
Appendix I:

Noise and Vibration

Section I.1:

Area A Preliminary Noise Study

Note: This appendix refers to Area A as Focus Area 1 and to Area B as Focus Area 2, a reflection of previous project nomenclature.



RE35-1- WATERFRONT EAST LRT UNION STATION - QUEENS QUAY LINK

Baseline Design Review Submission – Preliminary Noise Study

Project # OISO52004

Prepared for:

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East LRT Union Station - Queens Quay
Link Concept Design Review Submission



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List of Acronyms and Abbreviations

ABN	Air-Borne Noise
BDRS	Baseline Design Review Submission
CALTRANS	California Department of Transportation
CDRS	Conceptual Design Review Submission
FTA	Federal Transit Administration
FHWA	U.S. Federal Highway Administration
GBN	Ground-Borne Noise
GBV	Ground-Borne Vibration
HVAC	Heating, Ventilation, and Air Conditioning
LRT	Light Rail Transit
MTM	Modified Transverse Mercator
NVCM	Noise and Vibration Control Measures
PDE	Preliminary Design and Engineering
PPV	Peak Particle Velocity
PWL	Sound Power Level
RCNM	Roadway Construction Noise Model
RMS	Root Mean Square
TTC	Toronto Transit Commission
UPS	Uninterruptible Power Supply
WELRT	Waterfront East LRT
ZOI	Zone of Influence



1.0 Introduction

WSP E&I Canada Limited (WSP) previously Wood Environment & Infrastructure Solutions a Division of Wood Canada Limited has been retained by the Toronto Transit Commission (TTC) to complete the Preliminary Design and Engineering (PDE) to produce a Baseline Design (approximately 30% design completion) for the expansion of the existing Union Light Rail Transit (LRT) and Queens Quay LRT Stations and new running tunnel and portal as part of the Waterfront East LRT (WELRT) project (the Project).

The focus area of the Project is below grade between the Union Station Loop and the future Portal east of Bay Street on Queens Quay (including the Union and Queens Quay Stations). A Preliminary Noise Study has been prepared to support the PDE with respect to the acoustics, noise and vibration aspects of the design and to provide design recommendations for the following components:

1. Expansion of the TTC Union and Queens Quay **Stations**;
2. **Operations** of the streetcar between the Union Station Loop and the future Portal on Queens Quay; and
3. **Construction** of the station expansion, trackwork, streetcar tunnel and portal structures under considerations of the Project.

A Conceptual Design Review Submission (CDRS, approximately 15% design completion) of the Project has been completed. A Preliminary Noise Study Report (version R1, dated December 2020) (Wood Environment & Infrastructure Solutions, 16/12/2020) was included in the submission which identified the acoustics, noise and vibration design criteria for the Project and provided preliminary design recommendations.

This report is intended to support the Baseline Design Review Submission (BDRS, approximately 30% design completion) of the Project. A review of the CDRS submission against the criteria established in the previous Preliminary Noise Study Report (version R1) has been conducted. Based on the information available from the CDRS submission and during the BDRS development¹, noise and vibration aspects in terms of the three components identified above (i.e. Stations, Operations and Construction) have been investigated. The primary objective of this report is to summarize the assessment results and provide design recommendations to support future development of the Project.

¹ This study has been conducted with the evolving of design details during the BDRS development. Major technical parameters used for this study reflect the information available from the progress set drawings dated early July 2021, and no significant updates have been identified (or assumed) in the BDRS submission drawings.



2.0 Union and Queens Quay Station

This section addresses the expected performance of the station spaces at the TTC Union and Queens Quay Stations. Discussions have been provided in Sections 2.1 and 2.2 with respect to the indoor acoustical environment and outdoor emissions, respectively. Each section includes a description of the applicable guidelines and criteria, as can be found in the previous Preliminary Noise Study Report (version R1), followed by the applicable assessment conducted based on the information available from CDRS submission and BDRS development. Design recommendations are presented at the end of each section for compliance with the applicable requirements.

2.1 Indoor Acoustical Design

2.1.1 Indoor Design Sound Levels

The following documentation has been reviewed for the indoor acoustical design of the TTC Union and Queens Quay Stations:

- TTC Design Manual, DM-0403-00 Acoustics (Toronto Transit Commission, Aug. 15, 2011); and
- TTC Design Manual, DM-0803-06 Communications (Toronto Transit Commission, Nov. 4, 2019).

The indoor design sound levels are defined as the A-weighted sound pressure levels taken with slow meter response when the area is empty of passengers and transit vehicles. Brief description of the established design sound levels are provided in Sections 2.1.1.1 through 2.1.1.5.

2.1.1.1 General Design Levels

The indoor design sound levels are established based on the level of required speech communications for a specific space. Table 2.1.1.1.1 summarizes the design sound levels which represent the combined sound levels for all steady noise sources, including equipment and ventilation.

Table 2.1.1.1.1. Station Space Design Sound Levels

Space Designation ¹	Design Sound Levels ²
All public (passenger) areas and leased areas	55 dBA
Rooms where moderately good listening conditions are required	50 dBA
Rooms where just acceptable speech communication is required	65 dBA
Rooms where speech communication is not an overriding concern	85 dBA

Note(s)

1. A detailed list of design sound levels for different station spaces is presented in Appendix A.
2. Infrequent noise sources such as train passbys, emergency fire ventilation, reciprocating compressors and diesel engine generators are not considered in the specified design sound levels.



2.1.1.2 Ventilation

In addition to the requirements listed in Section 2.1.1.1, the combined sound levels from the ventilation system, excluding the emergency ventilation fans, should meet the design goal of 55 dBA at all station public (passenger) areas during normal transit operations. If additional ventilation is required in summer, the design level may be increased to 60 dBA.

During emergency ventilation, the maximum design sound levels are: 80 dBA on the station platform, and 85 dBA in the trackway measured approximately 10 metres from the tunnel fan silencer.

2.1.1.3 Equipment

In addition to the requirements listed in Section 2.1.1.1, the combined sound levels from all ancillary equipment at all public areas should meet the design goal of 60 dBA.

To achieve the required area levels, equipment design sound levels should be taken into consideration during the equipment selection and review of the technical specifications.

2.1.1.4 Reverberation Time

Acoustic treatments shall be selected to reduce the reverberation time in enclosed public areas to less than 1.5 seconds at 500 Hz and above, when the area is unoccupied.

2.1.1.5 Public Address System

The indoor acoustical criteria for the Public Address (PA) systems are defined in terms of sound levels and intelligibility.

For all areas which require coverage, the PA system shall maintain a uniformly distributed sound level² measured at 1.5 m above the floor. The minimum sound levels for the PA system at different spaces are listed in Table 2.1.1.5.1. A minimum of 12 dB increase above the highest minimum sound level should be provided at each location without any increase in hum, noise or total harmonic distortion.

² No quantitative measure has been identified in the TTC Design Manual [2] with respect to the sound distribution. It is thus recommended that, in general, the PA system should be properly configured to avoid hot spots where the sound is noticeably higher nor dead zones where the sound is absent.



Table 2.1.1.5.1. Station Space Design Sound levels for Public Address System

Space Designation	Design Sound Level
Station Platform	The greater of: <ul style="list-style-type: none">• 10 dB above ambient noise levels to a maximum of 98 dBA; or• 78 dBA
All other station public areas	78 dBA
Workshops	78 dBA
Other areas	70 dBA

The intelligibility of the PA system is considered acceptable if at least 90% of the measurement locations within each ADS (Acoustically Distinguishable Space) have a measured STI (Speech Transmission Index) of not less than 0.45 and an average STI of not less than 0.5 STI³.

2.1.2 Indoor Acoustical Assessment

Based on a review of the design information¹ available at the current stage, it is recommended that the assessments of the indoor acoustical performance of the station spaces be performed at later stages of the Project when relevant information becomes available to support the assessments. As the Project design progresses to produce details on aspects such as finish schedules, selection of mechanical and electrical equipment, ventilation system etc., evaluation of the stations design can be performed with respect to the criteria summarized in Section 2.1.1.

2.1.3 Design Recommendations

Brief descriptions of the indoor acoustical design considerations for the Union and Queens Quay Stations have been provided in Sections 2.1.3.1 through 2.1.3.4. These include design for Sound Isolation, Background Noise, Reverberation Time and Speech Intelligibility which are recommended to be taken into consideration as the Project design advances.

When acoustical treatments are determined to be necessary as part of the design, other physical requirements should also be taken into consideration such as the selection of acoustical materials in compliance with TTC Design Manual Section DM-0409, Materials, and the preferred locations for acoustical treatment.

2.1.3.1 Sound Isolation

The station enclosure as well as each station component should be designed to provide adequate sound isolation to/from/within the station. In particular the following items are to be considered:

³ References were made in the TTC Design Manual to National Fire Alarm and Signaling Code, NFPA 72, Annex D, D.2.4.1.



- Isolation for rooms containing high energy noise sources to achieve the noise performance of adjacent spaces as specified in Section 2.1.1.1; and
- Isolation of station noise sources to achieve the desired speech intelligibility as specified in Section 2.1.1.5.

2.1.3.2 Indoor Background Noise

The ventilation system and ancillary equipment are the main considerations for indoor background mechanical noise. The following items are to be considered in particular:

- Selection of equipment to comply with the indoor design sound levels specified in Sections 2.1.1.1 and 2.1.1.3;
- Design of ventilation system (including emergency ventilation fans) to comply with the indoor design sound levels specified in Sections 2.1.1.1 and 2.1.1.2.

2.1.3.3 Reverberation Time

For optimum communication within the station, there should be adequate acoustical (sound absorbing) treatment as part of the area/room finishes to control sound reflections and reverberation to comply with the requirement specified in Section 2.1.1.4.

2.1.3.4 Speech Intelligibility

To achieve the desired speech intelligibility within the station, the following items are to be considered:

- Background noise level as discussed in Section 2.1.3.2;
- Acoustic treatments to achieve the required reverberation time as discussed in Section 2.1.3.3; and
- The design of the PA system to meet the requirement set in Section 2.1.1.5.

2.2 Outdoor Community Impact

2.2.1 Community Impact Criteria

A review of the following documentation has been conducted for the outdoor impact criteria of the TTC Union and Queens Quay Stations:

- The City of Toronto Municipal Code, Chapter 591 (§591), Noise (City of Toronto Council, 2019); and
- The Ministry of the Environment, Conservation and Parks (MECP)⁴, publication NPC-300, Environmental Noise Guideline Stationary and Transportation Sources – Approval and Planning (Ontario Ministry of the Environment and Climate Change (MOECC), August 2013).

Brief descriptions of the established design sound levels are provided in Sections 2.2.1.1 and 2.2.1.2.

⁴ At the time of publication, the MECP is the Ministry of the Environment and Climate Change (MOECC).



2.2.1.1 Stationary Sources

The MECP publication NPC-300 is considered the appropriate guideline to assess the potential outdoor impacts of the station operation. The NPC-300 establishes the sound level limits for stationary sources with respect to four classes of acoustical environments as characterized by the ambient background sound environment. The areas where the Union and Queens Quay Stations are located at are best described as a “Class 1 Area” which represents an area with an acoustical environment typical of a major population centre.

The assessment of stationary noise sources is conducted at outdoor points of perception and outdoor planes of windows. The sound level limit is expressed in terms of the one-hour L_{eq} and is defined as the higher of the applicable exclusion limit presented in Table 2.2.1.1.1, or the background sound level.

Table 2.2.1.1.1. NPC-300 Exclusion Sound Level Limit for Stationary Sources – Class 1 Area

Space	Daytime L_{eq} (7AM – 7PM)	Evening L_{eq} (7PM – 11PM)	Nighttime L_{eq} (11PM – 7AM)
Outdoor Points of Reception	50 dBA	50 dBA	N/A ¹
Outdoor Plane of Windows	50 dBA	50 dBA	45 dBA

Note(s)

1. The outdoor points of reception will be protected during the nighttime as a consequence of meeting the sound level limits at the adjacent plane of window of noise sensitive spaces.

Assessment of noise produced by the emergency equipment operation in non-emergency situations, such as the testing or maintenance of such equipment, is also discussed under the NPC-300. These situations should be assessed independently of all other stationary sources of noise and are subject to a noise limit 5-dB higher than that applicable to the stationary sources.

2.2.1.2 Public Address System

Chapter 591-2.1 (§591-2.1) “Amplified sound” of the Toronto Municipal Code defines the sound level limits for the emission of continuous amplified sound which apply to the PA system of the stations. The limits are expressed in terms of 10-minute L_{eq} in both A-weighted and C-weighted metrics. For a point of reception, the limit is the higher of the applicable limit value given in Table 2.2.1.2.1, or the background sound level.



Table 2.2.1.2.1. Community Sound Impact Limit for Public Address System

Metric ¹	Outdoor Living Area		Indoor Living Area ²	
	Daytime (7 AM – 11 PM)	Nighttime (11 PM – 7 AM)	Daytime (7 AM – 11 PM)	Nighttime (11 PM – 7 AM)
A-Weighted Sound Level	55 dBA	50 dBA	50 dBA	45 dBA
C-Weighted Sound Level	70 dBC	65 dBC	60 dBC	65 dBC

Note(s)

1. The assessment metric is expressed in terms of L_{eq} for a 10-minute period;
2. The indoor living area limit applies when it is determined by a By-law Enforcement Officer during the course of an investigation that it is not reasonable to measure from a point of reception in an outdoor living area.

The sound levels from the PA system during an emergency are exempt according to Chapter 591-3.1 (§591-3.1) "Safety and government work".

2.2.2 Outdoor Impact Assessment

This section describes the impact assessment conducted for the Union and Queens Quay Stations in term of outdoor noise emission. Impacts from the PA system of the stations were excluded from the assessment as relevant system specifications have not been developed in the current design stage of the Project. In addition, given that both the Union and Queens Quay Stations are located below grade, the surface noise as a result of the PA system broadcasting inside the station spaces can be considered insignificant.

2.2.2.1 Noise Sources

During normal operation of streetcar stations, the types of noise sources that are considered to be significant, i.e., capable of emitting noise at a level where their cumulative impacts could be of concern, may include:

- Streetcar movement;
- Ventilation system and the associated equipment;
- General mechanical equipment; and
- Power substation.

At the current stage of design, information regarding the above items are limited. Based on a review of the available design materials¹, most of the noise sources listed above are anticipated to be located inside the stations below ground level where their outdoor noise emissions through the station enclosures can be considered insignificant. The following street-level sources have been identified at the Union and Queens Quay Stations and included in the assessment:



- Union Station:
 - Two ventilation shaft openings; and
 - Two shaft openings for air supply to the mechanical condenser room;
- Queens Quay Station:
 - Two ventilation shaft openings; and
 - One shaft opening for air supply to the mechanical condenser room; and
 - Intake and exhaust for cooling of the electrical room

For the testing of emergency equipment, the following noise sources are considered to be significant contributors of potential impacts:

- Ventilation system running at full speed for emergency mode; and
- Emergency power equipment.

Noises from the ventilation shaft openings on street level have been considered under this scenario. A review of the electrical design¹ indicated that the emergency power room at Union and Queens Quay Stations will be located underground. As such, the associated noise sources are considered to be insignificant at street level.

2.2.2.2 Identified Sensitive Receptor

Four (4) Points of Reception (PORs) have been considered for this assessment. Table 2.2.2.2.1 provides a summary of the selected receptors, including the Modified Transverse Mercator (MTM) coordinates⁵ and the approximate distance to the ventilation shaft openings. All the assessed PORs represent outdoor plane of window locations.

The representative and physical receptors assessed and reported here in this report are the worst-impacted receptor locations only. For multi-floor residential receptors, the worst impacted floor is presented. The location of the modeled receptors with respect to the site location is shown in Appendix A.

Table 2.2.2.2.1. Identified Sensitive Receptors – Stations Study

Receptor ID	MTM Coordinates (Zone 10)		Approximate Distance to Closest Shaft Openings [m]	Height Above Ground [m]
	Easting [m]	Northing [m]		
POR01(S)	314559.8	4833760.6	115	7.5
POR02(S)	314678.1	4833387.2	50	4.5
POR03(S)	314750.2	4833241.5	70	13.5
POR04(S)	314704.6	4833220.5	75	7.5

⁵ The POR coordinates are presented in City of Toronto's operational coordinate system as shown in city website, the Modified Transverse Mercator (MTM) projection, North American Datum 1927 (NAD27), Zone 10.



2.2.2.3 Assessment Criteria

As discussed in Section 2.2.1.1, the impact criteria for stationary noise source assessment are defined as the higher of the applicable exclusion limit presented in Table 2.2.1.1.1 and the background noise levels. For the receptors identified in Section 2.2.2.2 which are located at the downtown area of the city, it is expected that the ambient noise levels due to roadway traffic may be higher than the exclusion criteria. As such, traffic noise predictions were conducted for the identified receptors in order to establish the assessment criteria.

The predictions were made using the calculation method of the Ontario Road Noise Analysis Method for Environment and Transportation (ORNAMENT) as recommended by the MECP. Information regarding AM/PK peak hour traffic data projected to Year 2025 construction conditions was made available during the BDRS stage and was used as input to the ORNAMENT model⁶. A summary of the complied traffic data used for the noise prediction as well as the assumptions used in estimating the Annual Average Daily Traffic (AADT) are included in Appendix A.

The NPC-300 requires that the assessment consider the potential sound impact during a predictable worst-case hour of operation where the noise emissions from the normally busy activity of the sources coincides with a low hourly background sound level. As such, the traffic noise predictions were conducted based on the lowest hourly traffic volumes during daytime, evening and nighttime, which were assumed to be 2%, 1% and 0.5% of the estimated AADT, respectively.

Table 2.2.2.3.1 lists the predicted road traffic noise levels at all receptors identified in Table 2.2.2.2.1. A copy of the calculation report from STAMSON version 5.04, the computerization of the ORNAMENT algorithm, can be found in Appendix A.

⁶ The use of Year 2025 traffic data was considered a conservative approach as the traffic is expected to continue growing with increasing road traffic noise levels.



Table 2.2.2.3.1. Predicted Road Traffic Noise – Stations Study

Receptor ID	Road Noise Sources Considered ¹	Daytime L_{eq}, 1hr (7AM – 7PM) [dBA]	Evening L_{eq}, 1hr (7PM – 11PM) [dBA]	Nighttime L_{eq}, 1hr (11PM – 7AM) [dBA]
POR01(S)	Front Street (York Street to Bay Street)	62	59	55
POR02(S)	<ul style="list-style-type: none">Harbour Street (York Street to Bay Street)Harbour Street (Bay Street to Yonge Street)	66	63	59
POR03(S)	<ul style="list-style-type: none">Queens Quay West (York Street to Bay Street)Queens Quay West (Bay Street to Yonge Street)	61	58	55
POR04(S)	<ul style="list-style-type: none">Queens Quay West (York Street to Bay Street)Queens Quay West (Bay Street to Yonge Street)	61	58	54

Note(s)

1. The road noise sources were selected on the basis of closest proximity and largest angle of exposure for each noise receptor.

Based on the discussions above, for all identified PORs, the noise limits were established to be the predicted traffic noise levels as shown in Table 2.2.2.3.1.

In addition to the noise limit established for sensitive receptors, the followings considerations were also taken during the study: given that the noise sources are located on street-level with the presence of bystanders and pedestrians, care should be taken that the noises received at sidewalks or other public areas do not exceed the level at which hearing protection would be required, i.e. 85 dBA (Ontario Regulation 381/15 - Noise Regulation under the Occupational Health and Safety Act, 2016).

2.2.2.4 Methodology

The primary focus of the assessment was to provide a guideline sound level limit to inform the station design. Based on the criteria established in Section 2.2.2.3, a target



sound power level (PWL) at each of the street-level openings has been provided. This level serves as a guide for subsequent design and equipment selection so that applicable measures, if necessary, will be incorporated to the design to meet the guideline sound level limits at sensitive receptor locations.

The noise assessment was completed using a sound prediction software package (Cadna/A), published by Datakustik GmbH, which was configured to implement the ISO 9613-2 environmental sound propagation algorithms. Off-site noise exposures due to the station operations were modelled. The Cadna/A noise modelling software is widely accepted by the consulting industry and the MECF. All steady noise sources were assumed to operate simultaneously to model the predictable worst-case operational hour within each of the day, evening and nighttime periods.

The following factors have been taken into account in predicting sound levels at a particular receptor due to noise emissions from a specific source(s):

- Source sound power level and directivity;
- Distance attenuation;
- Source-receptor geometry, including heights;
- Barrier effects of the surrounding buildings; and,
- Ground and air (atmospheric) attenuation.

2.2.2.5 Assessment Results

The nighttime noise limits represent the most stringent levels that need to be met for the stations. The assessment has been conducted for a predictable worst-case hour of operation where the noise emissions from the normally busy activity of the sources were compared to the quietest ambient sound level. Based on the nighttime noise limits presented in Section 2.2.2.3, the PWL at each of the shaft openings at the Union and Queens Quay Stations has been calculated. A summary of the target PWL values can be found in Table 2.2.2.5.1 and Table 2.2.2.5.2.

In determining the target sound power levels, considerations were also taken that the pedestrians should not be exposed to a noise level higher than 85 dBA which would require hearing protection. Four noise contour maps have been included in Appendix A which show the noise levels in areas surrounding the Union Station and Queens Quay Station during the regular operation and emergency testing scenarios.



Table 2.2.2.5.1. Target Shaft Opening Sound Power Level at Union Station

Shaft Opening	Regular Operation		Emergency Testing	
	Target Sound Power Level ₁ [dBA]	Sound Level and Limit at Receptor(s) ₂ [dBA]	Target Sound Power Level [dBA]	Sound Level and Limit at Receptor(s) ₃ [dBA]
Union - Vent 1	99	POR01(S):45 (55)	99	POR01(S):31 (60)
Union -Vent 2	99		99	
Union – Air Supply Opening 1 for Condenser Room	99		- 4	
Union – Air Supply Opening 2 for Condenser Room	99		- 4	

Note(s)

1. Target sound power levels were determined based on the sound level limits established at each identified POR as well as the consideration that pedestrians should not be exposed to a noise level higher than 85 dBA.
2. Sound level limit shown in bracket which was established based on the predicted nighttime traffic noise level.
3. Sound level limit shown in bracket which was established based on the predicted nighttime traffic noise level + 5dB.
4. Only ventilation shaft openings were considered in the emergency equipment testing scenario.



Table 2.2.2.5.2. Target Shaft Opening Sound Power Level at Queens Quay Station

Shaft Opening	Regular Operation		Emergency Testing	
	Target Sound Power Level ¹ [dBA]	Sound Level and Limit at Receiver(s) ² [dBA]	Target Sound Power Level ¹ [dBA]	Sound Level and Limit at Receptor(s) ³ [dBA]
QQ - Vent 1	99	POR02(S): 59 (59) POR03(S): 55 (55) POR04(S): 50 (54)	99	POR02(S): 59 (64) POR03(S): 55 (60) POR04(S): 50 (59)
QQ - Vent 2	99		99	
QQ – Air Supply Opening 1 for Condenser Room	83		- 4	
QQ – Intake for Cooling of Electrical Room	80		- 4	
QQ – Exhaust for Cooling of Electrical Room	80		- 4	

Note(s)

1. Target sound power levels were determined based on the sound level limits established at each identified POR as well as the consideration that pedestrians should not be exposed to a noise level higher than 85 dBA.
2. Sound level limit shown in bracket which was established based on the predicted nighttime traffic noise level.
3. Sound level limit shown in bracket which was established based on the predicted nighttime traffic noise level + 5dB.
4. Only ventilation shaft openings were considered in the emergency equipment testing scenario.

2.2.3 Design Recommendations

The primary focus of the assessment was to provide a guideline sound level limit to inform the stations design, in particular the design related to the Heating, Ventilation, and Air Conditioning (HVAC) system and associated equipment. The noise criteria established for the identified receptors were based on the background noise levels at the receptors as a result of the roadway traffic. The nighttime periods were deemed to be the most critical due to lowest background noise levels, and target sound power levels were calculated accordingly for each of the shaft openings.

Provided that the relevant systems, equipment selection and noise reduction packages (e.g. silencers, if necessary) can be designed to meet these sound levels, it is expected that the stations would operate in accordance with the applicable MECP NPC-300 criteria. It should be noted that the target sound power levels do not necessarily



represent recommendations as they were obtained based on back calculations to meet the defined criteria. These levels may also be further restrained by the indoor design sound levels presented in Section 2.1 (e.g. equipment design sound levels to comply with indoor area levels) as the assessment was based solely on the outdoor impact criteria.

The assessment was prepared based on the consideration that the noise generated from the equipment and relevant activities of the station operation would be below-grade within station enclosures and thus insignificant for the nearby sensitive receptors. Only the shaft openings located on street level are considered as significant noise sources and included in the assessment. In addition, the results presented in this section were obtained based on available design information and relevant assumptions set forth in this section. As the overall design of the stations continues to be developed, this assessment may need to be updated to identify potential issues which should be considered during further stages.



3.0 Streetcar Operations

This section addresses the expected impacts of noise and vibration from the operation of the streetcar between Union Station Loop and future Portal on Queens Quay. Applicable guidelines and criteria for the operational noise and vibration impacts have been discussed in detail in the previous Preliminary Noise Study report (version R1) (Wood Environment & Infrastructure Solutions, 16/12/2020) and are briefly presented in Section 3.1. General descriptions of the assessment procedure and input data collected for the analysis are provided in Section 3.2. Section 3.3 presents the sensitive receptors identified for the assessment and the impact assessment results are summarized in Section 3.4.

3.1 Operational Criteria

The MOE/TTC Protocol for Noise and Vibration Assessment for the Spadina Light Rail Transit Line (MOE/TTC, December 4, 1992) is considered the applicable assessment guideline for the Project. Sections 3.1.1 and 3.1.2 presents the criteria established in the MOE/TTC Protocol with respect to air-borne noise and ground-borne vibration⁷.

3.1.1 Air-Borne Noise

The MOE/TTC Protocol (MOE/TTC, December 4, 1992) establishes noise assessment criteria for receptors no less than 15 m from the nearest track centerline. The limits are defined for rail transit operating alone (i.e. excluding contributions from the ambient) and are expressed in terms of three sound level descriptors as shown in Table 3.1.1.1.

Table 3.1.1.1. Noise Limits for Spadina Light Rail Transit Line

Descriptor	Limit
Daytime $L_{eq,16hr}$ (7 AM – 11 PM)	The higher of: <ul style="list-style-type: none">• 55 dBA; or• Ambient $L_{eq,16hr}$
Nighttime $L_{eq,8hr}$ (11 PM – 7 AM)	The higher of: <ul style="list-style-type: none">• 50 dBA; or• Ambient $L_{eq,8hr}$
Passby Sound Level L_{passby} ¹	80 dBA

Note(s)

1. The limit is based on vehicles operating on tangent track and does not apply within 100m of special trackwork and excludes any effect due to wheel rail squeal.

The MOE/TTC Protocol specifies that mitigation measures are to be incorporated in the design of the line when predictions show that any of the defined limits is exceeded by more than 5 dB. Mitigation measures should be designed to ensure the predicted sound

⁷ Considerations of the ground-borne noise are not included in the MOE/TTC Protocol.



levels are as close to, or lower than, the respective limit as is technically, economically and administratively possible.

3.1.2 Ground-Borne Vibration

The MOE/TTC Protocol (MOE/TTC, December 4, 1992) defines the ground-borne vibration (GBV) limit in terms of the root-mean-square (rms) vibration velocity (V_{rms}) during the vehicle passby. The predicted V_{rms} levels at receptors no less than 15 m from the nearest track centerline are to be compared with the vibration criterion of 0.14 mm/s to determine whether mitigation is needed. Mitigation measures should be applied during the design to the extent that is technologically, economically and administratively feasible.

3.2 Methodology

For the assessment of noise and vibration levels from the streetcar operation, the use of general assessment procedure described in the Federal Transit Administration's publication, "Transit Noise and Vibration Impact Assessment Manual" (FTA Manual) (Quagliata, et al., 2018) has been considered the appropriate approach.

