, the passby sound level is defined as the A-weighted equivalent sound level, L_{eq} [Reference 2] over the passby time interval.

2.0 RAIL TRANSIT

In the assessment of noise impact, rail transit is considered to include the movement of trains between stations, the movement and idling of trains inside stations as well as the movement of trains between the mainline and ancillary facilities. Ancillary facilities are not considered part of the rail transit and are assessed as stationary sources. Trains idling in maintenance yards and storage facilities are part of the stationary source.

The assessment of noise impact resulting from Line is to be performed in terms of the following sound level descriptors:

1) Daytime equivalent sound level, $L_{eq,16h}$,
2) Nighttime equivalent sound level, $L_{eq,8h}$,
3) Passby Sound Level, L_{passby}.

The predicted daytime and nighttime equivalent sound levels include the effects of both passby sound level and frequency of operation and are used to assess the noise impact of the Line. The Passby Sound Level criterion is used to assess the sound levels received during a single train passby. The criteria and methods to be used are discussed in Sections 2.1 and 2.2.

2.1 Criteria

Noise impact shall be predicted and assessed during design of the Line using the following sound level criteria:

DAYTIME EQUIVALENT SOUND LEVEL:

The limit at a point of reception for the predicted daytime equivalent sound levels for rail transit operating alone (excluding contributions from the ambient) is 55 dBA or the ambient $L_{eq,16h}$, whichever is higher.

NIGHTTIME EQUIVALENT SOUND LEVEL:

The limit at a point of reception for the predicted nighttime equivalent sound levels for rail transit operating alone (excluding contributions from the ambient) is 50 dBA or the ambient $L_{eq,8h}$, whichever is higher.

PASSBY SOUND LEVEL:

The limit at a point of reception for predicted L_{passby} for a single train operating alone and excluding contributions from other sources is 80 dBA. This limit is based on vehicles operating on tangent track. It does not apply within 100m of special trackwork and excludes wheel rail squeal.

Mitigating measures will be incorporated in the design of the Line when predictions show that any of the above limits are exceeded by more than 5 dB. All mitigating measures shall ensure that the predicted sound levels are as close to, or lower than, the respective limits as is technologically, economically, and administratively feasible.

2.2 Prediction

In most cases, a reasonable estimate of the ambient sound level can be made using a road traffic noise prediction method such as that described in Reference 9, and the minimum sound levels in Table 106-2 of Reference 6. Prediction of road traffic L_{eq} is preferred to individual measurements in establishing the ambient. Prediction techniques for the L_{eq} from road traffic and the L_{eq} or L_{passby} from transit shall be compatible with one another. Any impact assessment following this protocol shall include a description of the prediction method and the assumptions and sound level data inherent in it. Prediction and measurement methods compatible with MOEE guidelines and procedures are being developed by the TTC at the date of this protocol in consultation with MTO and MOEE.

3.0 ANCILLARY FACILITIES

Predicted noise impacts from ancillary facilities shall be assessed during the design of the Line in accordance with the stationary source guidelines detailed in Reference 5. The predictions used shall be compatible with and at least as accurate as CSA Standard Z107.55.

4.0 BUSES IN MIXED TRAFFIC

Where buses are part of the road traffic there are no additional criteria requirements beyond those presented in the Ministry of Transportation of Ontario Protocol for dealing with noise concerns during the preparation, review and evaluation of Provincial Highways Environmental Assessments (Reference 1). Buses should be considered as medium trucks in the traffic noise prediction models.

5.0 CONSTRUCTION

Noise impacts from the construction of the Line are to be examined. For the purposes of impact assessment and identifying the need for mitigation, the Ministry of the Environment and Energy guidelines for construction presented in Reference 7 are to be referred to.

PART E. GROUND-BORNE VIBRATION

The assessment of ground-borne vibration impact is confined to the vibration that is produced by the operation of the Line and excludes vibration due to maintenance activities.

In recognition of the fact that the actual vibration response of a building is affected by its own structural characteristics, this document deals with the assessment of ground-borne vibration only on the outside premises. Structural characteristics of buildings are beyond the scope of this protocol and beyond the control of the TTC.

It is recognised that ground-borne vibration can produce air-borne noise inside a structure and there is a direct correlation between the two. The TTC can only control ground-borne noise by controlling ground-borne vibration. Accordingly, ground-borne noise will be predicted and assessed in terms of vibration measured at a point of assessment using the limit in Section 2.0, Vibration Assessment.