Section 3.2.1 summarizes the traffic parameters identified for the Project which determine the source emission levels of the streetcar. Sections 3.2.2 and 3.2.3 provide further discussions on the assessment methodology in terms of noise and vibration levels, respectively.

3.2.1 Project Traffic

The Project traffic scenario is identified in Table 3.2.1.1. The values presented include the current streetcar operation conditions and projections for the year 2041 which were obtained based on the planned service frequency provided by TTC and presented in the Passenger Flow Modelling Methodology (DRAFT) (OISO520004-MEM-011 R0, TTC Waterfront East LRT Design Study - Passenger Flow Modelling Methodology (DRAFT), February 2021).

**Table 3.2.1.1. General Input Parameters for Project Train Traffic**

Line	Input Parameters	Value		Notes
		Existing ¹	Year 2041	
1	Total Train Traffic Per Day (Union Loop – West of Queens Quay)	-	-	Per Track
1.a	Peak Hourly Traffic	16	13 ²	-
1.b	Average Hourly Daytime Traffic (7AM – 11PM)	14	12 ³	-
1.c	Average Hourly Nighttime Traffic (11 PM – 7AM)	6	6 ³	-
1.c	Peak Hourly Traffic	16	13 ³	-
2	Total Train Traffic Per Day (Union Loop – East of Queens Quay)	-	-	Per Track
2.a	Peak Hourly Traffic	-	20 ²	-
2.b	Average Hourly Daytime Traffic (7AM – 11PM)	-	18 ³	-
2.c	Average Hourly Nighttime Traffic (11 PM – 7AM)	-	9 ³	-
3	Typical Train Make-up			
3.a	Number of Cars	5 ⁴		Per Train
3.b	Total Train Length	99 ft ⁴		-
3	Speed ⁵			
3.a	Union Station Loop	10 km/h		-
3.a	Union Station - Queens Quay Station	30 km/h		-
3.a	Queens Quay Station	5 km/h		-
3.b	Along Queens Quay West	40 km/h ⁶		-

Note(s)

1. The values presented are based on the typical schedule of TTC streetcar operation for routes 509 and 510A in year 2021.
2. The values represent the AM peak hour traffic obtained based on the information presented the Passenger Flow Modelling Methodology (DRAFT) (OISO520004-MEM-011 R0, TTC Waterfront East LRT Design Study - Passenger Flow Modelling Methodology (DRAFT), February 2021).
3. The values were estimated based on the peak hourly traffic in row 1.a/2.a and the existing streetcar operational schedule (i.e. ratio of peak hourly traffic and average daytime/nighttime hourly traffic)
4. The values presented are based on the Flexity Outlook model of streetcar vehicles.
5. The values represent general assumptions of the operation speed based on TTC's existing speed restriction.
6. The streetcar speed is considered to be consistent with the posted speed limit of the roadways in proximity of the Project focus area.



3.2.2 Air-Borne Noise

The FTA Manual documents detailed guidelines for performing a General Noise Assessment⁸. This section provides a brief description of the major steps taken to predict the air-borne noise levels from a fixed-guideway transit source, which are outlined as follows:

- **Step 1:** Determine project noise source reference levels – This step includes:
 - Determining the reference source noise levels 50 ft from the track in terms of Sound Exposure Level (SEL) at a reference speed; and
 - Estimating the project noise exposure in terms of $L_{eq(1hr)}$ at the reference distance of 50 ft considering operational characteristics (i.e. number of train passbys, train consist, operation speed, etc).
- **Step 2:** Estimate project noise exposure by distance – Estimate project noise exposure at distances beyond 50 ft considering propagation characteristics using a simplified procedure.

For Step 1 of the assessment, reference SEL levels for streetcars can be found in *Table 4-9* of the FTA Manual. Based on gathered operation data, the noise exposure ($L_{eq(1hr)}$ or L_{dn}) at the reference distance of 50 ft is calculated using the equation provided⁹ in the FTA Manual which can be presented as follows:

$$L_{eq(1hr),50ft} = SEL_{ref} + 10 \log(N_{cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6 + Adj_{track}$$

Where:

- $L_{eq(1hr),50ft}$ is the L_{eq} at 50 ft, in dBA;
- SEL_{ref} is the applicable reference SEL¹⁰, in dBA;
- N_{cars} is the average number of cars per train;
- S is the speed of train, in miles per hour;
- V is the average hourly volume of train traffic, trains per hour; and
- Adj_{track} is the track adjustment factor:
 - Special trackwork such as turnout and crossovers can increase noise levels. The FTA Manual recognizes this situation in the general assessment by applying a +5 dB adjustment when the special trackwork is within 300 ft of the receptor;
 - For embedded track on grade, a +3 dB adjustment is applied;
 - If a barrier blocks the line of sight, a -5 dB adjustment is applied.

For Step 2 of the assessment, to calculate the project noise exposure at a distance other than 50 ft, a correction factor of $15 \log(D/50)$ is used by the FTA Manual which is illustrated by the propagation curve shown in Figure 3.2.2.1.

⁸ See *Section 4.4* of the FTA Manual.

⁹ See *Table 4-10* of the FTA Manual.

¹⁰ See *Table 4-9* of the FTA Manual.

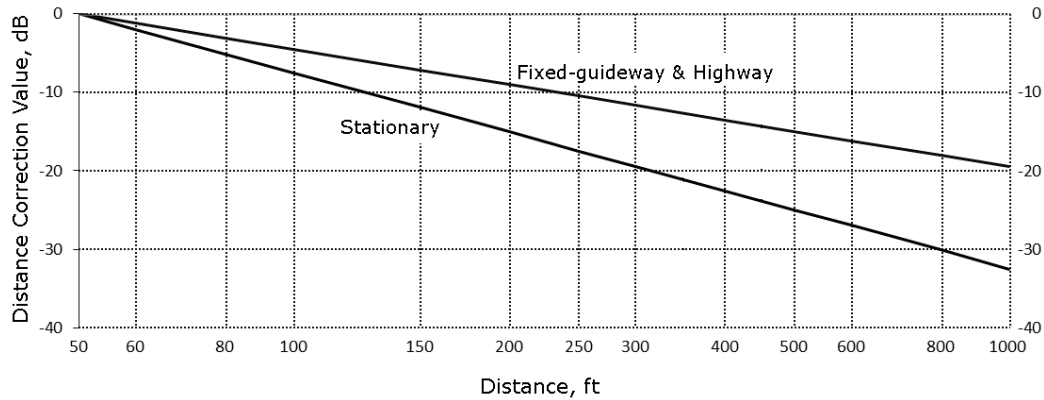


Figure 3.2.2.1. Curves for Estimating Exposure vs. Distance in General Noise Assessment¹¹

To estimate the passby level as identified in the noise assessment criteria listed in Table 3.1.1, references have been sought from the Federal Railroad Administration's publication "High-Speed Ground Transportation Noise and Vibration Impact Assessment" (FRA Manual) (Hanson, Ross, & Towers, 2012). Based on the guidance provided in the FRA Manual¹², the following equation is used to estimate the passby level from the SEL level:

$$L = D - 10 \log(\quad) - 1$$

Where:

- SEL_D is the SEL level calculated at a distance D based on the methodologies presented above;
- Δt is the time interval of the passby, calculated by dividing the length of the train by its speed; and
- The constant "1" (dB) is included to account for the sound energy received during the time intervals just before and after the passby that is included in the SEL.

3.2.3 Ground-Borne Vibration

The FTA Manual documents detailed guidelines for performing a General Vibration Assessment¹³. This section provides a brief description of the major steps taken to predict the ground-borne vibration levels from a transit vibration source, which are outlined as follows:

- **Step 1:** Select base curve for ground surface vibration level - Select a standard vibration curve to represent general vibration characteristics for the source; and
- **Step 2:** Apply adjustments - Apply project-specific adjustments to the standard vibration curve.

For Step 1 of the assessment, Figure 3.2.3.1 shows the generalized vibration curves provided by the FTA Manual for vibration assessment. The "Rapid Transit or Light Rail

¹¹ Reproduced from Figure 4-6 of the FTA Manual.

¹² See Section 2.1 and Appendix C of the FRA Manual.

¹³ See Section 6.4 of the FTA Manual.



Vehicles” curve shown in Figure 3.2.3.1 is considered to be applicable for the Project. The following equation is provided¹⁴ in the FTA Manual that characterizes the curve:

$$L_v = 92.29 + 14.81 \log(D) - 14.17 \log^2(D) + 1.65 \log^3(D)$$

Where

- L_v is the velocity level in VdB; and
- D is the distance in ft.

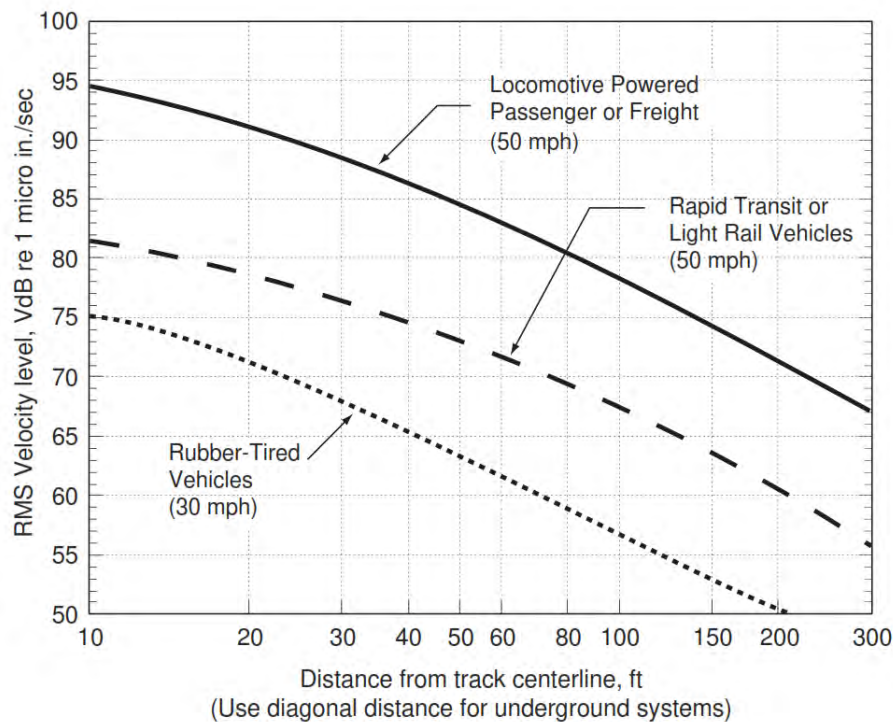


Figure 3.2.3.1. Generalized Ground Surface Vibration Curves¹⁵

For Step 2 of the assessment, the adjustment factors are described in *Table 6-11*, *Table 6-12* and *Table 6-13* of the FTA Manual. The applicable adjustments are generally determined by several factors:

- Train speed;
- Vehicle conditions, e.g. suspension stiffness, wheels condition;
- Track conditions, e.g. special trackwork:
 - Special trackwork such as turnout and crossovers can increase vibration levels. The FTA Manual recognizes this situation in the general assessment by applying the following factors¹⁶:
 - +10 dB when the special trackwork is within 100 ft of the receptor.
 - +5 dB when the special trackwork is within 100 ft to 200 ft of the receptor.

¹⁴ See *Table 6-10* of the FTA Manual.

¹⁵ Reproduced from *Figure 6-4* of the FTA Manual.

¹⁶ See *Table 6-11* of the FTA Manual.



- 0 dB when the receptor is more than 200 ft from the special trackwork.
- Propagation characteristics, e.g. soil conditions, building foundation coupling; and
- Receptor structure amplification or attenuation.

3.3 Inventory of Sensitive Sites

3.3.1 Land Use Category

The FTA Manual identifies three main types of land use that are considered for assessment of noise and vibration:

- Category 1 – High Sensitivity;
- Category 2 – Residential; and
- Category 3 – Institutional

A generic description of the land use categories is presented in Table 3.3.1.1. Noise and vibration sensitive land uses in the context of the MOE/TTC Protocol are defined in a similar manner:

“... noise or vibration sensitive land uses include, but are not limited to, existing residential development (both single and multi-family dwellings) and proposed residential development (both single and multi-family dwellings) which has received appropriate development approval. The protocol also applies to existing and appropriately approved proposed nursing homes, group homes, hospitals and noise or vibration sensitive institutional land uses. Other noise or vibration sensitive land uses would be assessed on a case by case basis.”

Table 3.3.1.1. Land Use Categories and Descriptions

Land Use Category	Land Use Type	Description of Land Use Category
1	High Sensitivity	There are two types of spaces: <ul style="list-style-type: none">• Outdoor land spaces where quiet is an essential element of its intended purpose; and• Buildings where noise and/or vibration would interfere with interior operation.
2	Residential	This category is applicable to all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Institutional	This category is applicable to institutional land uses with primarily daytime and evening use.

3.3.2 Identified Sensitive Receptors

Based on the land use category described in Section 3.3, a review of the land use surrounding the focus area of the Project was conducted. A series of sensitive receptors



have been identified and presented in Table 3.3.2.1. An aerial view of the identified receptors can be found in Appendix B.

Table 3.3.2.1. Identified Sensitive Receptors – Operation Impact Assessment

Receptor ID	MTM Coordinates (Zone 10)		Horizontal Distance to Nearest Track Centerline [m]	Land Use ¹
	Easting [m]	Northing [m]		
POR01(O)	314422.3	4833767.6	112	Residential
POR02(O)	314559.8	4833760.6	6	Institutional
POR03(O)	314678.1	4833387.2	17	Residential
POR04(O)	314708.9	4833310.1	15	Institutional
POR05(O)	314704.6	4833220.5	19	Residential
POR06(O)	314750.2	4833241.5	19	Residential
POR07(O)	314813.7	4833317.1	19	Residential
POR08(O)	314855.3	4833376.3	54	Residential

Note(s)

1. Land use category as defined in Table 3.3.1.1.

3.4 Impact Assessment

3.4.1 No-Build Scenario

Under the No-Build Scenario, streetcar operations are expected to continue between the Union and Queens Quay Stations with increased capacity to serve the Waterfront West area. An increased service level (i.e. frequency of events per day) is anticipated and no significant changes to the streetcar vehicle and average operating speeds (as identified in Table 3.2.1.1) have been identified.

While the increase in traffic volume will likely result in marginal increases in operational noise levels, noises generated inside the streetcar tunnel will remain insignificant for the surface receptors. Noises from streetcars serving the Waterfront West area is also anticipated to be insignificant for receptors located along the Waterfront East area.

For operational vibration levels, since the operating conditions (train type, operating speed, etc) are not expected to change significantly, the magnitude and propagation of vibration are anticipated to stay the same.

3.4.2 Build Scenario

3.4.2.1 Air-Borne Noise

The focus area of the Project is below grade between Union Station Loop and the future Portal east of Bay Street on Queens Quay. Noises from streetcar operation inside the tunnel are considered to be insignificant for surface receptors along the underground alignment, i.e. POR01(O) to POR06(O).

A review of the alignment drawings indicated that receptors POR07(O) and POR08(O) are located near the future Portal where the surface streetcar operation could be of



potential impact before entering into (or after emerging from) the tunnel. As such, the operational noise impact assessment has been conducted for POR07(O) and POR08(O).

As discussed in Section 3.1.1, the operational noise impact criteria are defined as the higher of the applicable exclusion limit presented in Table 3.1.1.1 and the ambient noise levels. For receptors POR07(O) and POR08(O), traffic from Queens Quay West and Yonge Street was considered the most significant contributor to the ambient noise levels. Traffic noise predictions were made using the ORNAMENT calculation method. Information regarding AM/PM peak hour traffic data projected to Year 2025 was made available during the BDRS stage and was used as input to the ORNAMENT model¹⁷. A summary of the complied traffic data used for the noise prediction is included in Appendix B.

Table 3.4.2.1.1 lists the predicted road traffic noise levels at POR07(O) and POR08(O). A copy of the STAMSON calculation report can be found in Appendix B.

Table 3.4.2.1.1. Predicted Road Traffic Noise – Operation Impact Assessment

Receiver ID	Road Noise Sources Considered ¹	Daytime Leq, 16hr (7AM – 11PM) [dBA]	Nighttime Leq, 8hr (11PM – 7AM) [dBA]
POR07(O)	<ul style="list-style-type: none">Queens Quay West (York Street to Bay Street)Queens Quay West (Bay Street to Yonge Street)	66	59
POR08(O)	<ul style="list-style-type: none">Queens Quay West (Bay Street to Yonge Street)Yonge Street (Harbour Street and Queens Quay West)	63	56

Note(s)

1. The road noise sources were selected on the basis of closest proximity and largest angle of exposure for each noise receptor.

Based on the methodologies presented in Section 3.2, the operational noise levels were calculated for POR07(O) and POR08(O) under the future Build Scenario. The assessment results are presented in detail in Appendix B and a summary of the impact assessment can be found in Table 3.4.2.1.2. The assessment results suggest the operational noise levels are expected to meet the applicable MOE/TTC criteria at POR07(O) and POR08(O) during daytime, nighttime and a passby event.

¹⁷ The use of Year 2025 traffic data was considered a conservative approach as the traffic is expected to continue growing with increasing road traffic noise levels.

**Table 3.4.2.1.2. Summary of Operational Noise Impacts**

Receiver ID	Descriptor	No-Build Noise Level [dBA]	Build Noise Level [dBA]	Noise Limit ¹ [dBA]	Impact [Y/N]
POR07(O)	Daytime $L_{eq,16hr}$	- ²	59 ³	66	N
	Nighttime $L_{eq,8hr}$	- ²	56 ³	59	N
	Passby Sound Level L_{passby} ⁴	- ²	74 ³	80	N
POR08(O)	Daytime $L_{eq,16hr}$	- ²	58	63	N
	Nighttime $L_{eq,8hr}$	- ²	54	56	N
	Passby Sound Level L_{passby} ⁴	- ²	72	80	N

Note(s)

- Noise limits are defined as the higher of the applicable exclusion limit presented in **Table 3.1.1.1** and the ambient noise levels presented in **Table 3.4.2.1.1**.
- Under the No-Build Scenario, the noise level at the receptor due to operation of the streetcar in the Waterfront West Area is considered insignificant.
- Based on a review of the track grade plan and cross-section geometry of the sound propagation path between the noise source and receptor POR07(O), it was determined that the portal structure (i.e. walls) would break the line of sight between the source and receptor, and a -5 dB adjustment was applied.
- The passby sound level has been calculated for streetcar passing by on the track closest to the receptor.

3.4.2.2 Ground-Borne Vibration

Based on the methodologies presented in Section 3.2, the operational vibration levels were calculated for the identified receptors for both the No-Build Scenario and the future Build Scenario. The assessment results are presented in detail in Appendix B and a summary of the impact assessment can be found in Table 3.4.2.2.1.

A comparison of the assessment results under the No-Build and Build scenarios indicated increased vibration levels at POR06(O), POR07(O) and POR08(O) due to the introduction of Waterfront East alignment. Nevertheless, the vibration levels from the streetcar operations are expected to meet the applicable MOE/TTC criteria with values approximately an order of magnitude lower than the limit at all receptors.



Table 3.4.2.2.1. Summary of Operational Vibration Impacts

Receiver ID	No-Build Vibration Level [mm/s]	Build Vibration Level ¹ [mm/s]	Vibration Limit [mm/s]	Impact [Y/N]
POR01(O)	<0.01	<0.01	0.14	N
POR02(O)	0.01	0.01	0.14	N
POR03(O)	0.01	0.01	0.14	N
POR04(O)	<0.01	<0.01	0.14	N
POR05(O)	<0.01	<0.01	0.14	N
POR06(O)	<0.01	<0.01	0.14	N
POR07(O)	<0.01	0.02	0.14	N
POR08(O)	<0.01	<0.01	0.14	N

Note(s)

1. The use of ballast mat has been included in the assessment for special track locations based on review of the Track Design Brief (Wood Environment & Infrastructure Solutions, 12/16/2020).

3.5 Design Recommendations

Taking into consideration the assessment results presented in Section 3.4, it is expected that the Project will not result in noise nor vibration related operational impacts.

The assessment was prepared based on the information available from the CDRS submission and during the BDRS development, as well as relevant assumptions set forth in this section. As the overall design of the Project advances, this assessment may need to be updated to identify potential issues which should be considered during further stages.



4.0 Construction

This section addresses the expected impacts of noise and vibration from the construction of the Project. Detailed discussions of applicable guidelines and criteria for the construction noise and vibration impacts have been provided in the previous Preliminary Noise Study report (version R1) (Wood Environment & Infrastructure Solutions, 16/12/2020) and are briefly presented in Section 4.1. Section 4.2 provides brief descriptions of the methodologies for assessing construction noise and vibration impacts. The impact assessment results in terms of Zone of Influence (ZOI) setback distances and potentially impacted sensitive receptors are presented in Section 4.3. Discussions of Noise and Vibration Control Measures (NVCM) recommended for the Project to address the temporary impacts during construction are provided in Section 4.4, and further documented in the Noise and Vibration Control Measures report (Wood Environment & Infrastructure Solutions, July 2021) under a separate cover.

4.1 Construction Criteria

4.1.1 Construction Noise

For this Project, no quantitative limits for construction noise levels at sensitive receptor locations have been identified based on a review of relevant documentations including:

- TTC Design Manual, DM-0106-00 Noise and Vibration, General (Toronto Transit Commission, Sep. 14, 2011);
- The City of Toronto Municipal Code, Chapter 591, Noise (City of Toronto Council, 2019); and
- MECP¹⁸, publication NPC-115, Construction Equipment (Ontario Ministry of the Environment and Climate Change, 1977).

For the assessment described in this section, references for applicable construction noise limits were drawn from the FTA Manual. A general assessment of construction noise as described in the FTA Manual¹⁹ was conducted which is appropriate for projects in an early assessment stage when the equipment roster and schedule are undefined and only a rough estimate of construction noise levels is practical. The assessment was based on the combined noise levels, from the two noisiest pieces of equipment that could be used on the Project, under the assumption that they operate at the same time and location.

Table 4.1.1.1 presents the construction noise criteria listed in the FTA Manual which are established based on the receptor land use type and time periods.

¹⁸ At the time of publication MECP was the Ministry of the Environment (MOE)

¹⁹ See *Section 7.1* of the FTA Manual.

**Table 4.1.1.1. Construction Noise Criteria**

Land Use	L _{eq,equip} (1hr) [dBA]	
	Day	Night
Residential	90	80
Commercial	100	100
Industrial	100	100

4.1.2 Construction Vibration

The TTC Design Manual Section DM-0106-00 Noise and Vibration (Toronto Transit Commission, Sep. 14, 2011) does not contain vibration limits for construction. Guidelines have been identified in the City of Toronto Municipal Code Chapter 363, Article 5, Construction Vibrations (§363-5) (City of Toronto Council, 2019) which outlines the limits on maximum allowable peak particle velocity (PPV) vibration levels at receptors due to construction activities (Table 4.1.2.1).

Table 4.1.2.1. City of Toronto Prohibited Construction Vibrations

Frequency of Vibration	Maximum Allowable Peak Particle Velocity
< 4 Hz	8 mm/s
4 Hz – 10 Hz	15 mm/s
> 10 Hz	25 mm/s

Chapter 363-5 (§363-5) also identifies the Zone of Influence (ZOI) of the construction site as the area within or adjacent to the site, including any buildings or structures, that potentially may be impacted by vibrations emanating from a construction activity. The ZOI of a construction site corresponds to a peak particle velocity of 5 mm/s at any frequency.

Based on the discussion above, a limit of PPV at 5 mm/s was retained for this study.

4.2 Methodology**4.2.1 Construction Noise**

The construction noise ZOI assessment described in this section was conducted based on the guidance from the FTA Manual, U.S. Federal Highway Administration (FHWA) Construction Noise Handbook (U.S. Department of Transportation, Federal Highway Administration, August 2006) and the FHWA Roadway Construction Noise Model (RCNM) (U.S. Department of Transportation, Federal Highway Administration, 2006), all of which provide similar calculation methods and emission values.

The equation used for construction noise predictions is given as follows:

$$L_{eq,equip} = L_{max@50ft} - 20 \log \left(\frac{D}{50} \right) + 10 \log(U.F. \%/100)$$



Where:

- $L_{eq, equip} = L_{eq(t)}$ at a receptor from the operation of a single piece of equipment over a specified time period, in dBA;
- $L_{max, 50ft}$ is the emission level for the equipment at 50 ft, obtained from the FTA Manual and/or RCNM, in dBA;
- D is the distance, between the equipment and the receptor, in feet; and
- $U.F. \% / 100$ is the time-averaging equipment usage factor, in percent;

For a general assessment of construction noise, the usage factor is assumed to be 1, indicating a time period of one-hour with full power operation of the equipment. The $L_{eq, equip}$ is determined for the two noisiest pieces of equipment expected to be used in each phase of construction. The noises levels are summed logarithmically and used for calculation of the ZOI setback distance corresponding to the noise criteria.

4.2.2 Construction Vibration

Vibration impacts for construction activities were predicted based on reference levels and propagation models established and published in the FTA Manual, California Department of Transportation's Transportation and Construction Vibration Guidance Manual (CALTRANS Manual) (California Department of Transportation, September 2013), and British Standard 5228-2 2009 (BS 5228) (British Standards Institution (BSI), 2009).

A typical equation for predicting the peak particle velocity (PPV) from a piece of construction equipment is given as follows:

$$PPV_{equip} = PPV_{ref} \times \left(\frac{25}{D}\right)^n$$

Where:

- PPV_{equip} is the peak particle velocity of the equipment adjusted for distance, in in/sec;
- PPV_{ref} is the source reference vibration level at 25 ft, in in/sec;
- D is the distance, between the equipment and the receptor, in feet; and
- n is the vibration attenuation rate as determined by the soil characteristics.

4.3 Construction Impact Assessment

4.3.1 Construction Staging

The construction staging of the Project has been assessed with respect to the Union Station site and Queens Quay Station site. A review of the preliminary structural drawings, staging drawings and construction schedule ¹ has been conducted to determine the construction activities associated with each phase of construction at each site.

4.3.1.1 Union Station

The following construction phases have been identified for the Union Station site:



- Phase 1: Southwest entrance & tunnel with underpinning of three columns at Qe-2,3, & 4;
- Phase 2: Underpinning & excavation at Columns QE-5, 6, & 7 and Northwest Loop underpinning & excavation;
- Phase 3: Underpinning & excavation at Gridline QE-8, 9, & 10 and construction near Gridline SE-1, 2, 3, 4, & 5, TE-4 & 5, & 81 Bay Street Station Egress;
- Phase 4: Underpinning & excavation at Gridline QE-11, 12, & 13 and SE-6, 7, 8, & 9;
- Phase 5: Underpinning & excavation at Gridline SE-10, 11, & 12 and East loop at 141 Bay and finishing of Union Station perimeter;
- Phase 6: Underpinning & excavation along Gridline Re from Re-1.2 to Re-13;
- Phase 7: Construction of Southeast portion of tunnel to Queen's Quay; and
- Phase 8: Complete finishing & commissioning of Union Station, and Bay Street road restoration.

A review of the staging drawings 1 suggests that the construction staging at the Union Station site will be arranged as follows:

- Layout 1: applies to Phase 1 and Phase 2 construction;
- Layout 2: applies to Phase 3, Phase 4 and Phase 5 construction;
- Layout 3: applies to Phase 6 construction;
- Layout 4: applies to Phase 7 construction; and
- Layout 5: applied to road restoration for Bay Street.

The assessment described in this section has been conducted with respect to the staging layout identified above. Estimation of the required equipment was made as no detailed information regarding equipment selection and usage was available at the time of this study

4.3.1.2 Queens Quay Station

The following construction phases have been identified for the Queens Quay Station site:

- Phase 1: West Portal and tunnel reconstruction;
- Phase 2: Pedestrian tunnel construction and upgrades at the Northwest corner of Queens Quays and Bay Street intersection;
- Phase 3: Pedestrian tunnel construction and upgrades at the Northeast corner of Queens Quays and Bay Street intersection;
- Phase 4: Wye modification and construction of pedestrian tunnel to Harbour Square;
- Phase 5: East Portal and tunnel construction;
- Phase 6: Reconstruction of the West side of Queens Quay Station;
- Phase 7: Reconstruction of the East side of Queens Quay Station; and



- Phase 8: Complete finishing & commissioning of Queens Quay Station, and road restoration of Bay Street and Queens Quay West²⁰.

A review of the staging drawings 1 suggests that the construction staging at the Queens Station site will be arranged with respect to each phase identified above, i.e. Layout 1 through Layout 8 for Phase 1 through Phase 8, respectively. The assessment described in this section has been conducted with respect to each construction layout/phase identified above. Estimation of the required equipment was made as no detailed information regarding equipment selection and usage was available at the time of this study.

4.3.2 Construction Noise

4.3.2.1 Predicted Zone of Influence

Table 4.3.2.1.1 and Table 4.3.2.1.3 summarizes the equipment anticipated to be used as part of the construction activities at the Union Station site and Queens Quay Station site. The noise characteristics presented for the equipment were taken from either the FHWA RCNM Model (U.S. Department of Transportation, Federal Highway Administration, 2006) or the FTA Manual²¹.

20 For the assessment described in this report, the potential impact of roadway restoration on Queens Quay West between Bay Street and Yonge Street was assessed based on a construction area that was limited to the road surface (i.e. from curb to curb). The restoration of roadway East of Bay Street on Queens Quay West is expected to be completed by another group (Waterfront Toronto), and no references have been made in this study to the associated design (Waterfront East LRT – Area 2A).

21 See *Table 7-1* of the FTA Manual.



Table 4.3.2.1.1. Expected Construction Equipment and Corresponding Noise Emission Levels – Union Station

Equipment	Typical Noise Level 50 ft from Source [dBA]	Construction Staging				
		Layout 1 (Phase 1/2)	Layout 2 (Phase 3/4/5)	Layout 3 (Phase 6)	Layout 4 (Phase 7)	Layout 5 (Phase 8)
Air Compressor	80	Y	Y	Y	Y	Y
Backhoe	80	Y	Y	Y	Y	- ¹
Concrete Mixer	85	Y	Y	Y	Y	Y
Concrete Pump	82	Y	Y	Y	Y	Y
Crane	85	Y	Y	Y	Y	Y
Dozer	85	Y	Y	Y	Y	Y
Drill Rig	84	Y	Y	Y	Y	- ¹
Excavator	85	Y	Y	Y	Y	- ¹
Flat Bed Truck	84	Y	Y	Y	Y	Y
Front End Loader	80	Y	Y	Y	Y	Y
Generator	82	Y	Y	Y	Y	Y
Hydraulic Breaker	90	Y	Y	Y	Y	- ¹
Roller	85	Y	Y	Y	Y	Y
Spike Driver	77	- ¹	- ¹	- ¹	- ¹	Y ²
Tie Cutter	84	- ¹	- ¹	- ¹	- ¹	Y ²
Tie Handler	80	- ¹	- ¹	- ¹	- ¹	Y ²
Tie Inserter	85	- ¹	- ¹	- ¹	- ¹	Y ²

Note(s)

1. Not expected to be used for the identified phase of construction.
2. The installation of tracks in tunnel is expected to be underground (i.e. under decking/pavement). The noise emissions from corresponding equipment are considered insignificant for the zone of influence study where surface equipment is of greater concern.



Table 4.3.2.1.2. Expected Construction Equipment and Corresponding Noise Emission Levels – Queens Quay Station

Equipment	Typical Noise Level 50 ft from Source [dBA]	Construction Staging							
		Layout 1 (Phase 1)	Layout 2 (Phase 2)	Layout 3 (Phase 3)	Layout 4 (Phase 4)	Layout 5 (Phase 5)	Layout 6 (Phase 6)	Layout 7 (Phase 7)	Layout 8 (Phase 8)
Air Compressor	80	Y	Y	Y	Y	Y	Y	Y	Y
Backhoe	80	Y	Y	Y	Y	Y	Y	Y	- ¹
Concrete Mixer	85	Y	Y	Y	Y	Y	Y	Y	Y
Concrete Pump	82	Y	Y	Y	Y	Y	Y	Y	Y
Crane	85	Y	Y	Y	Y	Y	Y	Y	Y
Dozer	85	Y	Y	Y	Y	Y	Y	Y	Y
Drill Rig	84	Y	Y	Y	Y	Y	Y	Y	- ¹
Excavator	85	Y	Y	Y	Y	Y	Y	Y	- ¹
Flat Bed Truck	84	Y	Y	Y	Y	Y	Y	Y	Y
Front End Loader	80	Y	Y	Y	Y	Y	Y	Y	Y
Generator	82	Y	Y	Y	Y	Y	Y	Y	Y
Hydraulic Breaker	90	Y	Y	Y	Y	- ¹	Y	Y	- ¹
Roller	85	Y	Y	Y	Y	Y	Y	Y	Y
Spike Driver	77	Y	- ¹	- ¹	- ¹	Y	- ¹	- ¹	Y ²
Tie Cutter	84	Y	- ¹	- ¹	- ¹	Y	- ¹	- ¹	Y ²
Tie Handler	80	Y	- ¹	- ¹	- ¹	Y	- ¹	- ¹	Y ²
Tie Inserter	85	Y	- ¹	- ¹	- ¹	Y	- ¹	- ¹	Y ²

Note(s)

1. Not expected to be used for the identified phase of construction.
2. The installation of tracks in tunnel is expected to be underground (i.e. under decking/pavement). The noise emissions from corresponding equipment are considered insignificant for the zone of influence study where surface equipment is of greater concern.



Following the noise assessment methodology described in Section 4.2.1, for each stage of construction work, the combined noise level in one hour from the two noisiest classes of construction equipment anticipated for the construction work was evaluated. The ZOI for various land uses as defined in Table 4.1.1.1 was calculated based on the identified criteria.

Table 4.3.2.1.3 shows the ZOI setback distance for each of the construction staging arrangements at the Union Station site and Queens Quay Station site.

Table 4.3.2.1.3. Construction Noise Zone of Influence

Site	Construction Staging	Land Use	Distance to Impact ¹ [m]	
			Day	Night
Union Station	Layout 1 (Phase 1/2)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 2 (Phase 3/4/5)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 3 (Phase 6)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 4 (Phase 7)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 5 (Phase 8)	Residential	13	39
		Commercial	4	4
		Industrial	4	4
Queens Quay Station	Layout 1 (Phase 1)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 2 (Phase 2)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 3 (Phase 3)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 4 (Phase 4)	Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 5 (Phase 5)	Residential	13	39
		Commercial	4	4
		Industrial	4	4
	Layout 6 (Phase 6)	Residential	18	56
		Commercial	6	6



Site	Construction Staging	Land Use	Distance to Impact ¹ [m]	
			Day	Night
	Layout 7 (Phase 7)	Industrial	6	6
		Residential	18	56
		Commercial	6	6
		Industrial	6	6
	Layout 8 (Phase 8)	Residential	13	39
		Commercial	4	4
		Industrial	4	4

Note(s)

1. Measured from the boundary of the corresponding construction area.

4.3.2.2 Identified Sensitive Receptors

An overview of the ZOI identified in Table 4.3.2.1.3 has been conducted with the ZOI overlaid on the aerial map at each site. The results are presented in a series of maps included in Appendix C. A number of potentially impacted receptors²² have been identified and a summary of the construction noise impacts has been provided in Table 4.3.2.2.1.

Table 4.3.2.2.1. Summary of Construction Noise Impact

Site	Construction Staging	Land Use	Number of Buildings within ZOI	
			Day	Night
Union Station	Layout 1 (Phase 1/2)	Residential	0	0
		Commercial	3	3
		Industrial	0	0
	Layout 2 (Phase 3/4/5)	Residential	0	0
		Commercial	2	2
		Industrial	0	0
	Layout 3 (Phase 6)	Residential	0	0
		Commercial	1	1
		Industrial	0	0
	Layout 4 (Phase 7)	Residential	0	1
		Commercial	1	1
		Industrial	0	0
	Layout 5 (Phase 8)	Residential	0	1
		Commercial	1	1
		Industrial	0	0

²² The receptors assessed in this study have been identified based on existing buildings and land uses. Although active developments have been identified near the Project area, e.g. 141, 30 and 11 Bay Street developments, the respective completion timeline relative to the Project construction timeline is yet to be defined.



Site	Construction Staging	Land Use	Number of Buildings within ZOI	
			Day	Night
Queens Quay Station	Layout 1 (Phase 1)	Residential	2	3
		Commercial	0	0
		Industrial	0	0
	Layout 2 (Phase 2)	Residential	0	2
		Commercial	1	1
		Industrial	0	0
	Layout 3 (Phase 3)	Residential	0	2
		Commercial	1	1
		Industrial	0	0
	Layout 4 (Phase 4)	Residential	2	2
		Commercial	0	0
		Industrial	0	0
	Layout 5 (Phase 5)	Residential	2	2
		Commercial	0	0
		Industrial	0	0
	Layout 6 (Phase 6)	Residential	0	3
		Commercial	2	2
		Industrial	0	0
	Layout 7 (Phase 7)	Residential	0	3
		Commercial	1	1
		Industrial	0	0
	Layout 8 (Phase 8)	Residential	4	5
		Commercial	0	0
		Industrial	0	0

4.3.2.3 Construction Noise Control

The noise performance requirements for the Project, as identified in Section 4.1.1 and in the previous Preliminary Noise Study report (version R1), include noise source emission limits which apply to the equipment utilized during construction. The TTC Design Manual DM-0106-00 (Toronto Transit Commission, Sep. 14, 2011) references the MECP²³ publication NPC-115 which establishes source-based noise emission limits for construction equipment. For the assessment described in this report, the equipment expected to be used for the construction along with the emission values which were used in the ZOI calculation have been summarized in Table 14. These emission values were obtained based on the FHWA material which is generally more stringent and contains details for a greater range of equipment than the NPC-115. Therefore, these values are considered to be representing the constraints on the equipment to be used in the construction.

²³ At the time of publication MECP was the Ministry of the Environment (MOE)



The noise ZOI assessment conducted has been prepared to support possible noise by-law exemption applications (§591-3.2, Toronto Municipal Code). The assessment results indicate the potential for sensitive receptors to be located within the identified construction noise ZOI. A noise control plan is thus recommended for the Project at those locations identified in Section 4.3.2.2. Considerations for the construction noise control plan have been incorporated into the Noise and Vibration Control Measures (NVCM) proposed for the Project. Further discussions of the NVCM can be found in Section 4.4 and the Noise and Vibration Control Measures report (Wood Environment & Infrastructure Solutions, July 2021).

4.3.3 Construction Vibration

4.3.3.1 Predicted Zone of Influence

Table 4.3.3.1.1 shows the anticipated pieces of construction equipment which represent significant vibration sources with respect to each construction phase. The vibration source levels at 25 ft in terms of peak particle velocity (PPV) values are also included in the table which were taken from the FTA Manual and CALTRANS Manual (California Department of Transportation, September 2013).



Table 4.3.3.1.1. Expected Construction Equipment and Corresponding Vibration Source Levels – Union Station

Equipment	PPV at 25 ft from Source [in/sec]	Construction Staging				
		Layout 1 (Phase 1/2)	Layout 2 (Phase 3/4/5)	Layout 3 (Phase 6)	Layout 4 (Phase 7)	Layout 5 (Phase 8)
Caisson Drilling	0.089	Y	Y	Y	Y	- ²
Large Bulldozer	0.089	Y	Y	Y	Y	Y
Loaded Trucks	0.076	Y	Y	Y	Y	Y
Vibratory Roller	0.21	Y	Y	Y	Y	Y
Hydraulic Breaker ¹	0.24	Y	Y	Y	Y	- ²

Note(s)

1. The assessment of hydraulic breaker was based on equipment with a rated energy level of 5,000 ft-lbs.
2. Not expected to be used for the identified phase of construction.

Table 4.3.3.1.2. Expected Construction Equipment and Corresponding Vibration Source Levels – Queens Quay Station

Equipment	PPV at 25 ft from Source [in/sec]	Construction Staging							
		Layout 1 (Phase 1)	Layout 2 (Phase 2)	Layout 3 (Phase 3)	Layout 4 (Phase 4)	Layout 5 (Phase 5)	Layout 6 (Phase 6)	Layout 7 (Phase 7)	Layout 8 (Phase 8)
Caisson Drilling	0.089	Y	Y	Y	Y	Y	Y	Y	- ²
Large Bulldozer	0.089	Y	Y	Y	Y	Y	Y	Y	Y
Loaded Trucks	0.076	Y	Y	Y	Y	Y	Y	Y	Y
Vibratory Roller	0.21	Y	Y	Y	Y	Y	Y	Y	Y
Hydraulic Breaker ¹	0.24	Y	Y	Y	Y	Y	Y	Y	- ²

Note(s)

1. The assessment of hydraulic breaker was based on equipment with a rated energy level of 5,000 ft-lbs.
2. Not expected to be used for the identified phase of construction.



The methodology described in Section 4.2.2 was used to identify the ZOI. A soil class II²⁴ was considered representative of the area of construction, taking into consideration the description of the soils in the following reference reports:

- “Union Station - Queens Quay Transit Link, Preliminary Geotechnical Design Report, Queens Quay LRT Station Expansion, Contract G85-395 (Draft)” (TORONTO TRANSIT COMMISSION, July 2020), dated July 2020; and
- “Union Station - Queens Quay Transit Link, Preliminary Geotechnical Design Report, Union LRT Station Expansion, Contract G85-395 (Draft)” (TORONTO TRANSIT COMMISSION, July 2020), dated July 2020.

Table 4.3.3.1.3 shows the ZOI setback distance for each of the anticipated pieces of construction equipment which are considered to represent significant vibration sources. Based on the expected usage of equipment for each stage, the ZOI for construction vibration impacts has been summarized in Table 4.3.3.1.4.

Table 4.3.3.1.3. Calculated Vibration Zone of Influence for Construction Equipment

Equipment	ZOI Setback Distance (PPV ≤ 5 mm/s) [m]
Caisson Drilling	5
Large Bulldozer	5
Loaded Trucks	4
Vibratory Roller	9
Hydraulic Breaker ¹	9

Note(s): 1. Calculated based on equipment with a rated energy level of 5,000 ft-lbs.

Table 4.3.3.1.4. Construction Vibration Zone of Influence

Site	Construction Staging	Distance to Impact ¹ [m]
Union Station	Layout 1 (Phase 1/2)	9
	Layout 2 (Phase 3/4/5)	9
	Layout 3 (Phase 6)	9
	Layout 4 (Phase 7)	9
	Layout 5 (Phase 8)	9
Queens Quay Station	Layout 1 (Phase 1)	9
	Layout 2 (Phase 2)	9
	Layout 3 (Phase 3)	9
	Layout 4 (Phase 4)	9
	Layout 5 (Phase 5)	9

²⁴ As defined in *Table 17* of the CALTRANS Manual, Soil Class II is described as “Competent soils: most sands, sandy clays, silty clays, gravel, silts, weathered rock (can dig with shovel)” [15]. Therefore, from the table, the applicable vibration attenuation rate is represented with an “n”-value of 1.3.



Site	Construction Staging	Distance to Impact ¹ [m]
	Layout 6 (Phase 6)	9
	Layout 7 (Phase 7)	9
	Layout 8 (Phase 8)	9

Note(s)

1. Measured from the boundary of the corresponding construction area.

4.3.3.2 Heritage Building

Chapter §363-5.3 D(4) of the Toronto Municipal Code requires that in the determination of construction ZOI, the presence of heritage designated or listed properties and sensitive structures or buildings or infrastructure should be investigated. As such, a search was conducted based on the City of Toronto Heritage Property Search database.

Three heritage buildings have been found to be in close proximity of the construction site and are identified to be within the ZOI during the Union Station site construction. These include:

- Union Station - 61, 65 Front Street W, Toronto;
- 1 Front Street W, Toronto; and
- 40 Bay Street, Toronto.

4.3.3.3 Identified Sensitive Receptors

A total of twelve (12) buildings have been identified to be under potential impacts from the construction vibration throughout various stages of the construction. The number of buildings²¹ within the ZOI for each stage and at each site has been summarized in Table 4.3.3.3.1. Aerial maps can be found in Appendix C which present the extent of the vibration ZOI at each site.

Table 4.3.3.3.1. Summary of Construction Vibration Impact

Site	Construction Staging	Number of Buildings within ZOI	
		Heritage Building	Non-Heritage Building
Union Station	Layout 1 (Phase 1/2)	2	1
	Layout 2 (Phase 3/4/5)	2	1
	Layout 3 (Phase 6)	1	1
	Layout 4 (Phase 7)	0	1
	Layout 5 (Phase 8)	2	2
Queens Quay Station	Layout 1 (Phase 1)	0	0
	Layout 2 (Phase 2)	0	1



Site	Construction Staging	Number of Buildings within ZOI	
		Heritage Building	Non-Heritage Building
	Layout 3 (Phase 3)	0	1
	Layout 4 (Phase 4)	0	1
	Layout 5 (Phase 5)	0	0
	Layout 6 (Phase 6)	0	2
	Layout 7 (Phase 7)	0	1
	Layout 8 (Phase 8)	0	7

4.3.3.4 Construction Vibration Control

The assessment results presented in the previous sections indicate the potential for the construction vibration ZOI to extend to buildings adjacent to the construction site including three heritage buildings. As outlined in Chapter §363-5 of the Toronto Municipal Code, a series of requirements need to be fulfilled to support an application for a building permit such as:

- Pre-construction consultation with all property owners and occupants within the ZOI before proceeding with the work;
- Pre-construction measurements of background vibrations within the ZOI;
- Pre-construction inspection of adjacent buildings and structures within the ZOI;
- Identification of mitigation measures to reduce the impacts of construction-related vibrations;
- A monitoring program to measure variances in the vibration levels before and during construction activities; and
- Provision of public communications and compliant protocols.

The items listed above represent specific requirements to be considered for the Project construction in relation to a building permit application in accordance with the City of Toronto Municipal Code Chapter 363. No further discussions have been provided in this section as the specific permit requirements are yet to be defined due to the early stage of the Project and the preparation of permitting deliverables have been excluded from the scope of this study.

4.4 Noise and Vibration Control Measures

Based on the potential for sensitive receptors to be located within the identified ZOI's for both construction noise and vibration, Noise and Vibration Control Measures (NVCM) have been recommended for the Project and documented in a report under a separate cover (Wood Environment & Infrastructure Solutions, July 2021).

The construction noise and vibration assessment conducted as part of the Preliminary Noise Study highlights the specific construction phases/activities which have the potential to adversely affect sensitive areas surrounding the Project. These construction phases/activities may require additional analysis to identify specific, feasible and



actionable mitigation measures which cannot be identified at this level of Project design. As such, the NVCM is intended to advise a high-level approach to noise and vibration control during the construction of the Project. It presents a framework that can be used as risk management and mitigations relative to potential noise and vibration impacts from the construction. The items discussed in the NVCM do not represent specific Project commitment given the early stages of the design.



5.0 Conclusions

This report presents the Preliminary Noise Study conducted for the expansion of the existing Union Light Rail Transit (LRT) and Queens Quay LRT Stations and new running tunnel and portal as part of the Waterfront East LRT (WELRT) project.

The design criteria, noise and vibration assessment and design considerations outlined in this report will be used as supporting materials in developing the Baseline Design of the Project.

Based on the information presented within this report the following conclusions can be summarized:

- **Union and Queens Quay Stations:**
 - The expected performance of the station spaces in terms of indoor acoustical environment and the design recommendations are presented in Section 2.1. Assessment of the indoor acoustical performance is recommended for later stages of the Project when relevant design information becomes available;
 - The expected performance of the station spaces in terms of outdoor emissions and the design recommendations are presented in Section 2.2. Assessment of the outdoor noise impacts of the station operation has been conducted in accordance with the MECP NPC-300. Target sound power levels have been provided for the ventilation shafts at the Union and Queens Quay Stations.
- **Streetcar Operations:**
 - Assessment of operational noise and vibration impacts has been conducted based on the information available at current stage of design and the FTA general assessment methodologies;
 - It is expected that the Project will not result in noise nor vibration related operational impacts.
- **Construction:**
 - Assessment of the noise and vibration Zones of Influence has been conducted based on the information available at current stage of design;
 - Potential construction noise impacts have been identified to occur during both daytime and nighttime work scenarios at the Union Station and Queens Quay Station sites;
 - Potential construction vibration impacts have been identified at both the Union Station and Queens Quay Station sites. Three heritage buildings have been found to be within the vibration ZOI of the construction work at the Union Station site;
 - A Noise and Vibration Control Measures (NVCM) document has been prepared for the Project to provide a framework for risk management and mitigations relative to potential noise and vibration impacts from the construction.



6.0 References

- British Standards Institution (BSI). (2009). *BS 5228-2, Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration*.
- California Department of Transportation. (September 2013). *Transportation and Construction Vibration Guidance Manual*.
- City of Toronto Council. (2019). *City of Toronto Municipal Code, Chapter 363, Building Construction and Demolition*.
- City of Toronto Council. (2019). *City of Toronto Municipal Code, Chapter 591, Noise*.
- Hanson, C. E., Ross, J. C., & Towers, D. A. (2012, September). *High-Speed Ground Transportation Noise and Vibration Impact Assessment*. Washington: U.S. Department of Transportation, Federal Railroad Administration - Office of Railroad Policy and Development. doi:DOT/FRA/ORD-12/15
- MOE/TTC. (December 4, 1992). *Protocol for Noise and Vibration Assessment for the Spadina Light Rail Transit Line*.
- (February 2021). *OISO52004-MEM-011 R0, TTC Waterfront East LRT Design Study - Passenger Flow Modelling Methodology (DRAFT)*.
- Ontario Ministry of the Environment and Climate Change (MOECC). (August 2013). *Publication NPC-300, Noise Assessment Criteria for Stationary Sources and for Land Use Planning*.
- Ontario Ministry of the Environment and Climate Change. (1977). *Publication NPC-115 Construction Equipment, published under the Model Municipal Noise Control Bylaw*.
- (2016). *Ontario Regulation 381/15 - Noise Regulation under the Occupational Health and Safety Act*.
- Quagliata, A., Ahearn, M., Boeker, E., Roof, C., Meister, L., & Singleton, H. (2018). *Transit Noise and Vibration Impact Assessment Manual*. Washington, D.C.: U.S. Department of Transportation, Federal Transit Administration - Office of Planning and Environment.
- Toronto Transit Commission. (Aug. 15, 2011). *Design Manual DM-0403-00, Stations, Acoustics, General*.
- TORONTO TRANSIT COMMISSION. (July 2020). *Union Station - Queens Quay Transit Link, Preliminary Geotechnical Design Report, Queens Quay LRT Station Expansion, Contract G85-395*.
- TORONTO TRANSIT COMMISSION. (July 2020). *Union Station - Queens Quay Transit Link, Preliminary Geotechnical Design Report, Union LRT Station Expansion, Contract G85-395*.
- Toronto Transit Commission. (Nov. 4, 2019). *Design Manual DM-0803-06, Systems, Communications, Public Address System*.
- Toronto Transit Commission. (Sep. 14, 2011). *Design Manual DM-0106-00, General, Noise & Vibration, General*.
- U.S. Department of Transportation, Federal Highway Administration. (2006). *FHWA Roadway Construction Noise Model User's Guide*.
- U.S. Department of Transportation, Federal Highway Administration. (August 2006). *Construction Noise Handbook (FHWA-HEP-06-015)*.
- Wood Environment & Infrastructure Solutions. (12/16/2020). *OISO52004-REP-024 R3 Track Design Brief*.
- Wood Environment & Infrastructure Solutions. (16/12/2020). *OISO52004-REP-004 R1 Preliminary Noise Study*.
- Wood Environment & Infrastructure Solutions. (July 2021). *OISO52004-REP-050 R0 Noise and Vibration Control Measures*.

Appendix A

Station Acoustical Design and Assessment



Section	Subject	15-AUG-2011 PENDING APPROVAL	Page
ACOUSTICS	General		3

TABLE 2
STATION ROOM DESIGN SOUND LEVELS

		MAXIMUM SOUND LEVEL (dBA)
	SPACE DESIGNATION	
•	PUBLIC	
	Control Areas	55
	Public Areas and Passageways	55
	Subway, SRT and LRT Platforms	55
	Public Washrooms	55
•	STAFF	
	Collector's Booth	50
	Collector's Lobby	65
	Collector's Washroom	65
	Train Operators' Lunchroom	50
	Train Operators' Washroom	65
	Bus Operators' Lunchroom	50
	Bus Operators' Washrooms	65
	Attendants' Room	50
	Inspector's Room	50
	Staff Washrooms	65
•	LEASED AREAS	
	Retail Stores and Storage	55
	Kiosks and Storage	55
	Retail Carts (ATM and Vending Machine)	55
•	ELECTRICAL RELATED SERVICE ROOMS	
	AC Switchboard Room	65
	Emergency Power Room	65
	Switchgear Room	65
	Communication Equipment Room	65
	Telephone Equipment Room	65
	Traction Power Room	65



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**TABLE 2
STATION ROOM DESIGN SOUND LEVELS (con't)**

		MAXIMUM SOUND LEVEL (dBA)
•	MECHANICAL RELATED SERVICE ROOMS	
	Line Mechanic's Service Room	50
	Pump Room	85
	Refuse Storage Room	85
	Mechanical Room	65
	Valve Room	85
	Janitor Service Room	85
	Janitorial Machine Room	85
	Janitorial Relamper's Room	85
	Plant Maintenance and Storage Room	65
	Fire Prevention Room	65
	Maintenance Rooms	65
	Mechanical Storage Rooms	85
	HVAC Room	85
	Fire Booster Pump Room	85
•	SIGNAL RELATED SERVICE ROOMS	
	Local Tower Room	50
	Signal Relay Room	65
	Signal Power Supply Room	65
	Signal Maintainers' Room	65
	Signal Maintainers' Washroom	65
	Zone Control Panel Room	50
	Signal Maintainer's Lunchroom	50
	Signal Storage Room	85
	M.A. Room	85



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TABLE 2
STATION ROOM DESIGN SOUND LEVELS (con't)

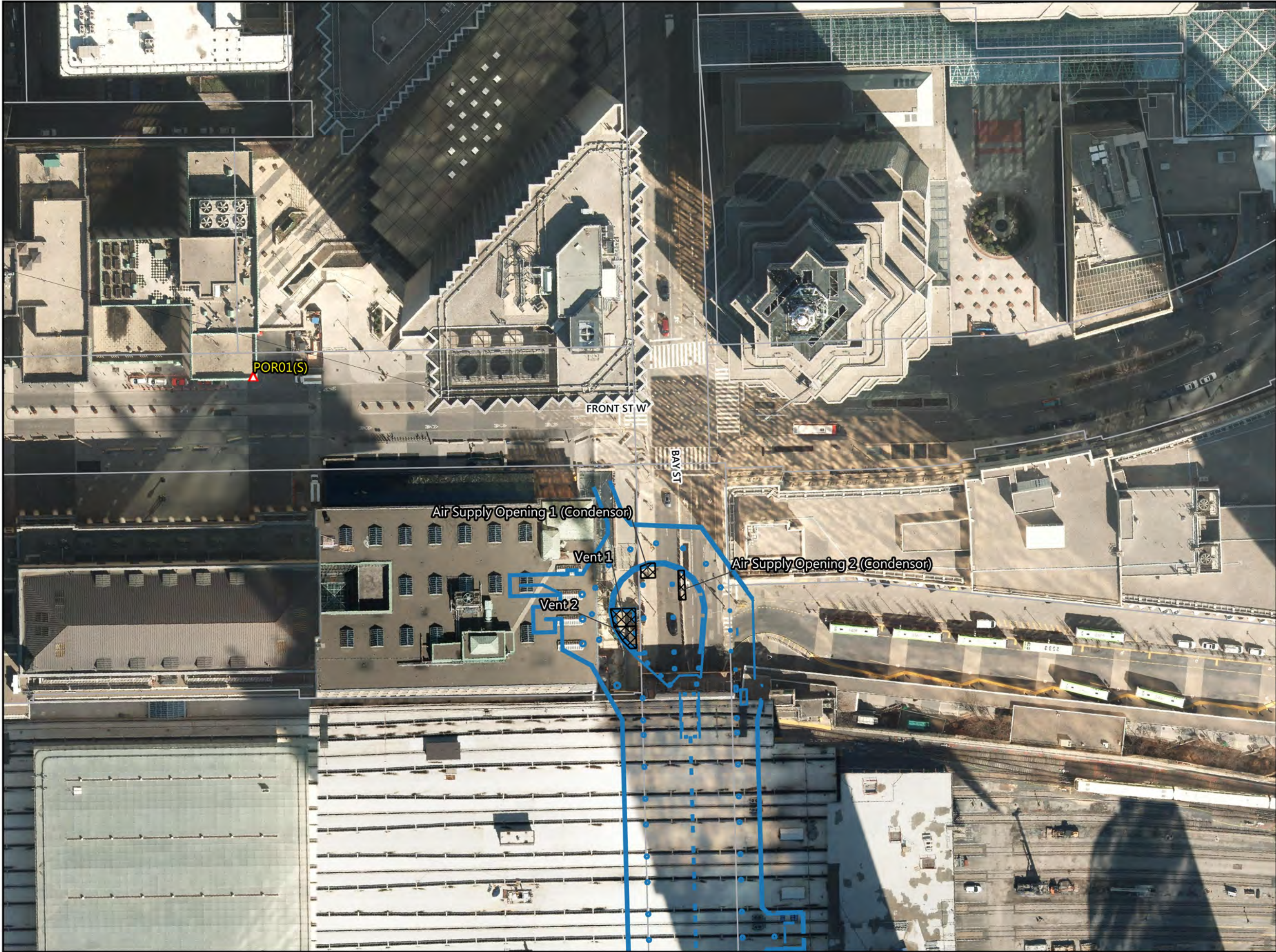
		MAXIMUM SOUND LEVEL (dBA)
•	ANCILLARY SPACES	
	Elevator Shaft	50
	Escalator Service Room	85
	Elevator Machine Room	85
	Security Room	50
	Track Patrol Room	65
•	ELECTRICAL SUBSTATION	
	Entrance Metering	85
	Control Room	65
	Rectifier Room	65
	Cable Room/Pit	85
	Washroom	65
	Battery Room	65
	Lunchroom – Terminal	50
	Storage Room	85
•	EMERG. SERVICE BLDG.	
	Fan Room	85
	Electrical Room (incl. Bat. area)	85
	Diesel Generator Room	85

2.5 **COMMUNITY**

2.5.1 The impact of noise from the normal operation of the station on the community shall be in compliance with the Toronto Noise Bylaw.