1.0 DEFINITIONS

The following definitions are to be used only within the context of Part E of this document.

Point of Assessment:

A point of assessment is any outdoor point on residential property, 15 m or more from the nearest track's centreline, where vibration originating from the Line is received.

Vibration Velocity:

Vibration Velocity is the root-mean-square (rms) vibration velocity assessed during a train pass-by. The unit of measure is metres per second (m/s) or millimetres per second (mm/s). For the purposes of this protocol only vertical vibration is assessed. The vertical component of transit vibration is usually higher than the horizontal. Human sensitivity to horizontal vibration at the frequencies of interest is significantly less than the sensitivity to vertical vibration.

2.0 VIBRATION ASSESSMENT

Vibration velocities at points of assessment shall be predicted during design of the Line. If the predicted rms vertical vibration velocity from the Line exceeds 0.1 mm/sec, mitigation methods shall be applied during the detailed design to meet this criterion to the extent technologically, economically, and administratively feasible. Where it is suitable, a double tie system or its equivalent will be the mitigation method of choice. This is a state of the art vibration isolation system developed by TTC and used where vibration isolation is required on new underground lines (see Reference 8).

Any impact assessment following this protocol shall include a description of the prediction method and the assumptions and data inherent in it. Prediction and measurement methods are being developed by the TTC at the date of this protocol in cooperation with MTO and MOEE.

References

1)**A Protocol for Dealing With Noise Concerns During the Preparation, Review and Evaluation of Provincial Highways Environmental Assessments**, Ministry of Transportation, February 1986.

2)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-101 Technical Definitions**, Ministry of the Environment, August 1978.

3)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-103 Procedures**, Ministry of the Environment, August 1978.

4)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-104 Sound Level Adjustments**, Ministry of the Environment, August 1978.

5)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-105 Stationary Sources**, Ministry of the Environment, August 1978.

6)**Model Municipal Noise Control By-Law, Final Report, Publication NPC-106 Sound Levels of Road Traffic**, Ministry of the Environment, August 1978.

7)**Noise Control Guideline For Class Environmental Assessment of Undertakings**, February 1980, Ministry of the Environment.

8)**Toronto Subway System Track Vibration Isolation System (Double Tie) - Technical Report**, TTC Engineering Department, June 1982.

9)**STAMSON 4.1**, Ontario Ministry of the Environment Road and Rail Noise Prediction Software

Appendix C

Future Ontario Line and GO Track Volumes

Forecast OL train volumes provided by Metrolinx

Name of Period	**Period**		**Trains per Hour**	**No. Hours per Period**	**No. Trains per Period**
	Start	**End**			
Weekday 1	6:00	7:00	18	1	18
Weekday 2	7:00	10:00	40	3	120
Weekday 3	10:00	15:00	24	5	120
Weekday 4	15:00	19:00	40	4	160
Weekday 5	19:00	22:00	24	3	72
Weekday 6	22:00	0:00	24	2	48
Weekday 7	0:00	1:30	18	1.5	27
			TOTAL		565
			Day	**07:00 to 23:00**	**496**
			Night	**23:00 to 07:00**	**69**