2.5.2 Typical predominant noise sources are:

- train operations (subway, LRV)
- work car/maintenance operations particularly at night
- station ventilation
- operation of tunnel ventilation
- routine testing of emergency ventilation at full speed



LEGEND

- Station Layout (Approximate)
- Vent Shaft Opening
- Representative Receptor
- Property Boundary



KEY MAP

NOTES:
- Aerial imagery extracted from ESRI and project database.



TTC Waterfront East LRT
Preliminary Noise Study

**Station Outdoor Impact Assessment
Union
Identified Receptor**

PROJECT NO: OISO52004	FIGURE: A-1
SCALE: 1:1000	DATE: June 2021

Datum & Projection:
NAD 27 / MTM zone 10



- LEGEND**
- Station Layout (Platform Level, Approximate)
 - Station Layout (Ped. Tunnel Level, Approximate)
 - Vent Shaft Opening
 - Representative Receptor
 - Property Boundary



NOTES:
- Aerial imagery extracted from ESRI and project database.



TTC Waterfront East LRT
Preliminary Noise Study

**Station Outdoor Impact Assessment
Queens Quay
Identified Receptor**

PROJECT NO: OISO52004	FIGURE: A-2
SCALE: 1:1000	DATE: June 2021

Datum & Projection:
NAD 27 / MTM zone 10

Table A-1: Future Traffic Data (Year 2025)

Road Name	Speed (km/h)	AM Peak Hour	PM Peak Hour	Estimated AADT	Hourly Daytime Traffic (Lowest Volume)			Hourly Evening Traffic (Lowest Volume)			Hourly Nighttime Traffic (Lowest Volume)		
					Car	Medium Truck	Heavy Truck	Car	Medium Truck	Heavy Truck	Car	Medium Truck	Heavy Truck
Front St (York-Bay)	40	875	780	9750	176	10	10	88	5	5	44	2	2
Harbour St (York-Bay)	50	2264	2221	27763	500	28	28	250	14	14	125	7	7
Harbour St (Bay-Yonge)	50	1797	2021	25263	455	25	25	227	13	13	114	6	6
Queens Quay (Bay-Yonge)	40	1510	1537	19213	346	19	19	173	10	10	86	5	5
Queens Quay (York-Bay)	40	1480	1428	17850	321	18	18	161	9	9	80	4	4

Notes:

1. The AADT estimates were calculated based on the assumptions that the PM peak hour volume represents approximately 8% of the total daily traffic and that the AM peak hour volume represents approximately 10% of the total daily traffic. The higher of the two AADT estimates (i.e. from AM and PM peak hours) in each case was used to represent the traffic volume for a given road segment.
2. Truck volumes were assumed to be 10% of AADT and these were further split into 5% medium trucks and 5% heavy trucks.
3. The roadway speeds are based on existing city road limits or a default city limit of 50 km/h.
4. The lowest hourly volume for day/evening/night traffic is assumed to be approximately 2%, 1% and 0.5% of AADT respectively.

Filename: por01d_s.te Time Period: 1 hours
 Description:

Road data, segment # 1: FRONT ST

Car traffic volume : 176 veh/TimePeriod
 Medium truck volume : 10 veh/TimePeriod
 Heavy truck volume : 10 veh/TimePeriod
 Posted speed limit : 40 km/h
 Road gradient : 0 %
 Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: FRONT ST

Angle1 Angle2 : -86.00 deg 87.00 deg
 Wood depth : 0 (No woods.)
 No of house rows : 0
 Surface : 2 (Reflective ground surface)
 Receiver source distance : 15.00 m
 Receiver height : 7.50 m
 Topography : 1 (Flat/gentle slope; no barrier)
 Reference angle : 0.00

Results segment # 1: FRONT ST

Source height = 1.50 m

ROAD (0.00 + 59.94 + 0.00) = 59.94 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-86	87	0.00	60.11	0.00	0.00	-0.17	0.00	0.00	0.00	59.94

Segment Leq : 59.94 dBA

Total Leq All Segments: 59.94 dBA

TOTAL Leq FROM ALL SOURCES: 59.94

Filename: por01e_s.te Time Period: 1 hours
 Description:

Road data, segment # 1: FRONT ST

Car traffic volume : 88 veh/TimePeriod
 Medium truck volume : 5 veh/TimePeriod
 Heavy truck volume : 5 veh/TimePeriod
 Posted speed limit : 40 km/h
 Road gradient : 0 %
 Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: FRONT ST

Angle1 Angle2 : -86.00 deg 87.00 deg
 Wood depth : 0 (No woods.)
 No of house rows : 0
 Surface : 2 (Reflective ground surface)
 Receiver source distance : 15.00 m
 Receiver height : 7.50 m
 Topography : 1 (Flat/gentle slope; no barrier)
 Reference angle : 0.00

Results segment # 1: FRONT ST

Source height = 1.50 m

ROAD (0.00 + 56.93 + 0.00) = 56.93 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-86	87	0.00	57.10	0.00	0.00	-0.17	0.00	0.00	0.00	56.93

Segment Leq : 56.93 dBA

Total Leq All Segments: 56.93 dBA

TOTAL Leq FROM ALL SOURCES: 56.93

Filename: por01n_s.te Time Period: 1 hours
 Description:

Road data, segment # 1: FRONT ST

Car traffic volume : 44 veh/TimePeriod
 Medium truck volume : 2 veh/TimePeriod
 Heavy truck volume : 2 veh/TimePeriod
 Posted speed limit : 40 km/h
 Road gradient : 0 %
 Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: FRONT ST

Angle1 Angle2 : -86.00 deg 87.00 deg
 Wood depth : 0 (No woods.)
 No of house rows : 0
 Surface : 2 (Reflective ground surface)
 Receiver source distance : 15.00 m
 Receiver height : 7.50 m
 Topography : 1 (Flat/gentle slope; no barrier)
 Reference angle : 0.00

Results segment # 1: FRONT ST

Source height = 1.43 m

ROAD (0.00 + 53.10 + 0.00) = 53.10 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-86	87	0.00	53.28	0.00	0.00	-0.17	0.00	0.00	0.00	53.10

Segment Leq : 53.10 dBA

Total Leq All Segments: 53.10 dBA

TOTAL Leq FROM ALL SOURCES: 53.10

Due to program limitation, STAMSON/ORNAMENT does not allow source-receiver distance under 15 m, additional adjustments was applied to the STAMSON/ORNAMENT output based on the formula: $10 \cdot \log(15/D)$ for refelective ground

$$\begin{aligned} D.Adj &= 10 \cdot \log(15/D) \\ &= 10 \cdot \log(15/10) \\ &= 1.76 \text{ dB} \end{aligned}$$

Day

$$\begin{aligned} Leq^* &= Leq + D.Adj \\ &= 59.94 + 1.76 \\ &= 61.70 \text{ dB} \end{aligned}$$

Evening

$$\begin{aligned} Leq^* &= Leq + D.Adj \\ &= 56.93 + 1.76 \\ &= 58.69 \text{ dB} \end{aligned}$$

Night

$$\begin{aligned} Leq^* &= Leq + D.Adj \\ &= 53.10 + 1.76 \\ &= 54.86 \text{ dB} \end{aligned}$$

Filename: por02d_s.te Time Period: 1 hours
Description:

Road data, segment # 1: HB YORK-BAY

Car traffic volume : 500 veh/TimePeriod
Medium truck volume : 28 veh/TimePeriod
Heavy truck volume : 28 veh/TimePeriod
Posted speed limit : 50 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: HB YORK-BAY

Angle1 Angle2 : 51.00 deg 87.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 15.00 m
Receiver height : 4.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: HB BAY-YON1

Car traffic volume : 455 veh/TimePeriod
Medium truck volume : 25 veh/TimePeriod
Heavy truck volume : 25 veh/TimePeriod
Posted speed limit : 50 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: HB BAY-YON1

Angle1 Angle2 : -80.00 deg 48.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 16.00 m
Receiver height : 4.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 3: HB BAY-YON2

Car traffic volume : 455 veh/TimePeriod
 Medium truck volume : 25 veh/TimePeriod
 Heavy truck volume : 25 veh/TimePeriod
 Posted speed limit : 50 km/h
 Road gradient : 0 %
 Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 3: HB BAY-YON2

Angle1 Angle2 : -79.00 deg -67.00 deg
 Wood depth : 0 (No woods.)
 No of house rows : 0
 Surface : 2 (Reflective ground surface)
 Receiver source distance : 39.00 m
 Receiver height : 4.50 m
 Topography : 1 (Flat/gentle slope; no barrier)
 Reference angle : 0.00

Results segment # 1: HB YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 59.37 + 0.00) = 59.37 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
51	87	0.00	66.36	0.00	0.00	-6.99	0.00	0.00	0.00	59.37

Segment Leq : 59.37 dBA

Results segment # 2: HB BAY-YON1

Source height = 1.49 m

ROAD (0.00 + 64.12 + 0.00) = 64.12 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-80	48	0.00	65.88	0.00	-0.28	-1.48	0.00	0.00	0.00	64.12

Segment Leq : 64.12 dBA

Results segment # 3: HB BAY-YON2

Source height = 1.49 m

ROAD (0.00 + 49.97 + 0.00) = 49.97 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-79	-67	0.00	65.88	0.00	-4.15	-11.76	0.00	0.00	0.00	49.97

Segment Leq : 49.97 dBA

Total Leq All Segments: 65.50 dBA

TOTAL Leq FROM ALL SOURCES: 65.50

Filename: por02e_s.te Time Period: 1 hours
Description:

Road data, segment # 1: HB YORK-BAY

Car traffic volume : 250 veh/TimePeriod
Medium truck volume : 14 veh/TimePeriod
Heavy truck volume : 14 veh/TimePeriod
Posted speed limit : 50 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: HB YORK-BAY

Angle1 Angle2 : 51.00 deg 87.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 15.00 m
Receiver height : 4.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: HB BAY-YON1

Car traffic volume : 227 veh/TimePeriod
Medium truck volume : 13 veh/TimePeriod
Heavy truck volume : 13 veh/TimePeriod
Posted speed limit : 50 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: HB BAY-YON1

Angle1 Angle2 : -80.00 deg 48.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 16.00 m
Receiver height : 4.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 3: HB BAY-YON2

Car traffic volume : 227 veh/TimePeriod
 Medium truck volume : 13 veh/TimePeriod
 Heavy truck volume : 13 veh/TimePeriod
 Posted speed limit : 50 km/h
 Road gradient : 0 %
 Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 3: HB BAY-YON2

Angle1 Angle2 : -79.00 deg -67.00 deg
 Wood depth : 0 (No woods.)
 No of house rows : 0
 Surface : 2 (Reflective ground surface)
 Receiver source distance : 39.00 m
 Receiver height : 4.50 m
 Topography : 1 (Flat/gentle slope; no barrier)
 Reference angle : 0.00

Results segment # 1: HB YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 56.36 + 0.00) = 56.36 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
51	87	0.00	63.35	0.00	0.00	-6.99	0.00	0.00	0.00	56.36

Segment Leq : 56.36 dBA

Results segment # 2: HB BAY-YON1

Source height = 1.51 m

ROAD (0.00 + 61.24 + 0.00) = 61.24 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-80	48	0.00	63.01	0.00	-0.28	-1.48	0.00	0.00	0.00	61.24

Segment Leq : 61.24 dBA

Results segment # 3: HB BAY-YON2

Source height = 1.51 m

ROAD (0.00 + 47.09 + 0.00) = 47.09 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-79	-67	0.00	63.01	0.00	-4.15	-11.76	0.00	0.00	0.00	47.09

Segment Leq : 47.09 dBA

Total Leq All Segments: 62.59 dBA

TOTAL Leq FROM ALL SOURCES: 62.59

Filename: por02n_s.te Time Period: 1 hours
Description:

Road data, segment # 1: HB YORK-BAY

Car traffic volume	:	125	veh/TimePeriod
Medium truck volume	:	7	veh/TimePeriod
Heavy truck volume	:	7	veh/TimePeriod
Posted speed limit	:	50	km/h
Road gradient	:	0	%
Road pavement	:	1	(Typical asphalt or concrete)

Data for Segment # 1: HB YORK-BAY

Angle1	Angle2	:	51.00	deg	87.00	deg
Wood depth	:	0	(No woods.)			
No of house rows	:	0				
Surface	:	2	(Reflective ground surface)			
Receiver source distance	:	15.00	m			
Receiver height	:	4.50	m			
Topography	:	1	(Flat/gentle slope; no barrier)			
Reference angle	:	0.00				

Road data, segment # 2: HB BAY-YON1

Car traffic volume	:	114	veh/TimePeriod
Medium truck volume	:	6	veh/TimePeriod
Heavy truck volume	:	6	veh/TimePeriod
Posted speed limit	:	50	km/h
Road gradient	:	0	%
Road pavement	:	1	(Typical asphalt or concrete)

Data for Segment # 2: HB BAY-YON1

Angle1	Angle2	:	-80.00	deg	48.00	deg
Wood depth	:	0	(No woods.)			
No of house rows	:	0				
Surface	:	2	(Reflective ground surface)			
Receiver source distance	:	16.00	m			
Receiver height	:	4.50	m			
Topography	:	1	(Flat/gentle slope; no barrier)			
Reference angle	:	0.00				

Road data, segment # 3: HB BAY-YON2

Car traffic volume : 114 veh/TimePeriod
 Medium truck volume : 6 veh/TimePeriod
 Heavy truck volume : 6 veh/TimePeriod
 Posted speed limit : 50 km/h
 Road gradient : 0 %
 Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 3: HB BAY-YON2

Angle1 Angle2 : -79.00 deg -67.00 deg
 Wood depth : 0 (No woods.)
 No of house rows : 0
 Surface : 2 (Reflective ground surface)
 Receiver source distance : 39.00 m
 Receiver height : 4.50 m
 Topography : 1 (Flat/gentle slope; no barrier)
 Reference angle : 0.00

Results segment # 1: HB YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 53.35 + 0.00) = 53.35 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
51	87	0.00	60.33	0.00	0.00	-6.99	0.00	0.00	0.00	53.35

Segment Leq : 53.35 dBA

Results segment # 2: HB BAY-YON1

Source height = 1.48 m

ROAD (0.00 + 57.96 + 0.00) = 57.96 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-80	48	0.00	59.72	0.00	-0.28	-1.48	0.00	0.00	0.00	57.96

Segment Leq : 57.96 dBA

Results segment # 3: HB BAY-YON2

Source height = 1.48 m

ROAD (0.00 + 43.81 + 0.00) = 43.81 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-79	-67	0.00	59.72	0.00	-4.15	-11.76	0.00	0.00	0.00	43.81

Segment Leq : 43.81 dBA

Total Leq All Segments: 59.37 dBA

TOTAL Leq FROM ALL SOURCES: 59.37

Filename: por03d_s.te Time Period: 1 hours
Description:

Road data, segment # 1: QQ YORK-BAY

Car traffic volume	:	321 veh/TimePeriod
Medium truck volume	:	18 veh/TimePeriod
Heavy truck volume	:	18 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 1: QQ YORK-BAY

Angle1	Angle2	:	-86.00 deg	-44.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	24.00 m		
Receiver height	:	13.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Road data, segment # 2: QQ BAY-YONGE

Car traffic volume	:	346 veh/TimePeriod
Medium truck volume	:	19 veh/TimePeriod
Heavy truck volume	:	19 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 2: QQ BAY-YONGE

Angle1	Angle2	:	-44.00 deg	83.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	24.00 m		
Receiver height	:	13.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Results segment # 1: QQ YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 54.31 + 0.00) = 54.31 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-86	-44	0.00	62.67	0.00	-2.04	-6.32	0.00	0.00	0.00	54.31

Segment Leq : 54.31 dBA

Results segment # 2: QQ BAY-YONGE

Source height = 1.49 m

ROAD (0.00 + 59.36 + 0.00) = 59.36 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-44	83	0.00	62.92	0.00	-2.04	-1.51	0.00	0.00	0.00	59.36

Segment Leq : 59.36 dBA

Total Leq All Segments: 60.54 dBA

TOTAL Leq FROM ALL SOURCES: 60.54

Filename: por03e_s.te Time Period: 1 hours
Description:

Road data, segment # 1: QQ YORK-BAY

Car traffic volume : 161 veh/TimePeriod
Medium truck volume : 9 veh/TimePeriod
Heavy truck volume : 9 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: QQ YORK-BAY

Angle1 Angle2 : -86.00 deg -44.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 24.00 m
Receiver height : 13.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: QQ BAY-YONGE

Car traffic volume : 173 veh/TimePeriod
Medium truck volume : 10 veh/TimePeriod
Heavy truck volume : 10 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: QQ BAY-YONGE

Angle1 Angle2 : -44.00 deg 83.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 24.00 m
Receiver height : 13.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Results segment # 1: QQ YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 51.30 + 0.00) = 51.30 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-86	-44	0.00	59.66	0.00	-2.04	-6.32	0.00	0.00	0.00	51.30

Segment Leq : 51.30 dBA

Results segment # 2: QQ BAY-YONGE

Source height = 1.51 m

ROAD (0.00 + 56.54 + 0.00) = 56.54 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-44	83	0.00	60.10	0.00	-2.04	-1.51	0.00	0.00	0.00	56.54

Segment Leq : 56.54 dBA

Total Leq All Segments: 57.68 dBA

TOTAL Leq FROM ALL SOURCES: 57.68

Filename: por03n_s.te Time Period: 1 hours
Description:

Road data, segment # 1: QQ YORK-BAY

Car traffic volume	:	80 veh/TimePeriod
Medium truck volume	:	4 veh/TimePeriod
Heavy truck volume	:	4 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 1: QQ YORK-BAY

Angle1	Angle2	:	-86.00 deg	-44.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	24.00 m		
Receiver height	:	13.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Road data, segment # 2: QQ BAY-YONGE

Car traffic volume	:	86 veh/TimePeriod
Medium truck volume	:	5 veh/TimePeriod
Heavy truck volume	:	5 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 2: QQ BAY-YONGE

Angle1	Angle2	:	-44.00 deg	83.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	24.00 m		
Receiver height	:	13.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Results segment # 1: QQ YORK-BAY

Source height = 1.46 m

ROAD (0.00 + 47.85 + 0.00) = 47.85 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-86	-44	0.00	56.22	0.00	-2.04	-6.32	0.00	0.00	0.00	47.85

Segment Leq : 47.85 dBA

Results segment # 2: QQ BAY-YONGE

Source height = 1.51 m

ROAD (0.00 + 53.53 + 0.00) = 53.53 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-44	83	0.00	57.08	0.00	-2.04	-1.51	0.00	0.00	0.00	53.53

Segment Leq : 53.53 dBA

Total Leq All Segments: 54.57 dBA

TOTAL Leq FROM ALL SOURCES: 54.57

Filename: por04d_s.te Time Period: 1 hours
Description:

Road data, segment # 1: QQ YORK-BAY

Car traffic volume : 321 veh/TimePeriod
Medium truck volume : 18 veh/TimePeriod
Heavy truck volume : 18 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: QQ YORK-BAY

Angle1 Angle2 : -85.00 deg 54.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 22.00 m
Receiver height : 7.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: QQ BAY-YONGE

Car traffic volume : 346 veh/TimePeriod
Medium truck volume : 19 veh/TimePeriod
Heavy truck volume : 19 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: QQ BAY-YONGE

Angle1 Angle2 : 54.00 deg 85.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 22.00 m
Receiver height : 7.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Results segment # 1: QQ YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 59.88 + 0.00) = 59.88 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-85	54	0.00	62.67	0.00	-1.66	-1.12	0.00	0.00	0.00	59.88

Segment Leq : 59.88 dBA

Results segment # 2: QQ BAY-YONGE

Source height = 1.49 m

ROAD (0.00 + 53.62 + 0.00) = 53.62 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
54	85	0.00	62.92	0.00	-1.66	-7.64	0.00	0.00	0.00	53.62

Segment Leq : 53.62 dBA

Total Leq All Segments: 60.80 dBA

TOTAL Leq FROM ALL SOURCES: 60.80

Filename: por04e_s.te Time Period: 1 hours
Description:

Road data, segment # 1: QQ YORK-BAY

Car traffic volume	:	161 veh/TimePeriod
Medium truck volume	:	9 veh/TimePeriod
Heavy truck volume	:	9 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 1: QQ YORK-BAY

Angle1	Angle2	:	-85.00 deg	54.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	22.00 m		
Receiver height	:	7.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Road data, segment # 2: QQ BAY-YONGE

Car traffic volume	:	173 veh/TimePeriod
Medium truck volume	:	10 veh/TimePeriod
Heavy truck volume	:	10 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 2: QQ BAY-YONGE

Angle1	Angle2	:	54.00 deg	85.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	22.00 m		
Receiver height	:	7.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Results segment # 1: QQ YORK-BAY

Source height = 1.50 m

ROAD (0.00 + 56.88 + 0.00) = 56.88 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-85	54	0.00	59.66	0.00	-1.66	-1.12	0.00	0.00	0.00	56.88

Segment Leq : 56.88 dBA

Results segment # 2: QQ BAY-YONGE

Source height = 1.51 m

ROAD (0.00 + 50.79 + 0.00) = 50.79 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
54	85	0.00	60.10	0.00	-1.66	-7.64	0.00	0.00	0.00	50.79

Segment Leq : 50.79 dBA

Total Leq All Segments: 57.84 dBA

TOTAL Leq FROM ALL SOURCES: 57.84

Filename: por04n_s.te Time Period: 1 hours
Description:

Road data, segment # 1: QQ YORK-BAY

Car traffic volume	:	80 veh/TimePeriod
Medium truck volume	:	4 veh/TimePeriod
Heavy truck volume	:	4 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 1: QQ YORK-BAY

Angle1	Angle2	:	-85.00 deg	54.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	22.00 m		
Receiver height	:	7.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Road data, segment # 2: QQ BAY-YONGE

Car traffic volume	:	86 veh/TimePeriod
Medium truck volume	:	5 veh/TimePeriod
Heavy truck volume	:	5 veh/TimePeriod
Posted speed limit	:	40 km/h
Road gradient	:	0 %
Road pavement	:	1 (Typical asphalt or concrete)

Data for Segment # 2: QQ BAY-YONGE

Angle1	Angle2	:	54.00 deg	85.00 deg
Wood depth	:	0	(No woods.)	
No of house rows	:	0		
Surface	:	2	(Reflective ground surface)	
Receiver source distance	:	22.00 m		
Receiver height	:	7.50 m		
Topography	:	1	(Flat/gentle slope; no barrier)	
Reference angle	:	0.00		

Results segment # 1: QQ YORK-BAY

Source height = 1.46 m

ROAD (0.00 + 53.43 + 0.00) = 53.43 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-85	54	0.00	56.22	0.00	-1.66	-1.12	0.00	0.00	0.00	53.43

Segment Leq : 53.43 dBA

Results segment # 2: QQ BAY-YONGE

Source height = 1.51 m

ROAD (0.00 + 47.78 + 0.00) = 47.78 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
54	85	0.00	57.08	0.00	-1.66	-7.64	0.00	0.00	0.00	47.78

Segment Leq : 47.78 dBA

Total Leq All Segments: 54.48 dBA

TOTAL Leq FROM ALL SOURCES: 54.48



LEGEND

- Station Layout (Approximate)
- Vent Shaft Opening
- Representative Receptor
- Property Boundary
- Building Outline

Noise Contours (dBA)

45	55	65	75
50	60	70	80

NOTES:
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Station Outdoor Impact Assessment
Union - Regular Operation
Nighttime Noise Contours**

PROJECT NO: OISO52004	FIGURE: A-3
SCALE: 1:1000	DATE: July 2021



LEGEND

- Station Layout (Approximate)
- Vent Shaft Opening
- Representative Receptor
- Property Boundary
- Building Outline

Noise Contours (dBA)