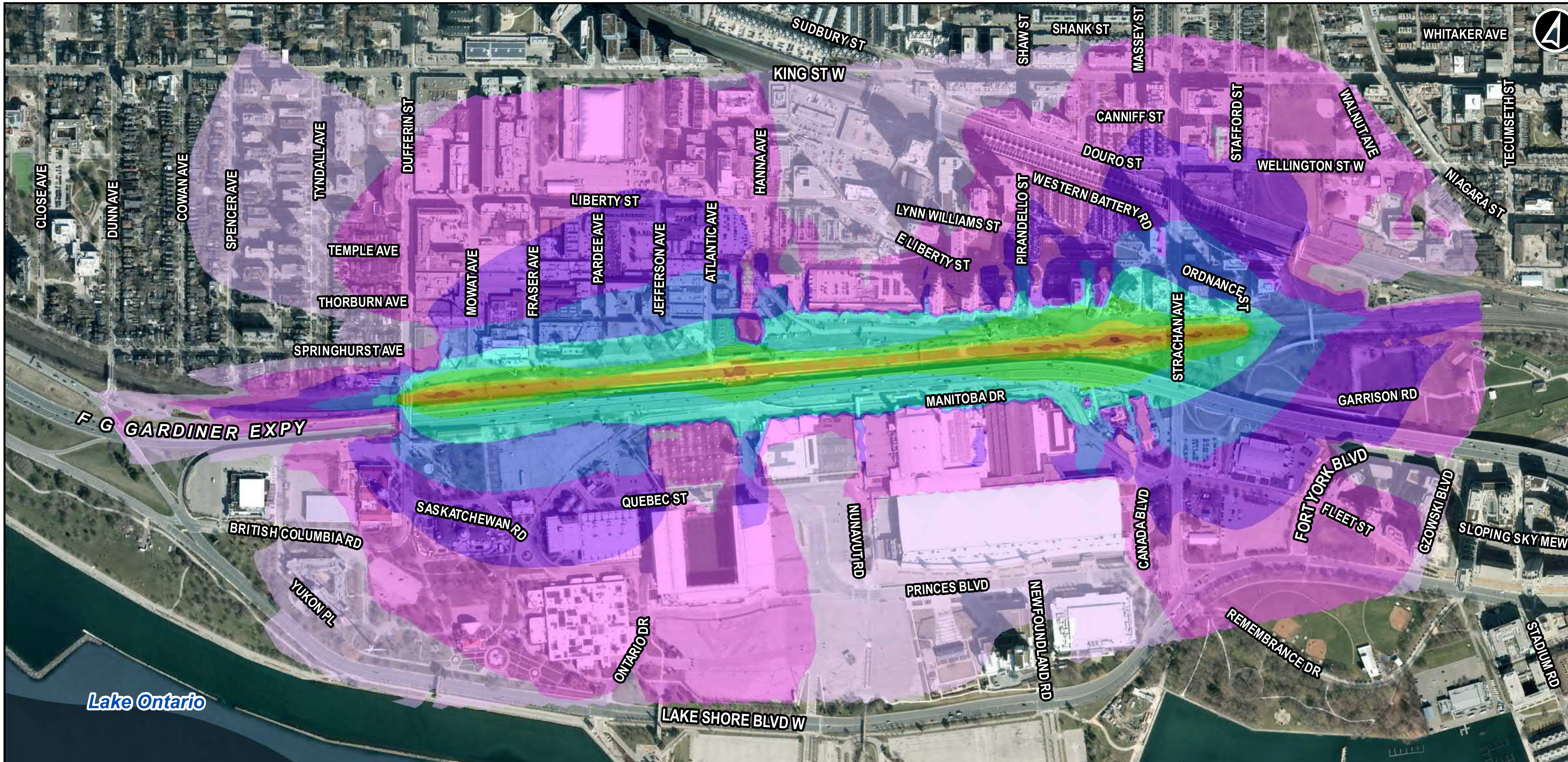
LSW GO Tracks

	Exhibition Station to Union Station - Combined Table							
	Track 1 (Local)		Track 2 (Express)		Track 3 (Express)		Track 4 (Local)	
	Day	Night	Day	Night	Day	Night	Day	Night
D1L6 (rev and non rev)	6	-	37	6	35	6	5	-
D2L12 (rev and non rev)	-	-	11	-	12	5	-	-
E1L6 (rev and non rev)	42	10	3	2	4	1	51	5
E2L12 (rev and non rev)	23	3	7	2	7	2	16	8
Freight	-	-	-	-	1	-	-	-
VIA	-	-	14	4	20	6	-	-

Station	Route	D1L6		D2L12		E1L6		E2L12	
		Day	Night	Day	Night	Day	Night	Day	Night
REVENUE									
Exhibition to Union	GO Eastbound Revenue Local	5	-	-	-	51	5	16	8
	GO Eastbound Revenue Express 1	-	-	-	-	1	-	1	1
	GO Eastbound Revenue Express 2	32	6	1	5	1	-	1	-
	GO Westbound Revenue Local	6	-	-	-	42	10	23	3
	GO Westbound Revenue Express 1	-	-	-	-	1	1	2	1
	GO Westbound Revenue Express 2	33	5	6	-	-	-	-	-

Appendix D

Noise Contour Figures



Legend

Existing - Day (dBA)

- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.

Ontario Line Project

Ontario Line - Lakeshore Segment West - Existing Day-time Noise Contours - 1.5m Height

0 0.25 0.5
Kilometers
DATUM: NAD 1983 UTM Zone 17N

Data Sources:
Contains Information licensed under the Open Government Licence Ontario, Ministry of Energy, Northern Development and Mines, City of Toronto and Metrolinx. Keymap provided by ESRI.

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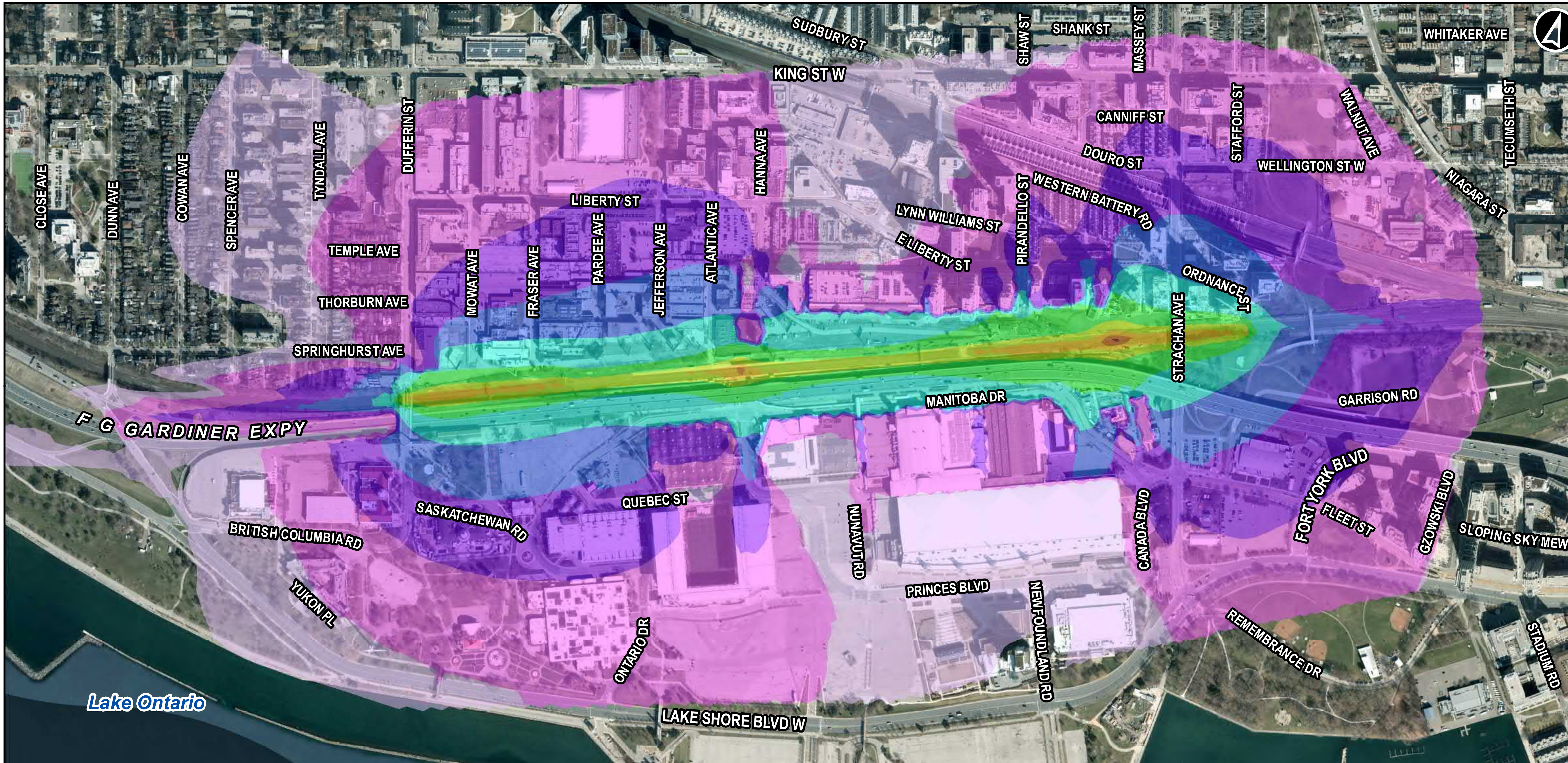
Feb, 2022
P#: 60611173 REV: 00



Legend

Existing - Night (dBA)

- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.