45	55	65	75
50	60	70	80

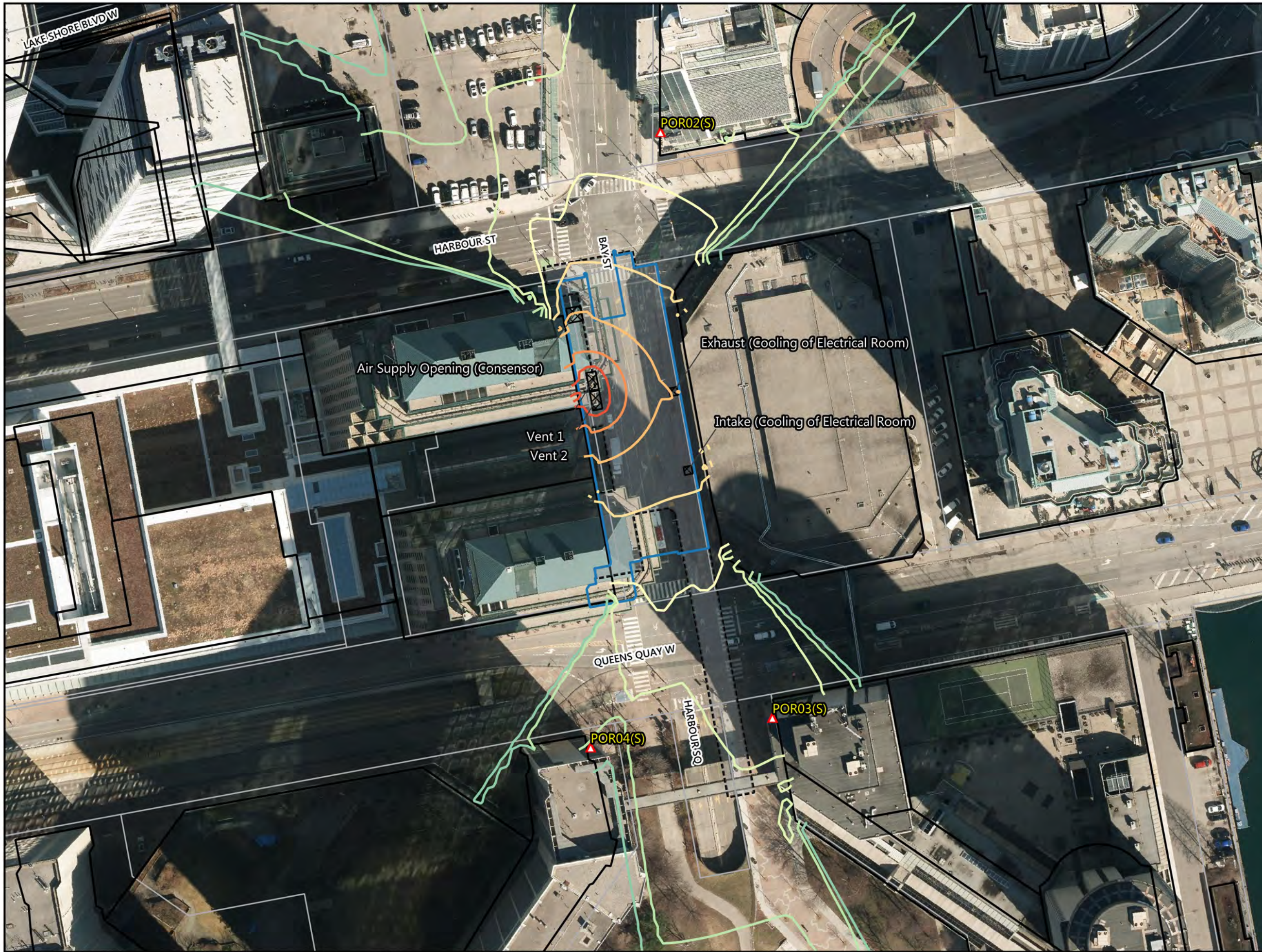
NOTES:

- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Station Outdoor Impact Assessment
Union - Emergency Testing
Nighttime Noise Contours**

PROJECT NO: OISO52004	FIGURE: A-4
SCALE: 1:1000	DATE: July 2021



LEGEND

- Station Layout (Platform Level, Approximate)
- Station Layout (Ped. Tunnel Level, Approximate)
- Vent Shaft Opening
- Representative Receptor
- Property Boundary
- Building Outline

Noise Contours (dBA)

45	55	65	75
50	60	70	80

NOTES:

- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Station Outdoor Impact Assessment
Queens Quay - Regular Operation
Nighttime Noise Contours**

PROJECT NO: OISO52004	FIGURE: A-5
SCALE: 1:1000	DATE: July 2021

Datum & Projection: NAD 27 / MTM zone 10	
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LEGEND

- Station Layout (Platform Level, Approximate)
- Station Layout (Ped. Tunnel Level, Approximate)
- Vent Shaft Opening
- Representative Receptor
- Property Boundary
- Building Outline

Noise Contours (dBA)

45	55	65	75
50	60	70	80

NOTES:

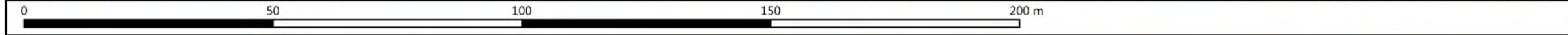
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Station Outdoor Impact Assessment
Queens Quay - Emergency Testing
Nighttime Noise Contours**

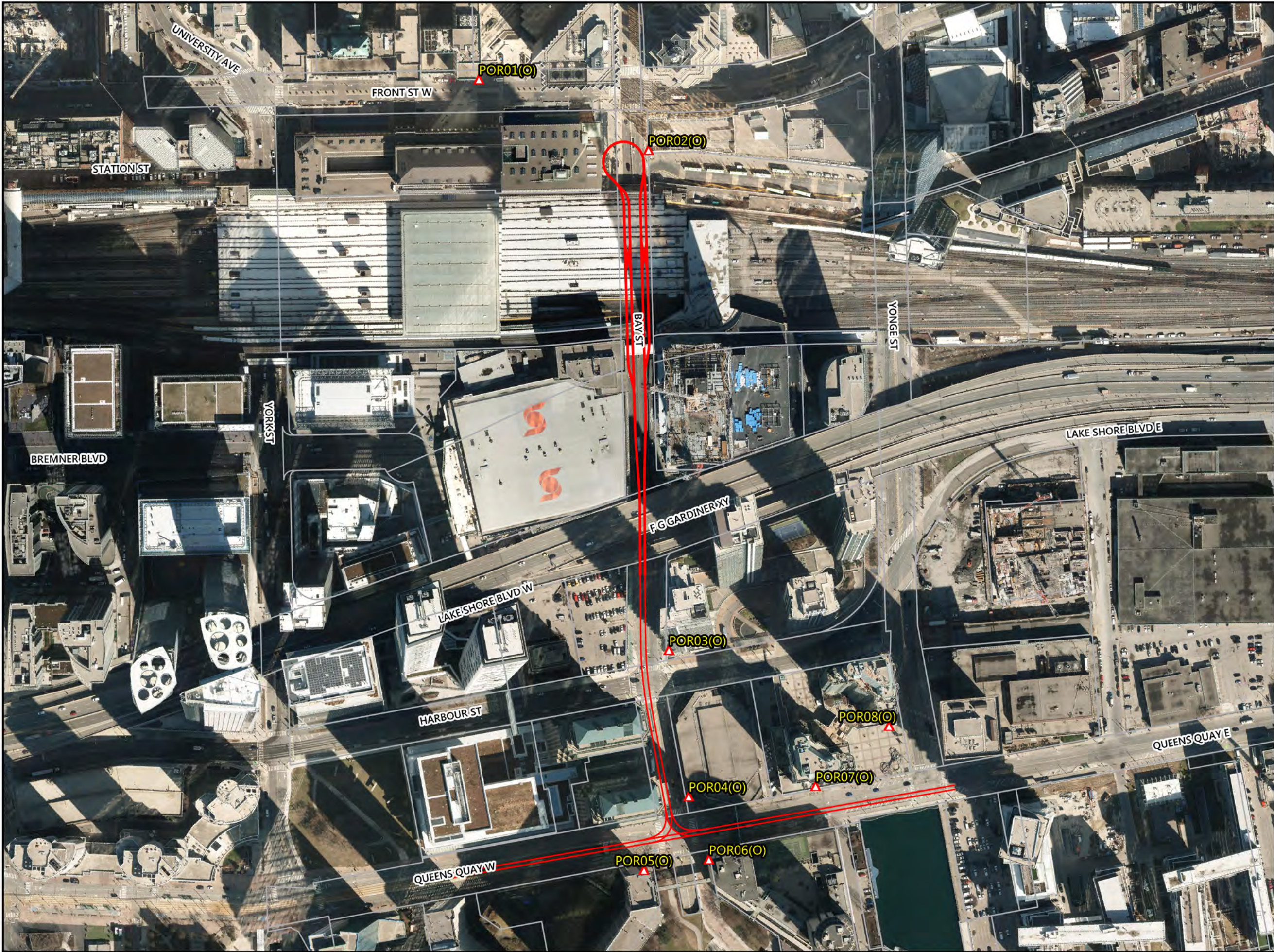
PROJECT NO: OISO52004	FIGURE: A-6
SCALE: 1:1000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



Appendix B

Streetcar Operation Impact Assessment



LEGEND

- Track Alignment
- Representative Receptor
- Property Boundary

NOTES:
- Aerial imagery extracted from ESRI and project database

TTC Waterfront East LRT
Preliminary Noise Study

**Operational Impact Assessment
Identified Receptors**

PROJECT NO: OISO52004	FIGURE: B-1
SCALE: 1:2800	DATE: June 2021

Table B-1: Future Traffic Data (Year 2025)

Road Name	Speed (km/h)	AM Peak Hour	PM Peak Hour	Estimated AADT	Traffic Split		Daytime Traffic (7AM-11PM)			Nighttime Traffic (11PM-7AM)		
					Day	Night	Car	Medium Truck	Heavy Truck	Car	Medium Truck	Heavy Truck
Queens Quay (Bay-Yonge)	40	1510	1537	19213	17291	1921	15562	865	865	1729	96	96
Yonge (Harbour-QQ)	40	679	729	9113	8201	911	7381	410	410	820	46	46
Queens Quay (York-Bay)	40	1480	1428	17850	16065	1785	14459	803	803	1607	89	89

Notes:

1. The AADT estimates were calculated based on the assumptions that the PM peak hour volume represents approximately 8% of the total daily traffic and that the AM peak hour volume represents approximately 10% of the total daily traffic. The higher of the two AADT estimates (i.e. from AM and PM peak hours) in each case was used to represent the traffic volume for a given road segment.
2. Truck volumes were assumed to be 10% of AADT and these were further split into 5% medium trucks and 5% heavy trucks.
3. The roadway speeds are based on existing city road limits or a default city limit of 50 km/h.
4. The day/night traffic split percentages were assumed to be approximately 90% and 10% respectively.

Filename: POR7_0.te Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: QQ BAY-YONGE (day/night)

Car traffic volume : 15562/1729 veh/TimePeriod
Medium truck volume : 865/96 veh/TimePeriod
Heavy truck volume : 865/96 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: QQ BAY-YONGE (day/night)

Angle1 Angle2 : -80.00 deg 83.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 19.00 / 19.00 m
Receiver height : 7.50 / 7.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: QQ YORK-BAY (day/night)

Car traffic volume : 14459/1607 veh/TimePeriod
Medium truck volume : 803/89 veh/TimePeriod
Heavy truck volume : 803/89 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: QQ YORK-BAY (day/night)

Angle1 Angle2 : 83.00 deg 86.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 19.00 / 19.00 m
Receiver height : 7.50 / 7.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Results segment # 1: QQ BAY-YONGE (day)

Source height = 1.50 m

ROAD (0.00 + 65.99 + 0.00) = 65.99 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-80	83	0.00	67.45	0.00	-1.03	-0.43	0.00	0.00	0.00	65.99

Segment Leq : 65.99 dBA

Results segment # 2: QQ YORK-BAY (day)

Source height = 1.50 m

ROAD (0.00 + 48.32 + 0.00) = 48.32 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
83	86	0.00	67.13	0.00	-1.03	-17.78	0.00	0.00	0.00	48.32

Segment Leq : 48.32 dBA

Total Leq All Segments: 66.06 dBA

Results segment # 1: QQ BAY-YONGE (night)

Source height = 1.50 m

ROAD (0.00 + 59.46 + 0.00) = 59.46 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-80	83	0.00	60.91	0.00	-1.03	-0.43	0.00	0.00	0.00	59.46

Segment Leq : 59.46 dBA

Results segment # 2: QQ YORK-BAY (night)

Source height = 1.49 m

ROAD (0.00 + 41.78 + 0.00) = 41.78 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
83	86	0.00	60.59	0.00	-1.03	-17.78	0.00	0.00	0.00	41.78

Segment Leq : 41.78 dBA

Total Leq All Segments: 59.53 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 66.06
(NIGHT): 59.53

Filename: por08_o.te Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: QUEENS QUAY (day/night)

Car traffic volume : 15562/1729 veh/TimePeriod
Medium truck volume : 865/96 veh/TimePeriod
Heavy truck volume : 865/96 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: QUEENS QUAY (day/night)

Angle1 Angle2 : -30.00 deg 30.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 55.00 / 55.00 m
Receiver height : 7.50 / 7.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: YONGE (day/night)

Car traffic volume : 7381/820 veh/TimePeriod
Medium truck volume : 410/46 veh/TimePeriod
Heavy truck volume : 410/46 veh/TimePeriod
Posted speed limit : 40 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: YONGE (day/night)

Angle1 Angle2 : -68.00 deg 68.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 21.00 / 21.00 m
Receiver height : 7.50 / 7.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Results segment # 1: QUEENS QUAY (day)

Source height = 1.50 m

ROAD (0.00 + 57.04 + 0.00) = 57.04 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-30	30	0.00	67.45	0.00	-5.64	-4.77	0.00	0.00	0.00	57.04

Segment Leq : 57.04 dBA

Results segment # 2: YONGE (day)

Source height = 1.50 m

ROAD (0.00 + 61.53 + 0.00) = 61.53 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-68	68	0.00	64.21	0.00	-1.46	-1.22	0.00	0.00	0.00	61.53

Segment Leq : 61.53 dBA

Total Leq All Segments: 62.85 dBA

Results segment # 1: QUEENS QUAY (night)

Source height = 1.50 m

ROAD (0.00 + 50.50 + 0.00) = 50.50 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-30	30	0.00	60.91	0.00	-5.64	-4.77	0.00	0.00	0.00	50.50

Segment Leq : 50.50 dBA

Results segment # 2: YONGE (night)

Source height = 1.50 m

ROAD (0.00 + 55.03 + 0.00) = 55.03 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-68	68	0.00	57.71	0.00	-1.46	-1.22	0.00	0.00	0.00	55.03

Segment Leq : 55.03 dBA

Total Leq All Segments: 56.34 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 62.85
(NIGHT): 56.34

Project: Design Services for Waterfront East LRT
Area: Union Station – Queens Quay Link
Date: July 23, 2021
Document: Table with noise levels



Table Notes:
(A) **Receiver** - Receiver labeling.
(B) **Easting** - Receiver coordinate in MTM Zone 10N.
(C) **Northing** - Receiver coordinate in MTM Zone 10N.
(D) **Land Use** - Land use for a receiver.
(E) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
(F) **Distance to Alignment [ft]** - Distance from receiver location to closest track centerline
(G-M) **Daytime Operation** - Noise level at receiver during daytime.
(G-I) **Noise Level - Track 1** - Noise level at receiver due to train operation on track 1 (closer track), calculated as per FTA General Noise Assessment methodology.
(G) **Noise Level at 50 ft** - Determined per FTA methodology based on several major operational factors: train composition, schedule, speed, special trackwork, etc.
(H) **Distance Correction** - Determined per FTA methodology based on the correction factor of 15log(D/50).
(I) **Noise Level at Receiver** - Determined per FTA methodology based on the noise exposure at 50 ft and distance correction.
(J-L) **Noise Level - Track 2** - Noise level at receiver due to train operation on track 2 (further track), calculated as per FTA General Noise Assessment methodology.
(N) **Noise Level** - Combined daytime noise level at receiver.
(N-T) **Nighttime Operation** - Noise level at receiver during nighttime.
(U) **SEL at Receiver - Track 1** - SEL level at receiver due to train operation on track 1 (closer track), calculated as per FTA General Noise Assessment methodology.
(V) **Approximate Passby Duration** - Approximate duration for streetcar to passby, determined by vehicle length and operation speed.
(W) **Passby Leq** - Passby Leq at receiver calculated using Leq, p,Tp = SEL - 10log(Tp) -1, the 1-dB was introduced based on the guidance provided in the FRA Manual (Section 2.1.3).

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)
Point of Reception				Project Alignment		Daytime Operation							Nighttime Operation							Streetcar Passby		
Receiver	Esting	Northing	Land Use	Train Speed [mph]	Distance to Alignment [ft]	Noise Level - Track 1			Noise Level - Track 2			Noise Level [dBA]	Noise Level - Track 1			Noise Level - Track 2			Noise Level [dBA]	Noise Level - Track 1		
						Noise Level at 50 ft [dBA]	Distance Correction [dB]	Noise Level at Receiver [dBA]	Noise Level at 50 ft [dBA]	Distance Correction [dB]	Noise Level at Receiver [dBA]		Noise Level at 50 ft [dBA]	Distance Correction [dB]	Noise Level at Receiver [dBA]	Noise Level at 50 ft [dBA]	Distance Correction [dB]	Noise Level at Receiver [dBA]		SEL at Receiver [dBA]	Estimated Passby Duration [sec]	Passby Leq [dBA]
POR07(O)	314813.7	4833317.1	Residential	25	60	57.9	-1.2	56.8	57.9	-2.2	55.8	59.3	54.9	-1.2	53.7	54.9	-2.2	52.7	56.3	79.8	2.7	74.5
POR08(O)	314855.3	4833376.3	Residential	25	178	62.9	-8.3	54.7	62.9	-8.6	54.3	57.5	59.9	-8.3	51.7	59.9	-8.6	51.3	54.5	77.7	2.7	72.4

Project: Design Services for Waterfront East LRT
Area: Union Station – Queens Quay Link
Date: July 23, 2021
Document: Table with impact assessment



Table Notes:

- (A) **Receiver** - Receiver labeling
 (B) **Easting** - Receiver coordinate in MTM Zone 10N.
 (C) **Northing** - Receiver coordinate in MTM Zone 10N.
 (D) **Land Use** - Land use for a receiver.
 (E) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
 (F) **Distance to Alignment [ft]** - Distance from receiver location to closest track centerline
 (G) **Noise Limit - Leq, 16hr** - Noise limit for daytime Leq (7AM - 11PM).
 (H) **Noise Limit - Leq, 8hr** - Noise limit for nighttime Leq (11PM - 7AM).
 (I) **Noise Limit - Lpassby** - Noise limit for passby Leq.
 (J) **Noise Level - Leq, 16hr** - Future noise levels (Leq, 16hr) calculated as per FTA General Noise Assessment methodology.
 (K) **Noise Level - Leq, 8hr** - Future noise levels (Leq, 8hr) calculated as per FTA General Noise Assessment methodology.
 (L) **Noise Level - Lpassby** - Future noise levels (Lpassby) calculated as per FTA/FRA General Noise Assessment methodology.
 (M) **Noise Impact - Leq, 16hr** - Impact assessment (Leq, 16hr) as per MOE/TTC Manual.
 (N) **Noise Impact - Leq, 8hr** - Impact assessment (Leq, 8hr) as per MOE/TTC Manual.
 (O) **Noise Impact - Lpassby** - Impact assessment (Lpassby) as per MOE/TTC Manual.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
Point of Reception				Project Alignment		Noise Limit			Noise Level			Impact Assessment		
Receiver	Easting	Northing	Land Use	Train Speed [mph]	Distance to Alignment [ft]	Leq,16hr [dBA]	Leq,8hr [dBA]	Lpassby [dBA]	Leq,16hr [dBA]	Leq,8hr [dBA]	Lpassby [dBA]	Leq,16hr	Leq,8hr	Lpassby
POR07(O)	314813.7	4833317.1	Residential	25	60	66	59	80	59	56	74	No Impact	No Impact	No Impact
POR08(O)	314855.3	4833376.3	Residential	25	178	63	56	80	58	54	72	No Impact	No Impact	No Impact

Project: Design Services for Waterfront East LRT
Area: Union Station – Queens Quay Link
Date: July 15, 2021
Document: Table with impact assessment (no-build scenario)



Table Notes:

(A) **Receiver** - Receiver labeling. NB - No-Build Scenario
 (B) **Easting** - Receiver coordinate in MTM Zone 10N.
 (C) **Northing** - Receiver coordinate in MTM Zone 10N.
 (D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
 (E) **Distance to Alignment [ft]** - Slant distance from receiver location to closest track centerline.
 (F) **MOE/TTC Limit [mm/s]** - Ground-borne vibration assessment limit based on MOE/TTC Protocol, unit: mm/s.
 (F) **MOE/TTC Limit [VdB]** - Ground-borne vibration assessment limit based on MOE/TTC Protocol, unit: VdB.
 (H-L) **Ground-Borne Vibration Level** - Ground-borne vibration level calculated as per FTA General Vibration Assessment methodology.
 (M) **Ground-Borne Vibration Level [VdB]** - Resultant ground-borne vibration level, unit: VdB.
 (N) **Ground-Borne Vibration Level [mm/s]** - Resultant ground-borne vibration level, unit: mm/s.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)
Point of Reception			Project Alignment		MOE/TTC GBV Limit		Ground-Borne Vibration Level						
Receiver	Easting	Northing	Train Speed [mph]	Distance to Alignment [ft]	[mm/s]	[VdB]	Type of Source	Base Level (Figure 6-4 FTA)	Total Source Adjustment [VdB]	Total Path Adjustment [VdB]	Total Receiver Adjustment [VdB]	GBV [VdB]	GBV [mm/s]
POR01(O)(NB)	314422.3	4833767.6	6	368.8	0.14	75	Rapid Transit or Light Rail	53.2	-18.4	-10.0	0.0	25	<0.01
POR02(O)(NB)	314561.3	4833750.3	6	30.9	0.14	75	Rapid Transit or Light Rail	76.3	-18.4	-10.0	0.0	48	0.01
POR03(O)(NB)	314678.1	4833387.2	19	65.3	0.14	75	Rapid Transit or Light Rail	71.1	-8.4	-10.0	0.0	53	0.01
POR04(O)(NB)	314722.5	4833283.6	3	54.2	0.14	75	Rapid Transit or Light Rail	72.5	-24.4	-10.0	0.0	38	<0.01
POR05(O)(NB)	314704.6	4833220.5	3	64.9	0.14	75	Rapid Transit or Light Rail	71.2	-24.4	-10.0	0.0	37	<0.01
POR06(O)(NB)	314750.2	4833241.5	3	122.0	0.14	75	Rapid Transit or Light Rail	65.7	-24.4	-10.0	0.0	31	<0.01
POR07(O)(NB)	314813.7	4833317.1	3	281.1	0.14	75	Rapid Transit or Light Rail	56.6	-24.4	-10.0	0.0	22	<0.01
POR08(O)(NB)	314855.3	4833376.3	3	434.8	0.14	75	Rapid Transit or Light Rail	51.0	-24.4	-10.0	0.0	17	<0.01

Project: Design Services for Waterfront East LRT
Area: Union Station – Queens Quay Link
Date: July 15, 2021
Document: Table with impact assessment (build scenario)



Table Notes:

(A) **Receiver** - Receiver labeling.
 (B) **Easting** - Receiver coordinate in MTM Zone 10N.
 (C) **Northing** - Receiver coordinate in MTM Zone 10N.
 (D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
 (E) **Distance to Alignment [ft]** - Slant distance from receiver location to closest track centerline.
 (F) **MOE/TTC Limit [mm/s]** - Ground-borne vibration assessment limit based on MOE/TTC Protocol, unit: mm/s.
 (F) **MOE/TTC Limit [VdB]** - Ground-borne vibration assessment limit based on MOE/TTC Protocol, unit: VdB.
 (H-L) **Ground-Borne Vibration Level** - Ground-borne vibration level calculated as per FTA General Vibration Assessment methodology.
 (M) **Ground-Borne Vibration Level [VdB]** - Resultant ground-borne vibration level, unit: VdB.
 (N) **Ground-Borne Vibration Level [mm/s]** - Resultant ground-borne vibration level, unit: mm/s.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)
Point of Reception			Project Alignment		MOE/TTC GBV Limit		Ground-Borne Vibration Level						
Receiver	Easting	Northing	Train Speed [mph]	Distance to Alignment [ft]	[mm/s]	[VdB]	Type of Source	Base Level (Figure 6-4 FTA)	Total Source Adjustment [VdB]	Total Path Adjustment [VdB]	Total Receiver Adjustment [VdB]	GBV [VdB]	GBV [mm/s]
POR01(O)	314422.3	4833767.6	6	369.1	0.14	75	Rapid Transit or Light Rail	53.2	-18.4	-10.0	0.0	25	<0.01
POR02(O)	314561.3	4833750.3	6	34.5	0.14	75	Rapid Transit or Light Rail	75.6	-18.4	-10.0	0.0	47	0.01
POR03(O)	314678.1	4833387.2	19	65.3	0.14	75	Rapid Transit or Light Rail	71.1	-8.4	-10.0	0.0	53	0.01
POR04(O)	314722.5	4833283.6	3	54.2	0.14	75	Rapid Transit or Light Rail	72.5	-24.4	-10.0	0.0	38	<0.01
POR05(O)	314704.6	4833220.5	3	65.6	0.14	75	Rapid Transit or Light Rail	71.1	-24.4	-10.0	0.0	37	<0.01
POR06(O)	314750.2	4833241.5	3	67.7	0.14	75	Rapid Transit or Light Rail	70.8	-24.4	-10.0	0.0	36	<0.01
POR07(O)	314813.7	4833317.1	25	61.7	0.14	75	Rapid Transit or Light Rail	71.6	-6.0	-10.0	0.0	56	0.02
POR08(O)	314855.3	4833376.3	25	177.8	0.14	75	Rapid Transit or Light Rail	61.8	-6.0	-10.0	0.0	46	<0.01

Project: Design Services for Waterfront East LRT
Area: Union Station – Queens Quay Link
Date: July 15, 2021
Document: Table with impact assessment



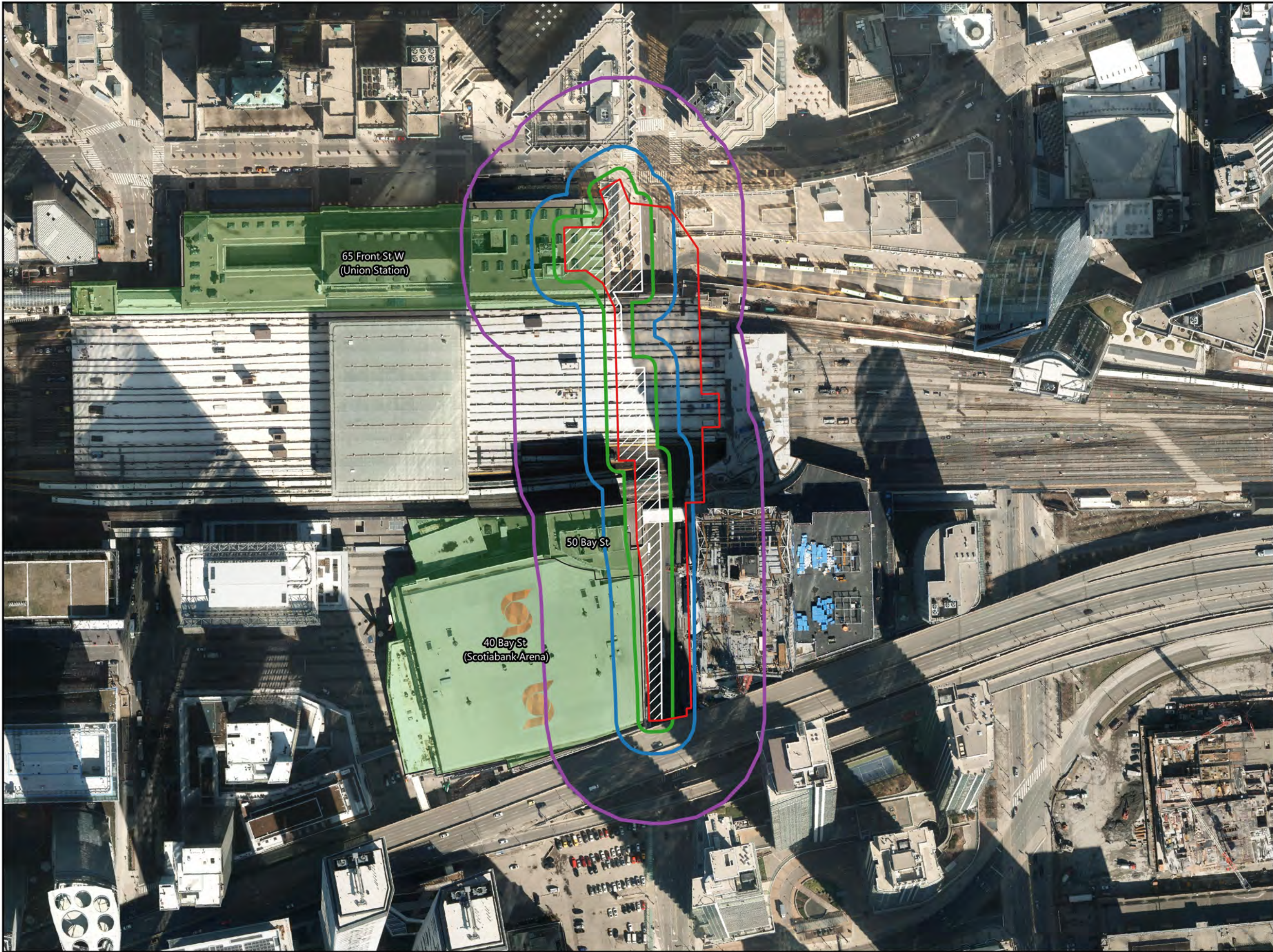
Table Notes:

- (A) **Receiver** - Receiver labeling.
 (B) **Easting** - Receiver coordinate in MTM Zone 10N.
 (C) **Northing** - Receiver coordinate in MTM Zone 10N.
 (D) **Train Speed [mph]** - Speed of the train traveling on the segment closest to the receiver.
 (E) **Distance to Alignment [ft]** - Slant distance from receiver location to closest track centerline.
 (F) **MOE/TTC Limit [mm/s]** - Ground-borne vibration assessment limit based on MOE/TTC Protocol, unit: mm/s.
 (G) **Ground-Borne Vibration Level [VdB]** - Resultant ground-borne vibration level, unit: VdB.
 (H) **Ground-Borne Vibration Level [mm/s]** - Resultant ground-borne vibration level, unit: mm/s.
 (I) **Impact Assessment** - Impact assessment as per MOE/TTC Protocol.

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
Point of Reception			Project Alignment		MOE/TTC GBV Limit [mm/s]	Ground-Borne Vibration Levels		
Receiver	Easting	Northing	Train Speed [mph]	Distance to Alignment [ft]		[VdB]	[mm/s]	Impact Under MOE/TTC Criteria
POR01(O)	314422.3	4833767.6	6	369.1	0.14	25	<0.01	No Impact
POR02(O)	314561.3	4833750.3	6	34.5	0.14	47	0.01	No Impact
POR03(O)	314678.1	4833387.2	19	65.3	0.14	53	0.01	No Impact
POR04(O)	314722.5	4833283.6	3	54.2	0.14	38	<0.01	No Impact
POR05(O)	314704.6	4833220.5	3	65.6	0.14	37	<0.01	No Impact
POR06(O)	314750.2	4833241.5	3	67.7	0.14	36	<0.01	No Impact
POR07(O)	314813.7	4833317.1	25	61.7	0.14	56	0.02	No Impact
POR08(O)	314855.3	4833376.3	25	177.8	0.14	46	<0.01	No Impact

Appendix C

Construction Zone of Influence



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Union - Phase 1/2**

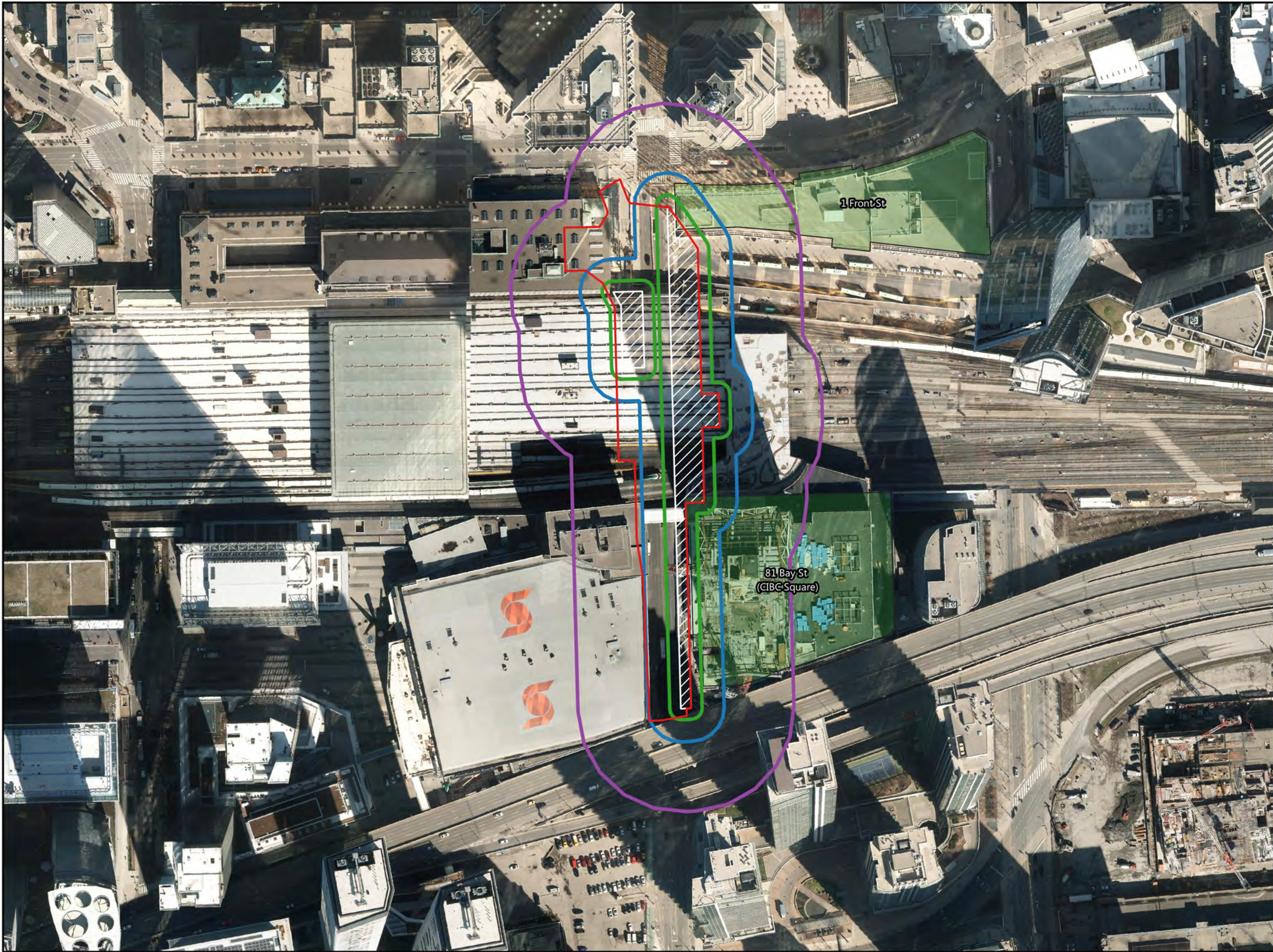
PROJECT NO: OISO52004

FIGURE: C-1

SCALE: 1:2000

DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Union - Phase 3/4/5**

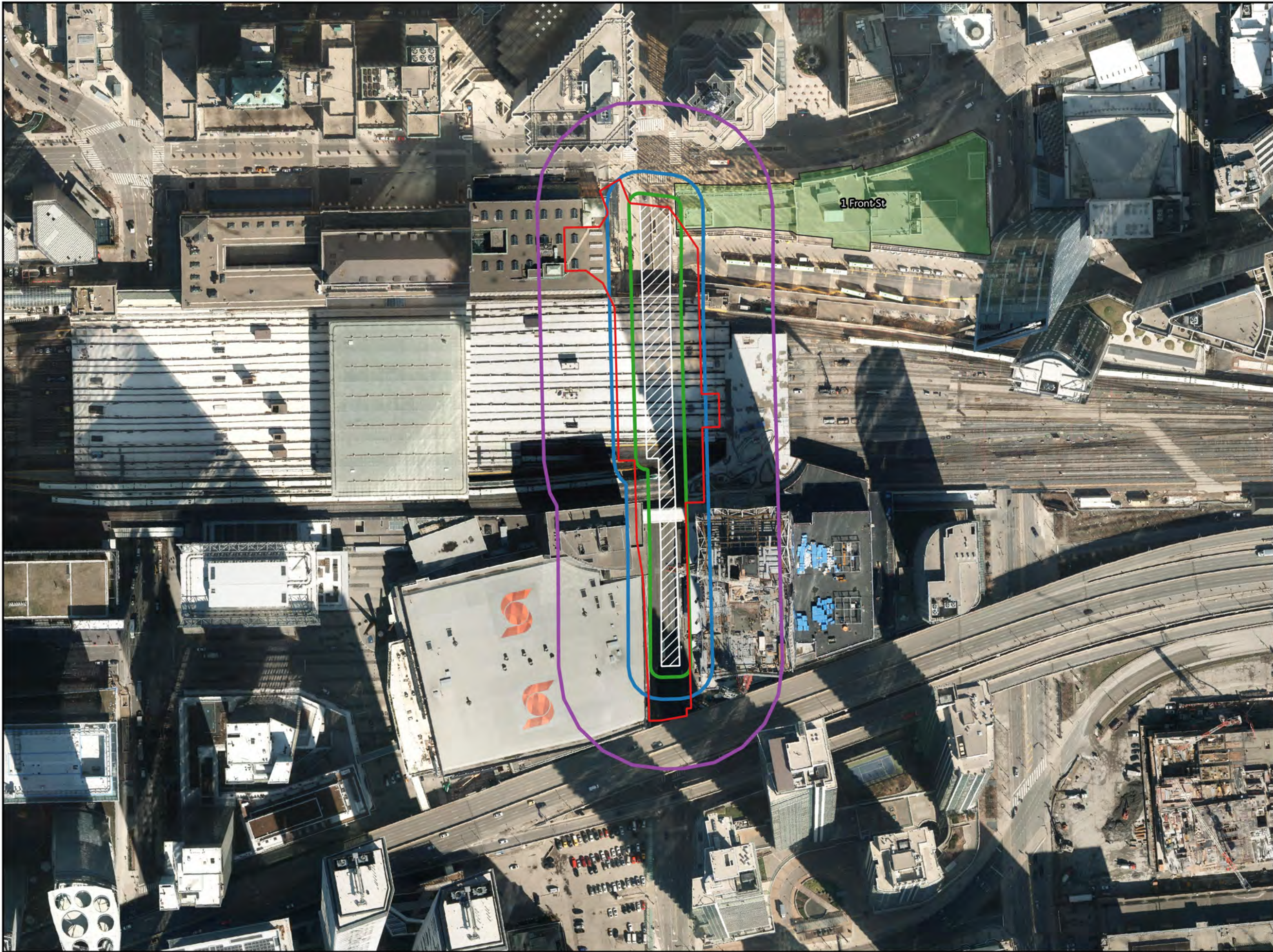
PROJECT NO: OISO52004

FIGURE: C-2

SCALE: 1:2000

DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Union - Phase 6**

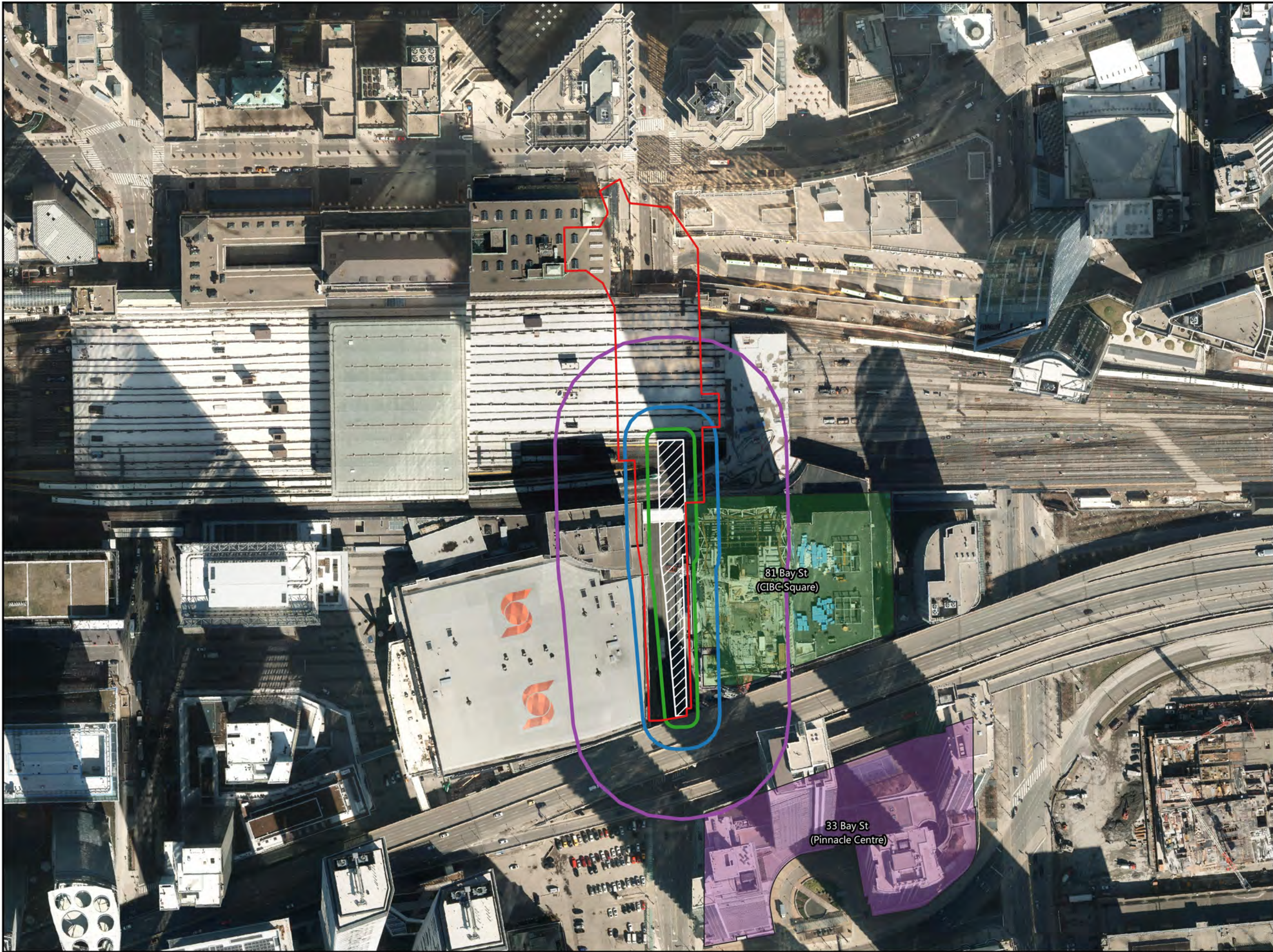
PROJECT NO: OISO52004

FIGURE: C-3

SCALE: 1:2000

DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database

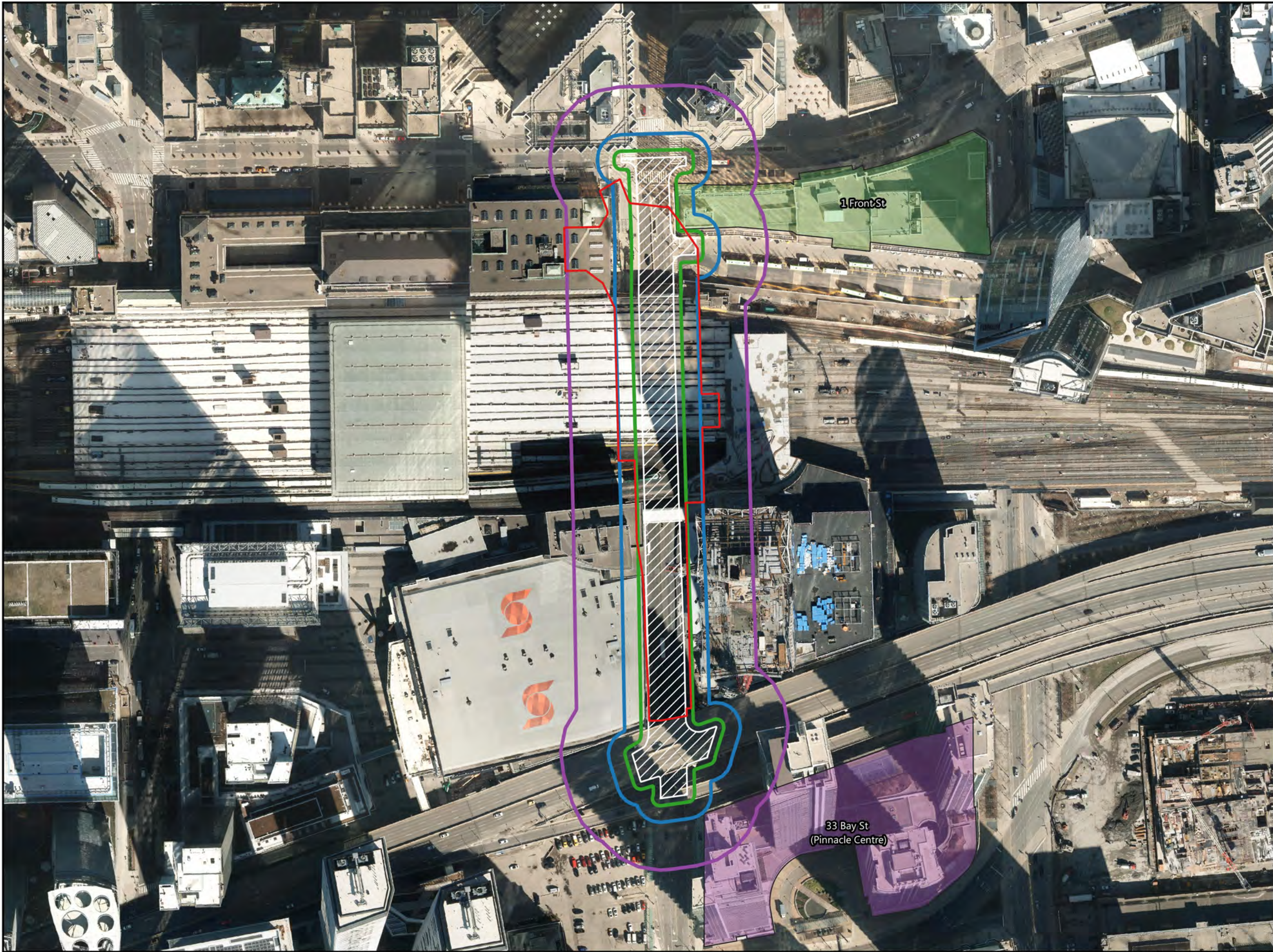


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Union - Phase 7**

PROJECT NO: OISO52004	FIGURE: C-4
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database

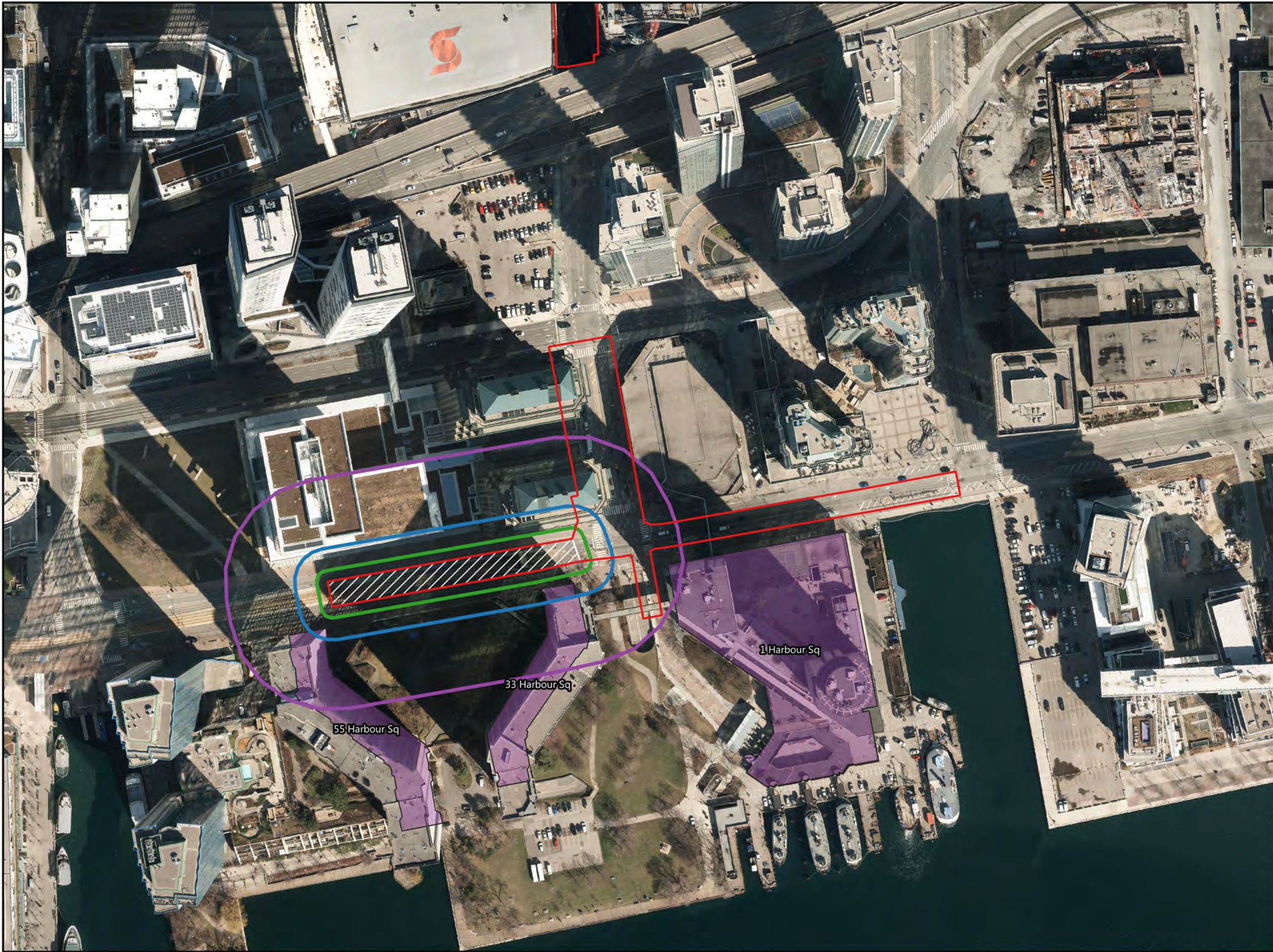


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Union - Phase 8 (Road Restoration)**

PROJECT NO: OISO52004	FIGURE: C-5
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database



TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 1**

PROJECT NO: OISO52004	FIGURE: C-6
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database

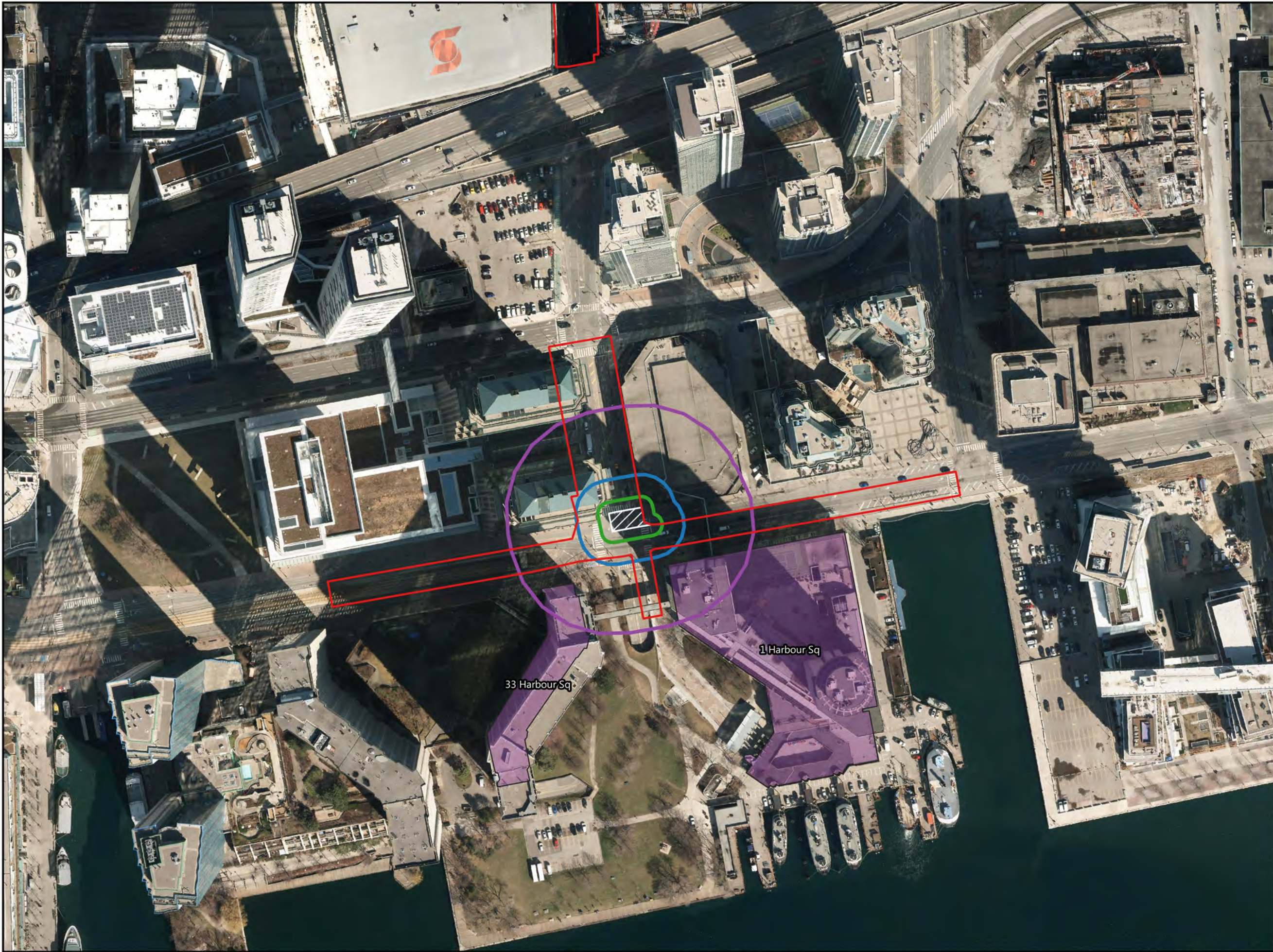


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 2**

PROJECT NO: OISO52004 FIGURE: C-7
SCALE: 1:2000 DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential

NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 3**

PROJECT NO: OISO52004

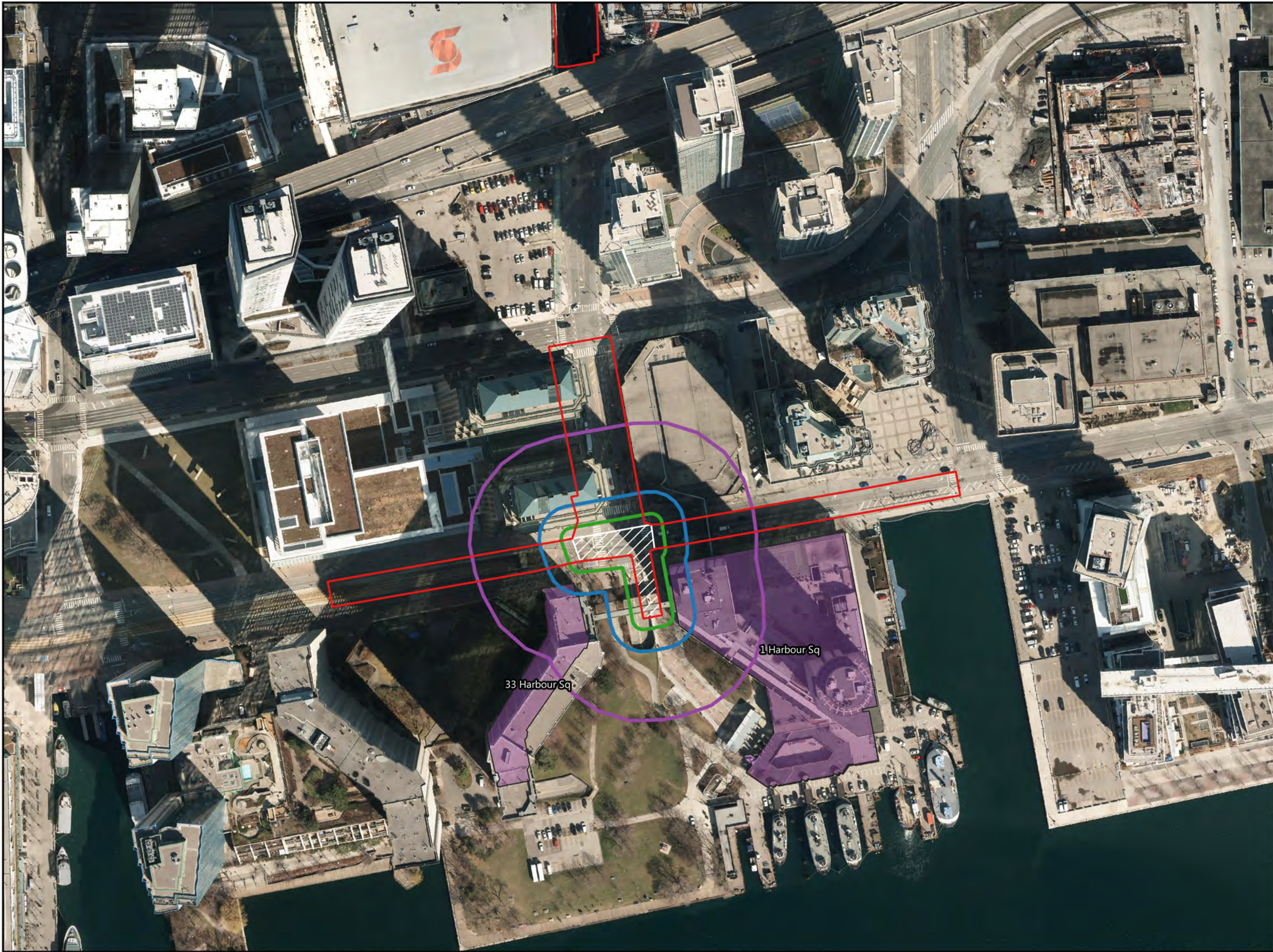
FIGURE: C-8

SCALE: 1:2000

DATE: July 2021

0 100 200 300 400 m

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database

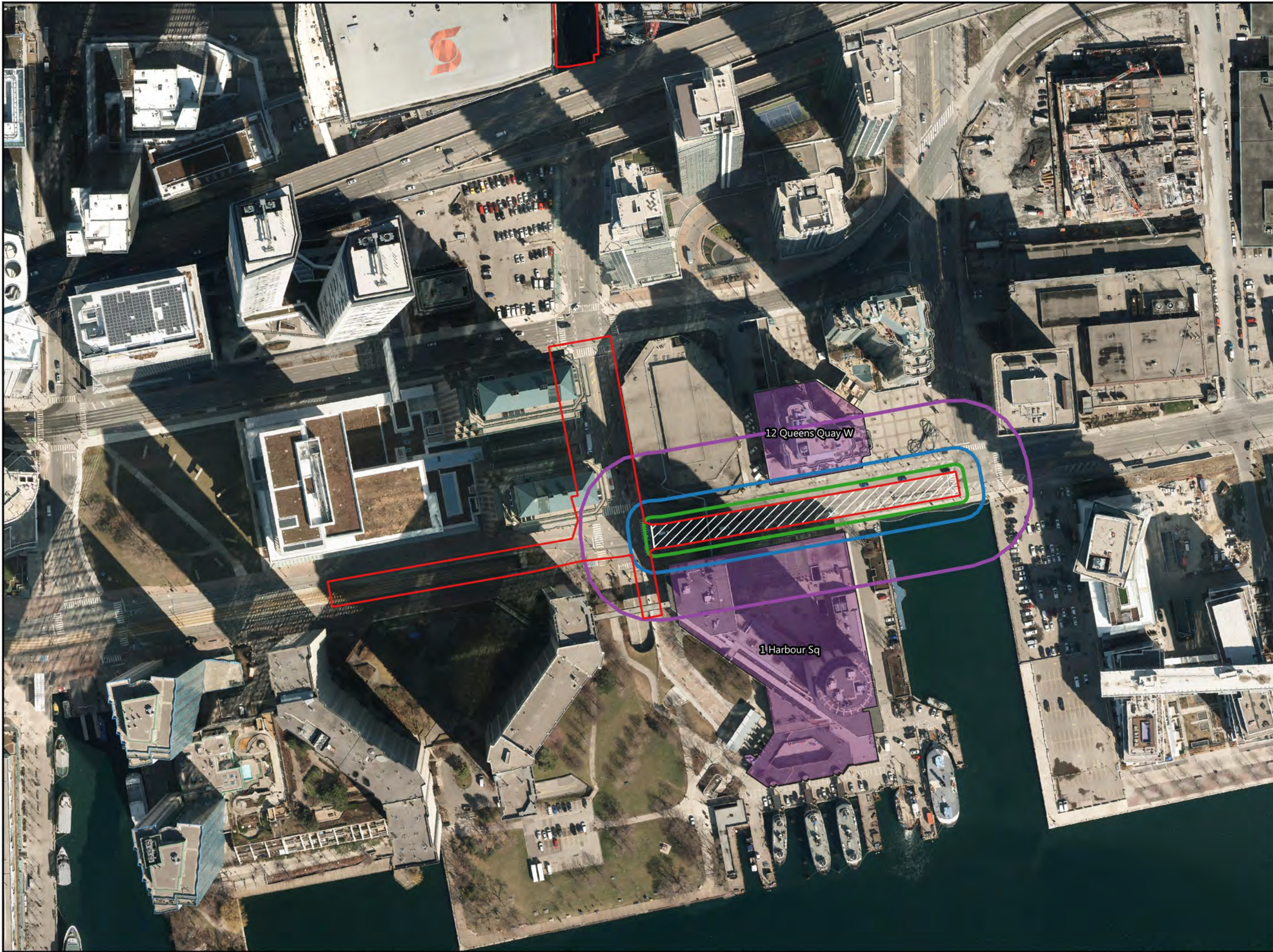


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 4**

PROJECT NO: OISO52004 FIGURE: C-9
SCALE: 1:2000 DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 5**

PROJECT NO: OISO52004

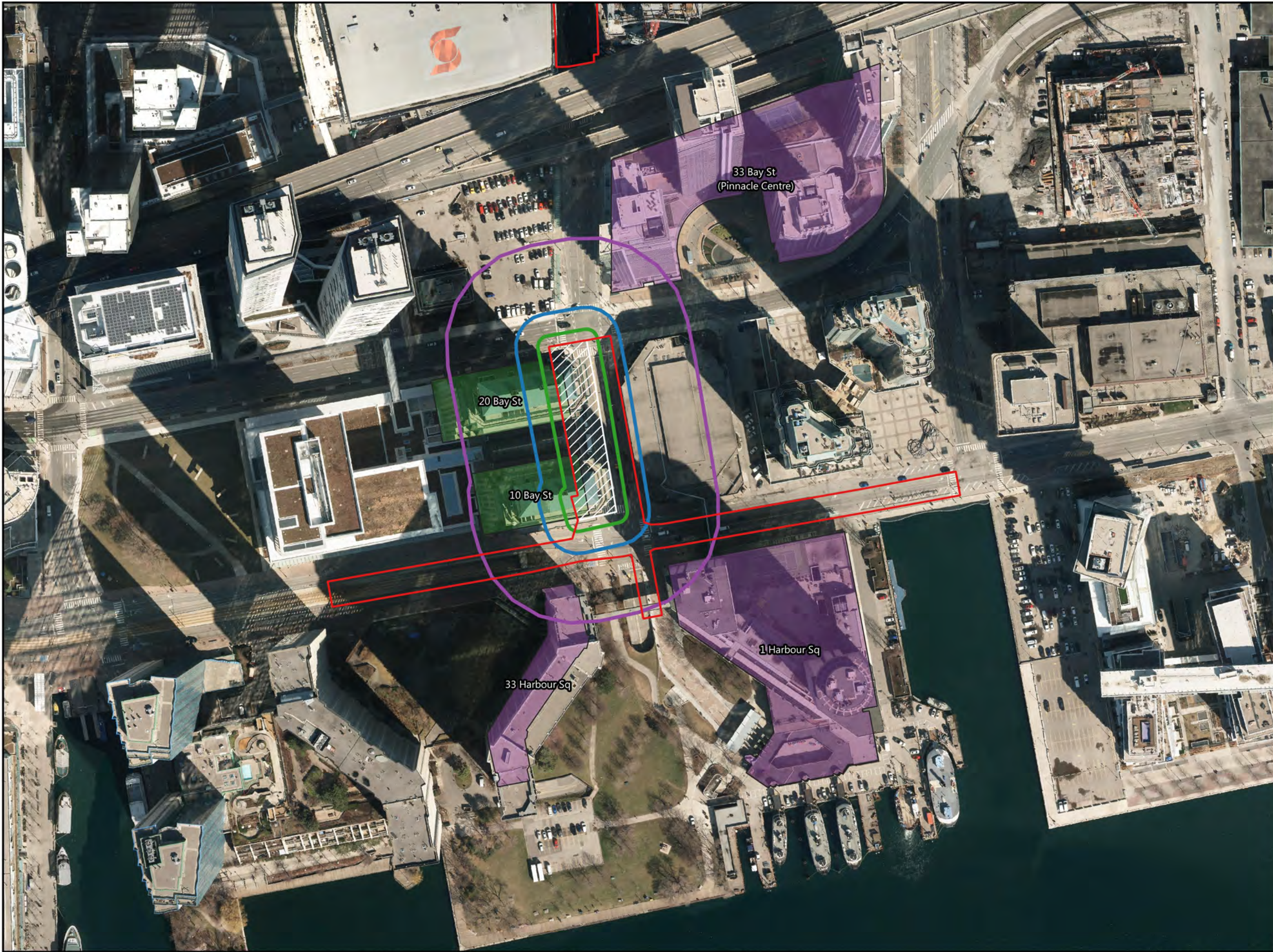
FIGURE: C-10

SCALE: 1:2000

DATE: July 2021

0 100 200 300 400 m

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



KEY MAP

NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 6**

PROJECT NO: OISO52004

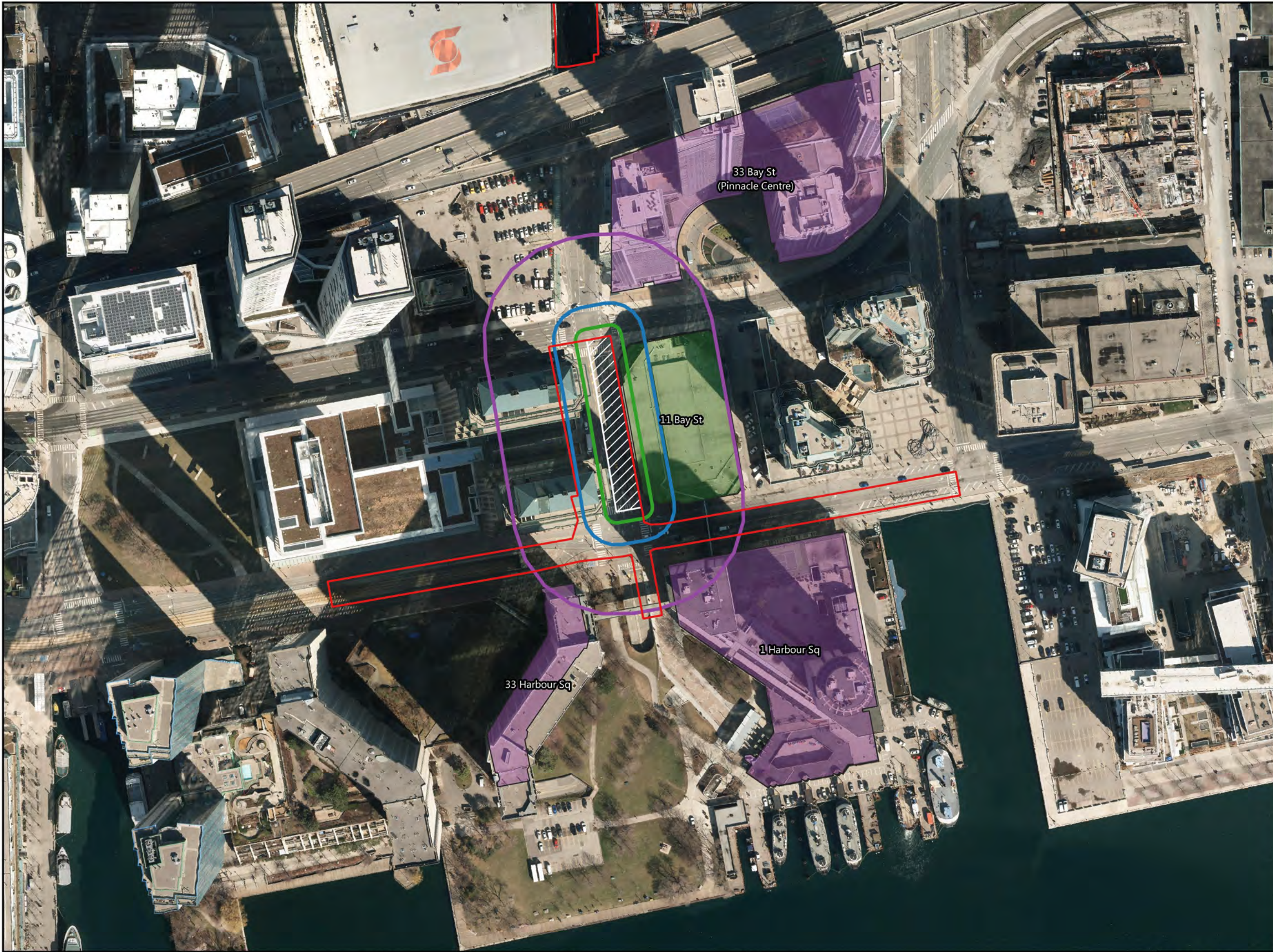
FIGURE: C-11

SCALE: 1:2000

DATE: July 2021

0 100 200 300 400 m

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database

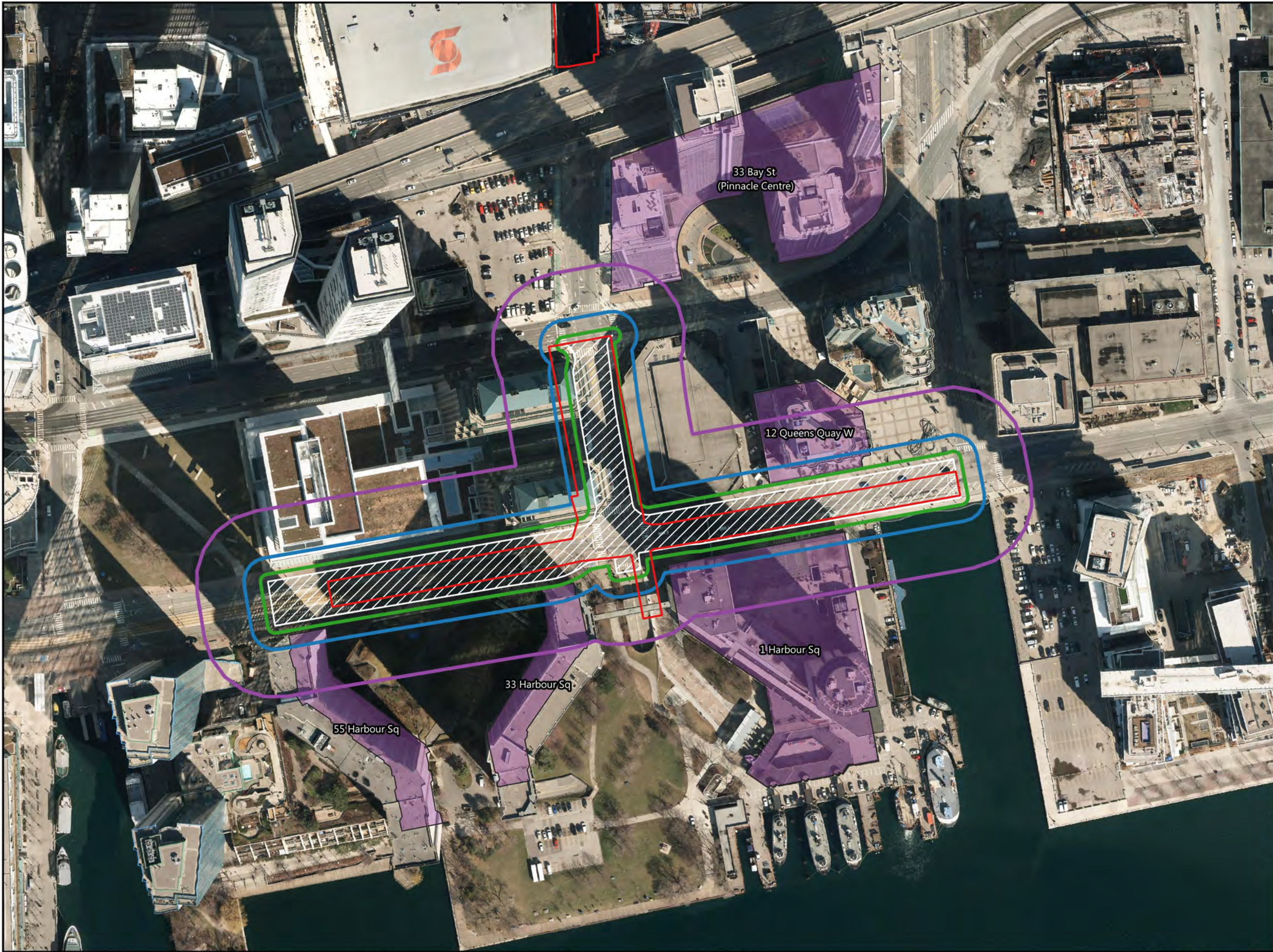


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 7**

PROJECT NO: OISO52004	FIGURE: C-12
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary

**Noise Zone of Influence
(Land Use, Noise Limit, Time of Day)**

- Commercial / Industrial, 100dBA, Day / Night
- Residential, 90dBA, Day
- Residential, 80dBA, Night

Buildings within ZOI

- Commercial / Industrial
- Residential



NOTES:
- Aerial imagery extracted from ESRI and project database

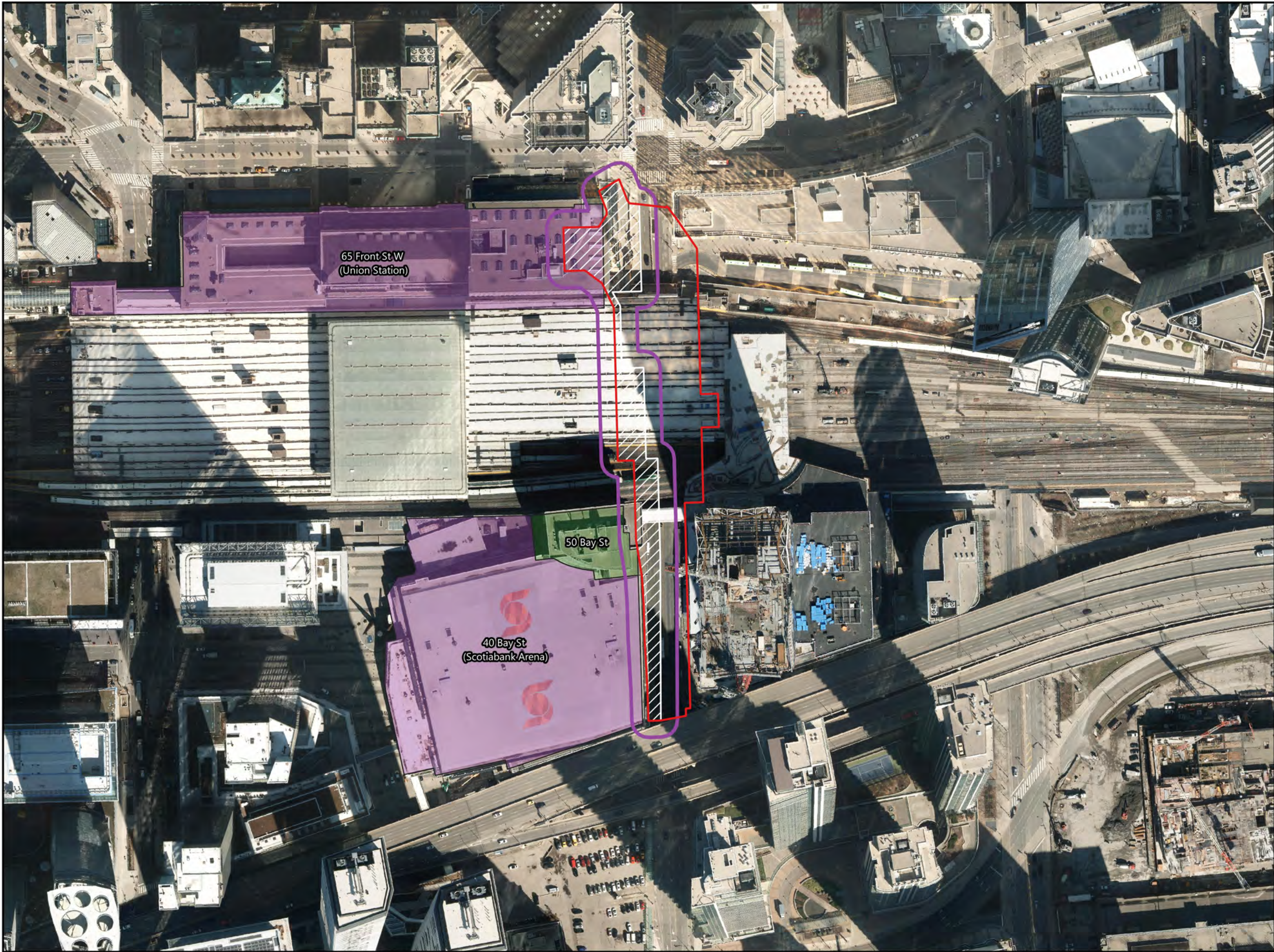


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Noise Zone of Influence
Queens Quay - Phase 8 (Road
Restoration)**

PROJECT NO: OISO52004 FIGURE: C-13
SCALE: 1:2000 DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

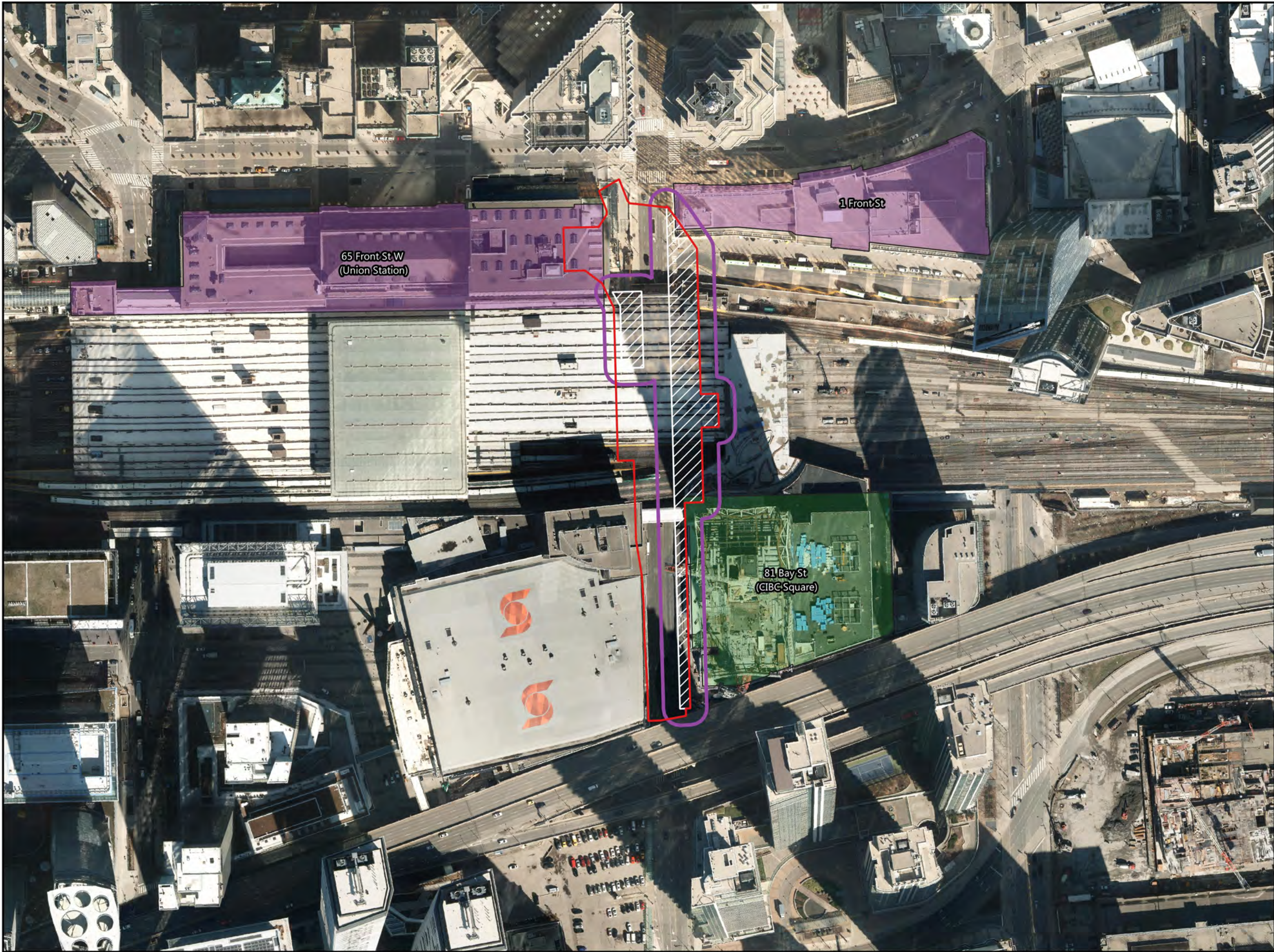
KEY MAP

NOTES:
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Union - Phase 1/2**

PROJECT NO: OISO52004	FIGURE: C-14
SCALE: 1:2000	DATE: July 2021



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

NOTES:
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Union - Phase 3/4/5**

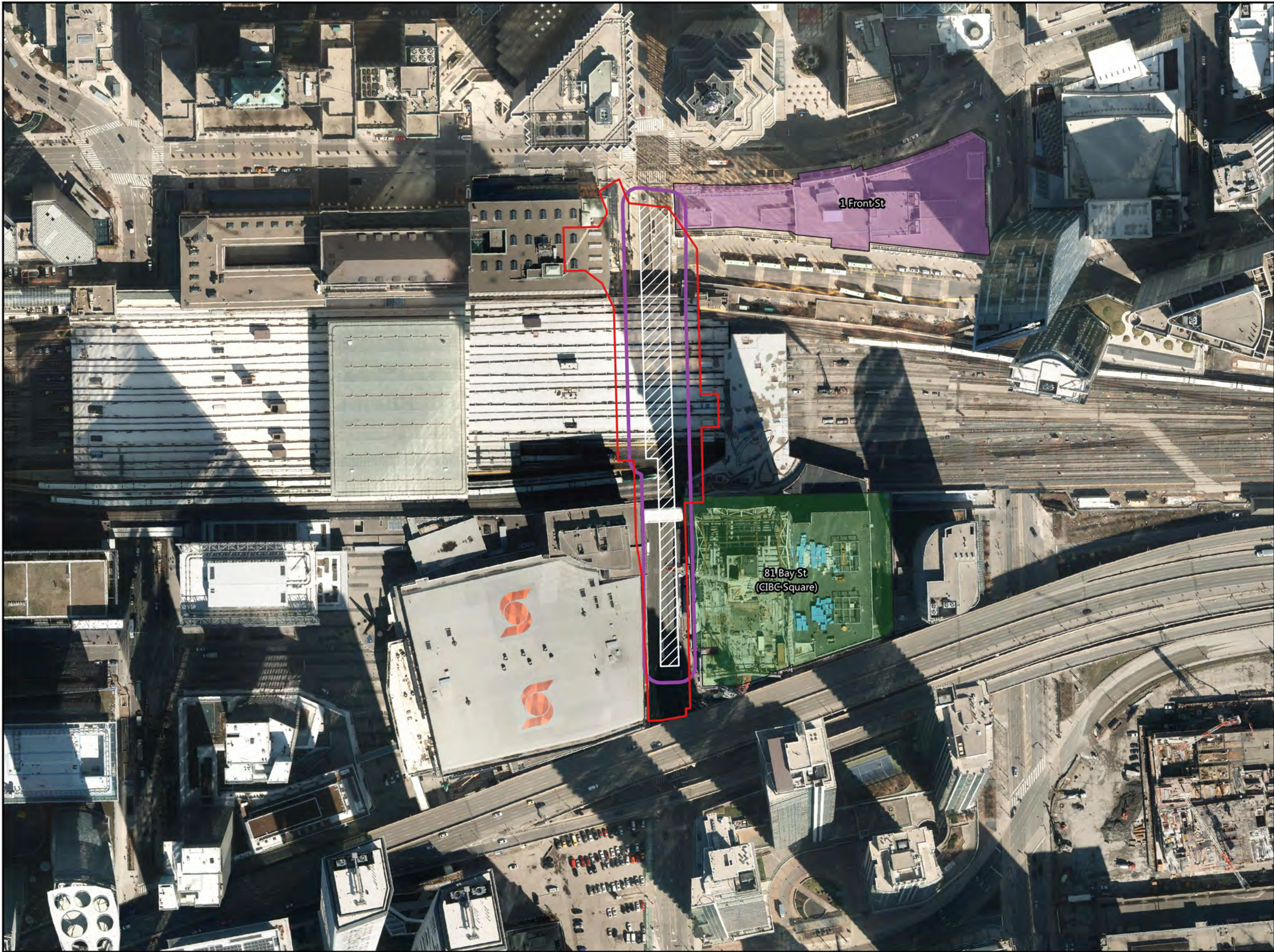
PROJECT NO: OISO52004

FIGURE: C-15

Datum & Projection:
NAD 27 / MTM zone 10

SCALE: 1:2000

DATE: July 2021



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

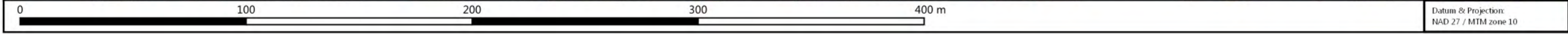
NOTES:
- Aerial imagery extracted from ESRI and project database.