Ontario Line Project

Ontario Line - Lakeshore Segment West - Existing Night-time Noise Contours - 4.5m Height

0 0.25 0.5

Kilometers

DATUM: NAD 1983 UTM Zone 17N

Data Sources:
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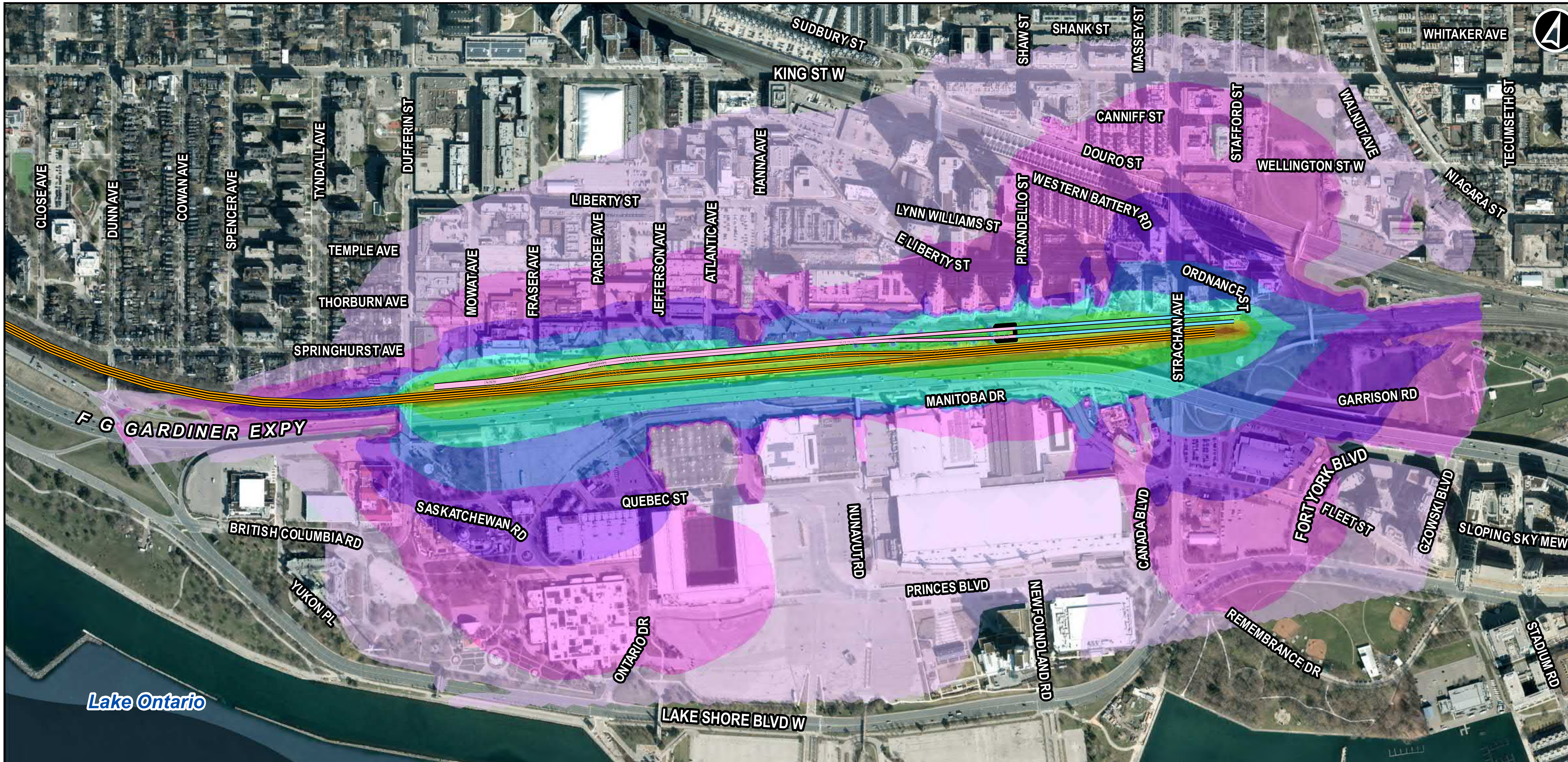

Legend

- Ontario Line - At Grade/Elevated
- Ontario Line - Tunneled
- Portal
- GO Track

Future - Day (dBA)

- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.