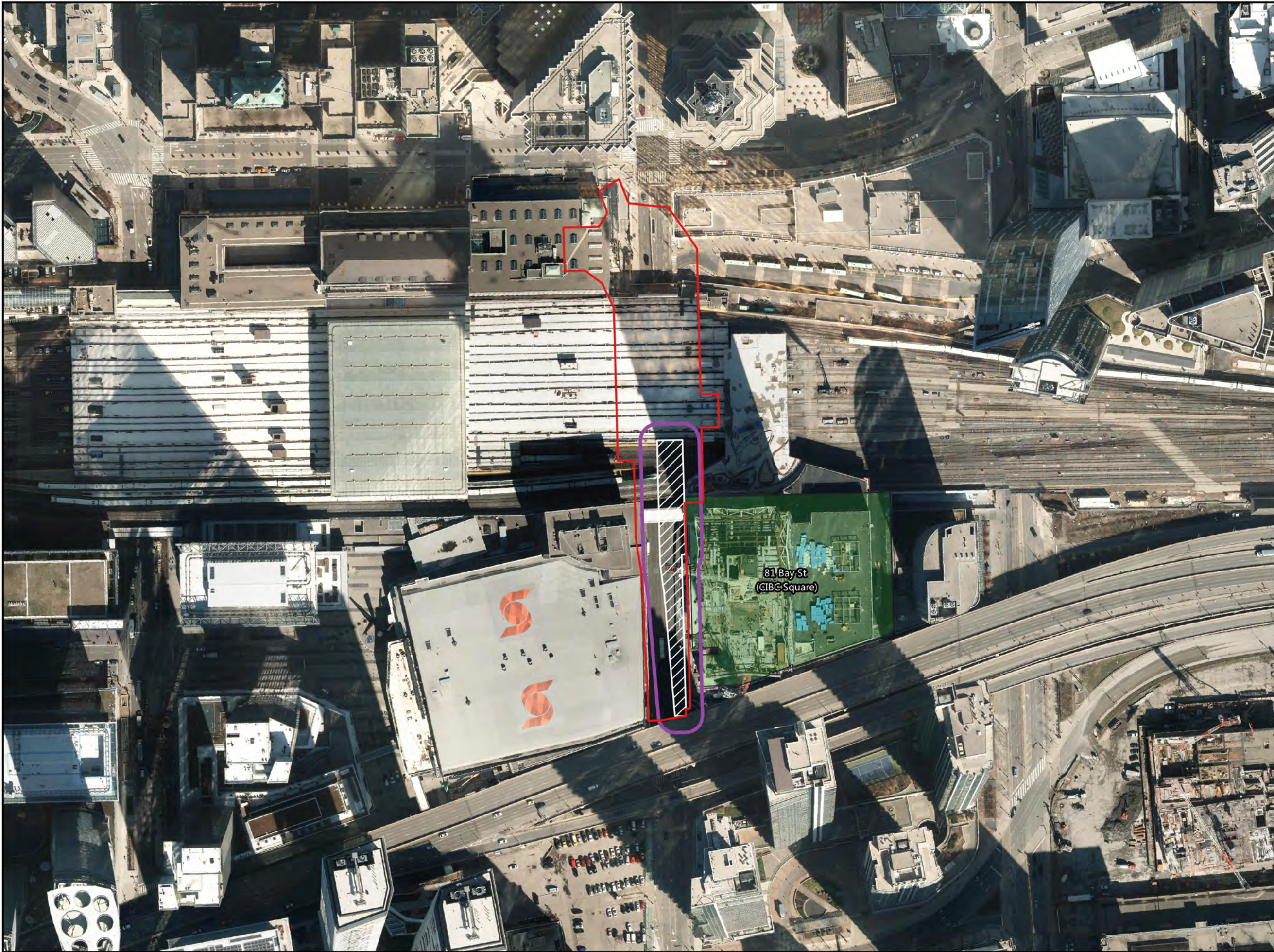
TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Union - Phase 6**

PROJECT NO: OISO52004	FIGURE: C-16
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10





LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

NOTES:
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Union - Phase 7**

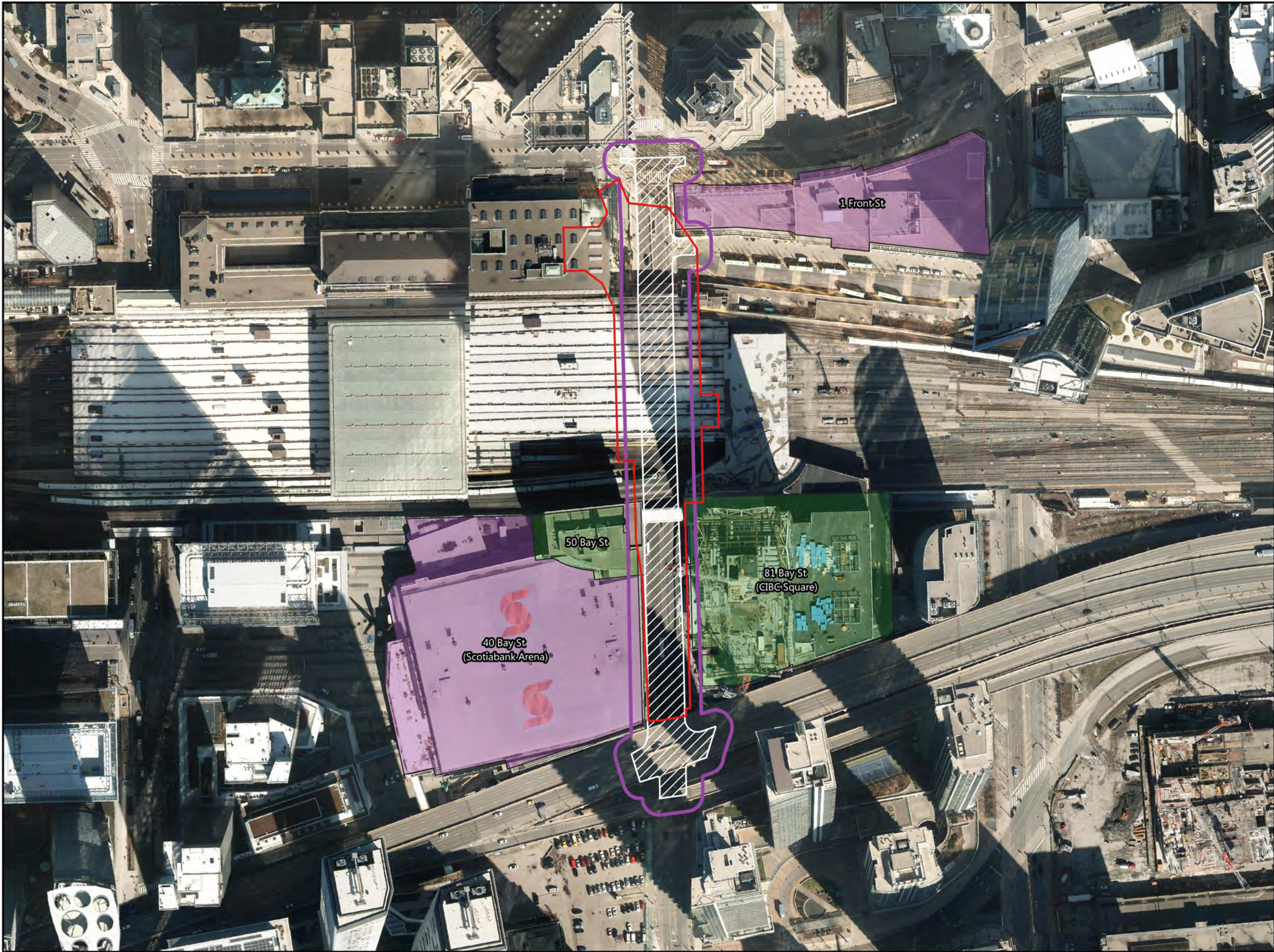
PROJECT NO: OISO52004

FIGURE: C-17

Datum & Projection:
NAD 27 / MTM zone 10

SCALE: 1:2000

DATE: July 2021



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

NOTES:
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Union - Phase 8 (Road Restoration)**

PROJECT NO: OISO52004	FIGURE: C-18
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage



NOTES:
- Aerial imagery extracted from ESRI and project database.



wood.

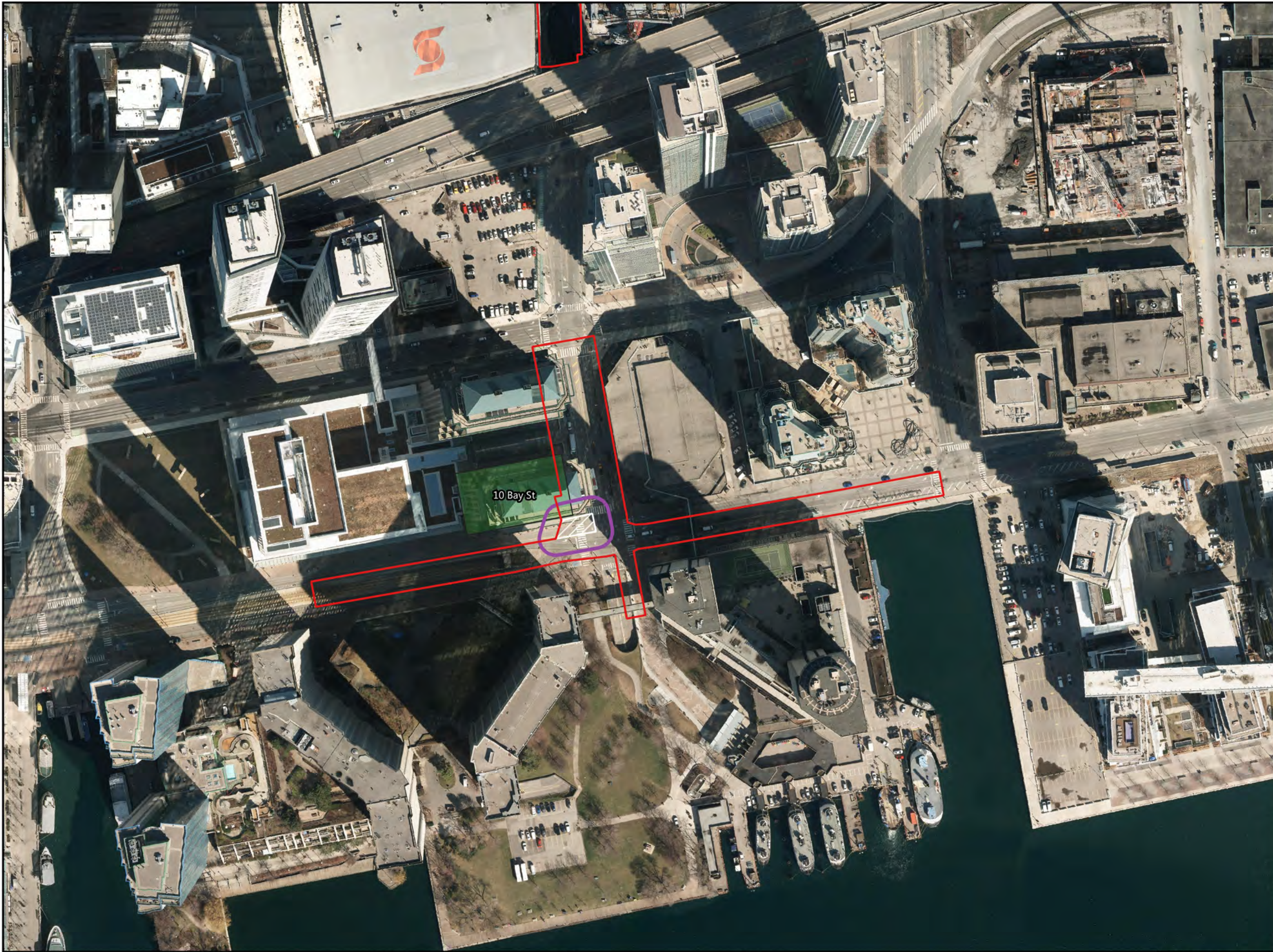
TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 1**

PROJECT NO: OISO52004	FIGURE: C-19
SCALE: 1:2000	DATE: July 2021

0 100 200 300 400 m

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage



NOTES:
- Aerial imagery extracted from ESRI and project database.



TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 2**

PROJECT NO: OISO52004	FIGURE: C-20
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage



KEY MAP

NOTES:
- Aerial imagery extracted from ESRI and project database.



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 3**

PROJECT NO: OISO52004	FIGURE: C-21
SCALE: 1:2000	DATE: July 2021

0 100 200 300 400 m

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

NOTES:
- Aerial imagery extracted from ESRI and project database.

TTC Waterfront East LRT
Preliminary Noise Study

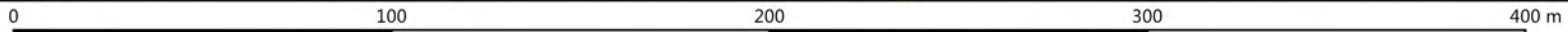
**Construction Vibration Zone of Influence
Queens Quay - Phase 4**

PROJECT NO: OISO52004

FIGURE: C-22

SCALE: 1:2000

DATE: July 2021



Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage

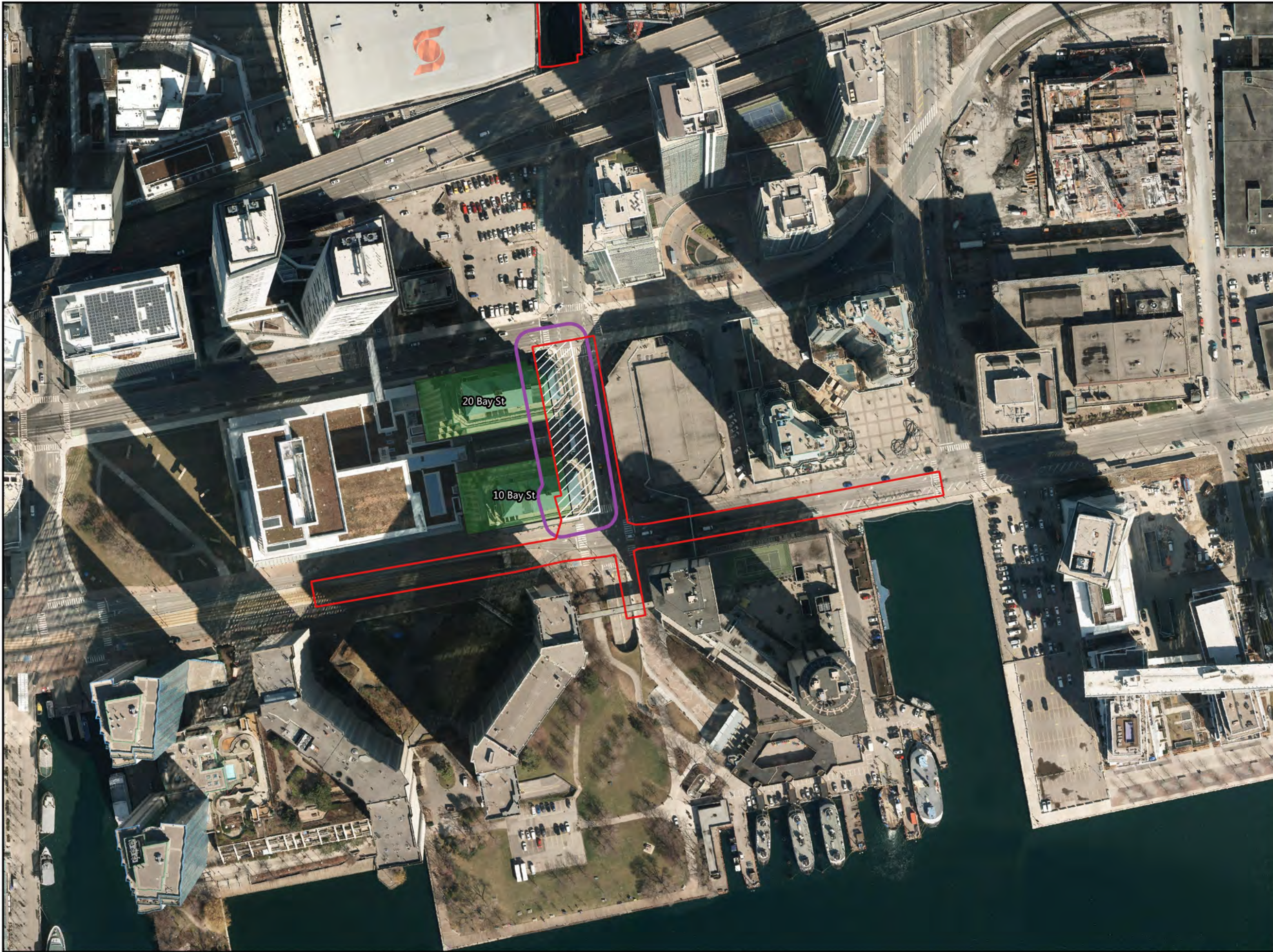


NOTES:
- Aerial imagery extracted from ESRI and project database.



TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 5**



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage



NOTES:
- Aerial imagery extracted from ESRI and project database.

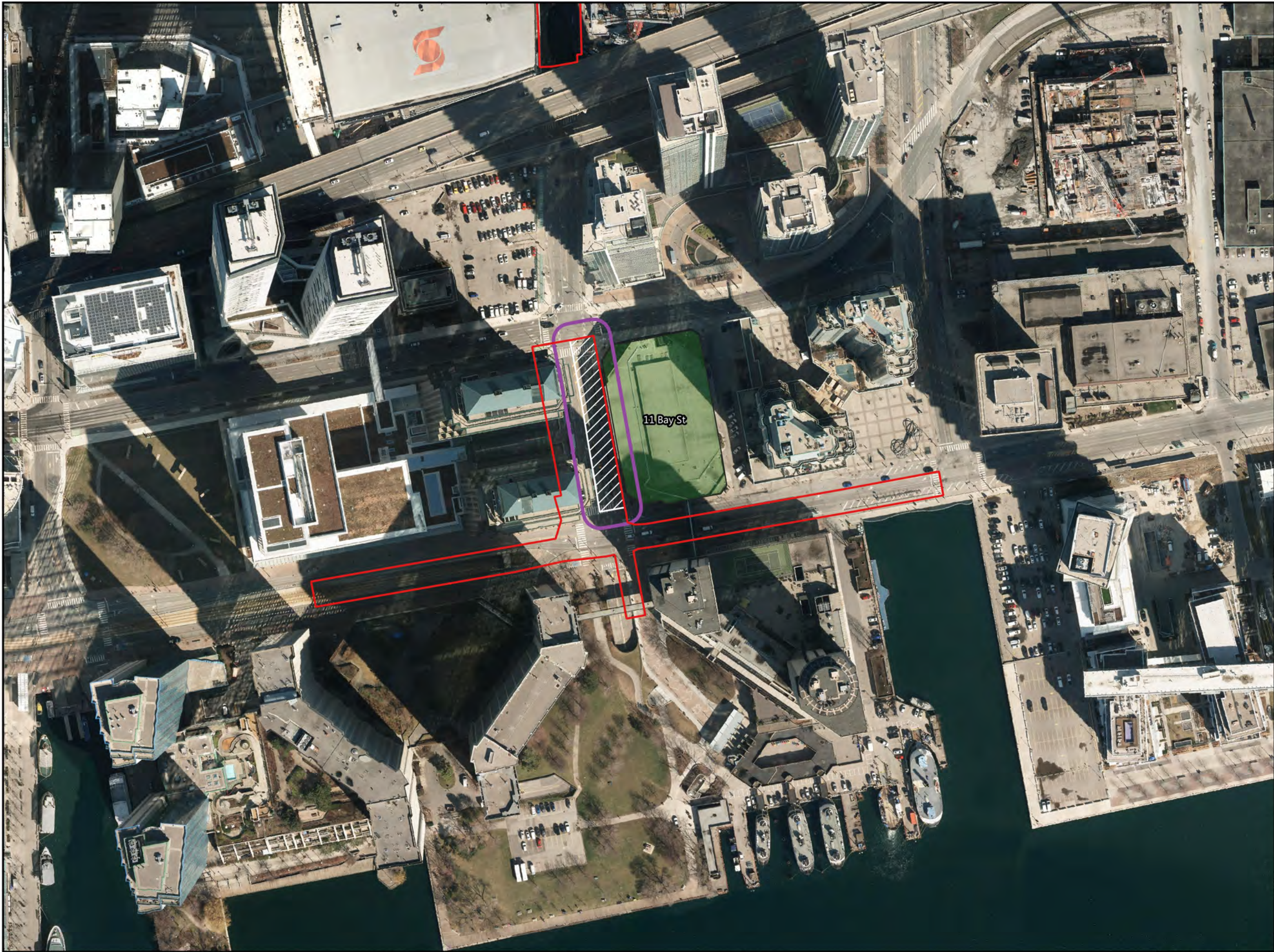


TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 6**

PROJECT NO: OISO52004	FIGURE: C-24
SCALE: 1:2000	DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage



NOTES:
- Aerial imagery extracted from ESRI and project database.



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 7**

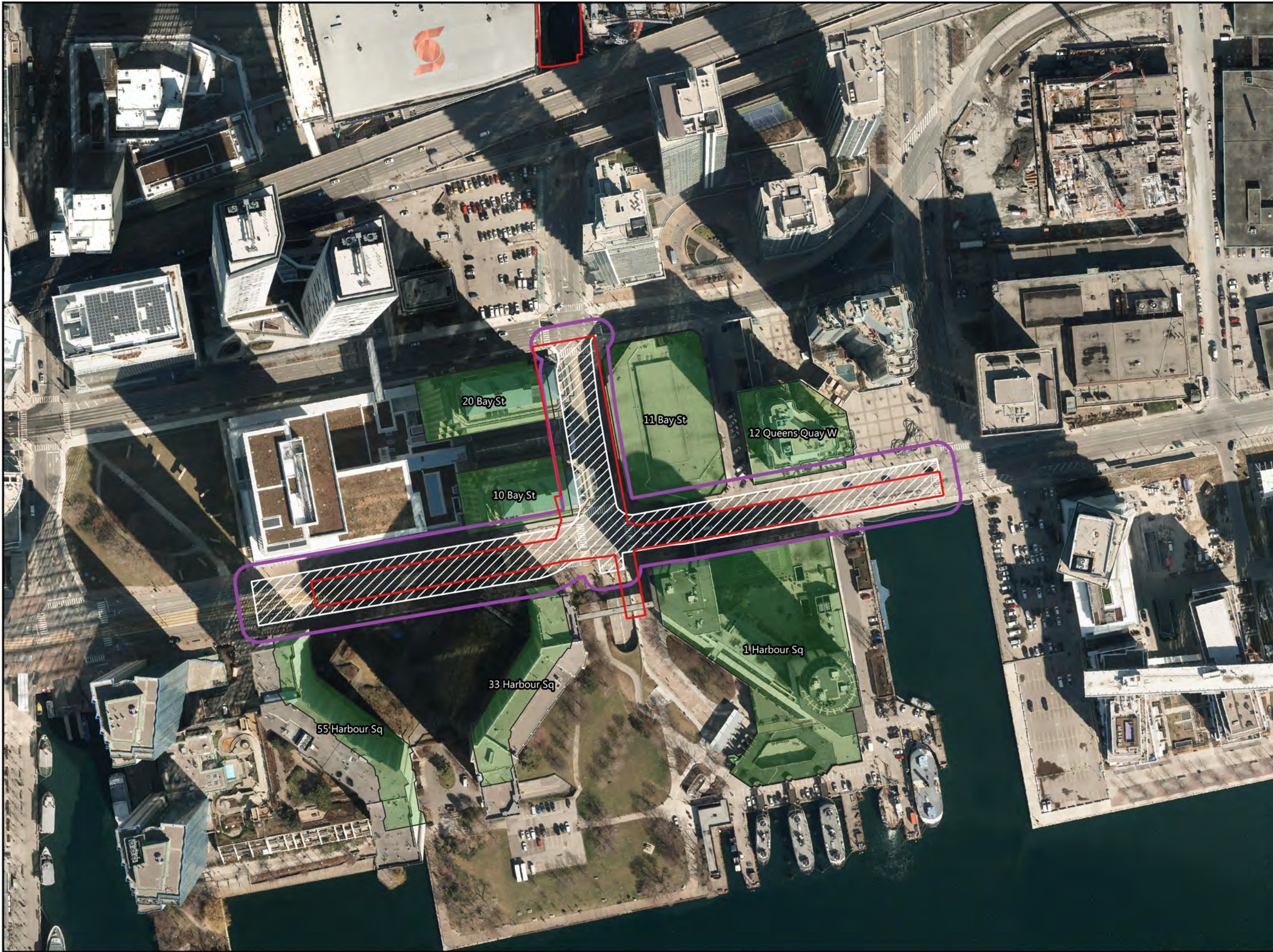
PROJECT NO: OISO52004

FIGURE: C-25

SCALE: 1:2000

DATE: July 2021

Datum & Projection:
NAD 27 / MTM zone 10



LEGEND

- Overall Staging Area
- Current Construction Area
- Property Boundary
- Vibration Zone of Influence (5 mm/s)

Buildings within ZOI

- Non-Heritage
- Heritage



NOTES:
- Aerial imagery extracted from ESRI and project database



wood.

TTC Waterfront East LRT
Preliminary Noise Study

**Construction Vibration Zone of Influence
Queens Quay - Phase 8 (Road
Restoration)**

PROJECT NO: OISO52004

FIGURE: C-26

SCALE: 1:2000

DATE: July 2021

0 100 200 300 400 m

Datum & Projection:
NAD 27 / MTM zone 10