Ontario Line Project

Ontario Line - Lakeshore Segment West - Future Day-time Noise Contours - 1.5m Height

0 0.25 0.5
Kilometers
DATUM: NAD 1983 UTM Zone 17N

Data Sources:
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METROLINX AECOM

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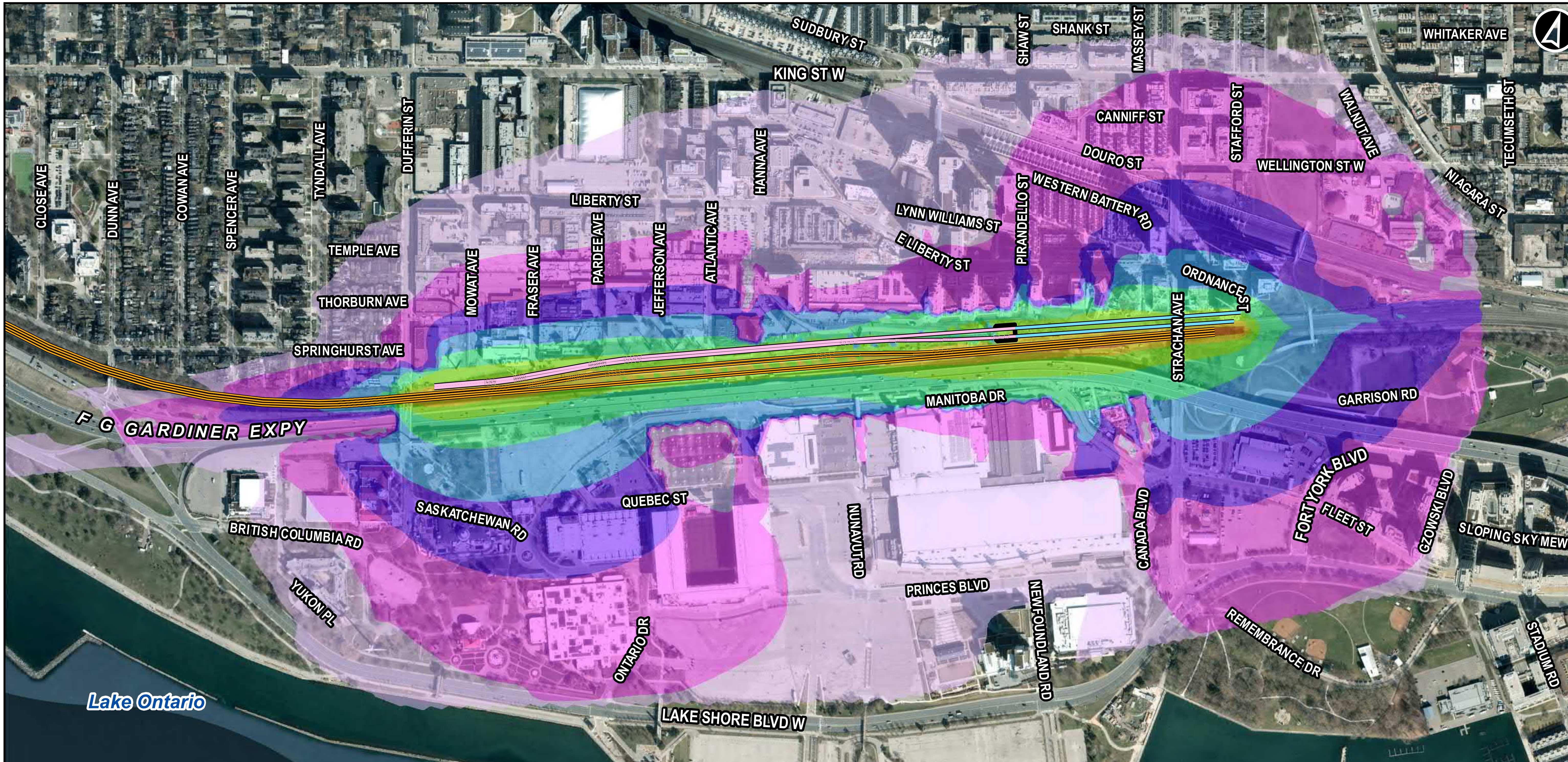

Legend

Ontario Line - At Grade/Elevated
Ontario Line - Tunneled
Portal
GO Track

Future - Night (dBA)

45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
85 - 90

* Note: Noise contours do not account for shielding from all buildings. Therefore, it can be expected that project sound levels will be lower than shown in the figure beyond receptors directly facing the corridor.

Ontario Line Project

Ontario Line - Lakeshore Segment West - Future Night-time Noise Contours - 4.5m Height

0 50 100 200 300 400 500
Meters
DATUM: NAD 1983 UTM Zone 17N

Data Sources:
Contains Information licensed under the Open Government Licence Ontario, Ministry of Energy, Northern Development and Mines, City of Toronto and Metrolinx. Keymap provided by ESRI.

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