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July 13, 2022

Mr. Goran Rakocevic
Fairview LP
2386 New Street
Burlington Ontario
L7R 1J7

SLR Project No.: 241.180239.A0000

RE: 2243-2269 FAIRVIEW ST AND 864 DRURY LANE: PHASE 1 – REVISED CONSTRUCTION VIBRATION CONTROL STUDY

SLR Consulting Canada Ltd. (SLR) has completed a construction vibration assessment to address planned construction activity associated with the proposed development at 2243-2269 Fairview Street and 864 Drury Lane in Burlington, Ontario. This letter presents our findings and recommendations.

1. PROJECT SITE AND LAND USES

The proposed development is situated on the northwest corner of the intersection at Fairview Street and Drury Lane. The proposed development includes several building ranging in height from 29 to 37 storeys. The development will include both residential and commercial spaces. This report will focus on construction vibration impact for Phase 1 (Building C).

Phase 1 of the proposed development will feature a 33-storey and 37-storey tower which share two levels of underground parking and a common podium.

All buildings on site are eventually to be demolished starting with the two buildings located in phase 1 of the development at 2243 Fairview Street: a 1 storey concrete building fronting onto Fairview street and a 1 storey metal building just south of the rail line. Current land uses surrounding the phase 1 construction area are listed in Table 1.

Table 1 Land Uses Adjacent to the Phase 1 Development Site

Location	Address	Use
East	864 Drury Lane	Commercial; 1 storey concrete and brick building
Southeast	2269 Fairview St	Commercial; 2 storey stone and stucco building
West	2207 Fairview St	Commercial; 1 storey steel and concrete building
North	CN/ Metrolinx Oakville Corridor	Rail corridor

2. PLANNED CONSTRUCTION ACTIVITIES

The activities anticipated to cause the highest ground vibration levels during construction of the new development include the following:

- Demolition of existing buildings at 2243 Fairview St;
- Excavation of the underground parking garage structure;
- Drilling of piles associated with the shoring for the towers and underground parking garage structure;
- Vibratory rolling during paving of the internal roadways;
- Compaction of soil as part of the landscaping and underground works.

Planned equipment typically used for these works includes:

- Hoe Ram;
- Jackhammer
- Bulldozer
- Excavators, backhoes, bobcats;
- Loaded trucks;
- Drill rig equipped with auger for soldier pile installation and tieback drill.
- Vibratory roller

Given the proximity to nearby land uses and the nature of the above activities, there exists potential for these activities to generate ground vibrations that impact adjacent structures owned by others, outside of the legal boundaries of the construction site. The anticipated impacts from these activities have been quantified as part of this this study.

3. CONSTRUCTION IMPACT ASSESSMENT

3.1 VIBRATION CRITERIA

Neither the City of Burlington not the Region of Halton have published guidelines for control of construction vibrations. Therefore, in keeping with local best practices, the City of Toronto's criteria have been adopted. The criteria used for the assessment are as specified in City of Toronto By-Law 514-2008. The By-Law specifies "Do-Not-Exceed" threshold limits as listed in **Table 2**.

Table 2 City of Toronto "Do-Not-Exceed" Threshold Limits

Frequency of Vibration	Peak Particle Velocity (mm/s)
Less than 4 Hz	8
Between 4 and 10 Hz	15
Greater than 10 Hz	25

A 5 mm/s threshold is specified as an appropriate cautionary threshold for most structures and serves as the basis for defining the Zone of Influence, as described below.

During a site visit on June 1, 2022, SLR staff was informed by the tenants of the car dealership located at 2207 Fairview Street that underground gasoline storage tanks are located near the western property line of the construction site. The dimensions and the extent of the underground gasoline tanks are unknown. The material from which the tanks are constructed was unknown during the site visit. Due to the close proximity of the underground storage tank to the construction site, the effect of construction activity on the underground gasoline storage tanks is also of concern from a vibration perspective. Guidelines for vibration limits for underground storage tanks are not available, however, vibration limits published for buried pipelines are considered as the guide limits for underground storage tanks. Studies conducted at a number of sites throughout the world indicate that PPV levels as high as 200 mm/s can be tolerated by buried pipelines prior to any cosmetic damage occurring. Since the construction material of the gasoline tanks is unknown, a do-not-exceed threshold of 50 mm/s is recommended as conservatism. The referenced DIN 4150-3 Standard's thresholds for pipelines are listed in **Table 3.**

Table 3 DIN 4150 Limits for Buried Pipelines[1][2]

Pipe Material	Guideline Value for Velocity Measured on the Pipe (mm/s)
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, metal (with or without flange)	80
Masonry, plastic	50

[1] DIN 4150-3:1999 Structural vibration – Effects of vibration on structures.

3.2 ZONE OF INFLUENCE OF CONSTRUCTION VIBRATION

A "Zone of Influence" (ZOI) approach has been taken in the assessment. A ZOI can be defined as:

> *"The area of land within or adjacent to a construction site, including any buildings or structures, that potentially may be impacted by vibrations emanating from a construction activity where the peak particle velocity measured at the point of reception is equal to or greater than five (5) mm/sec at any frequency or such greater area where specific site conditions are identified by the professional engineer in a preliminary vibration study."*[2]

For this study the model recommended by the Federal Transit Administration (FTA) in the United States has been applied for prediction of vibration impacts during construction and to establish the extent of the Zone of Influence. The source vibration levels associated with the equipment planned for shoring/excavation were specified based on data in the FTA document, as well as SLR' own measurement data from work conducted on other construction projects.

For this study, the ZOI was determined based on the following numerical model:

$$\mathrm{PPV}_{equip} = \mathrm{PPV}_{ref} \times (25/D)^{\gamma} \qquad (1)$$

Where:

- PPV_{equip} is the estimated peak particle (ground) velocity at distance *D* from the equipment;
- PPV_{ref} is the peak particle (ground) velocity due to operation of the source equipment at an offset distance of 25 ft (7.6 m); and,
- γ is the ground vibration decay factor (γ = 1.5 for the project site).

The ground vibration decay factor was specified for this site based on information in the geotechnical report prepared for the project by Pinchin Ltd. ('Geotechnical Investigation Phase 1 Construction – Buildings C1 and C2', dated August 12, 2021). The existing subsurface conditions consist of 150 mm of asphaltic concrete and < 100mm of fill followed by silt to a depth of 7m underlain by bedrock. Estimation of the ZOI requires solving equation (1) for *D* when PPV_{ref} = 5 mm/sec. This calculation is completed for each anticipated equipment type to establish the maximum (worst-case) offset of the ZOI from the extent of the shoring activity.

The source level for the equipment used in this study (PPV_{ref}), and associated ZOI offset distances are summarized in **Table 4**.

Table 4 Summary Of ZOI Offset Associated With Construction Activities

Equipment/Activity	ZOI[1] Setback Distance (m) for Structures	ZOI[2] Setback Distance (m) for Underground Gasoline Tanks, Pipes & Utilities
2 tons dropped from 4 ft	4	1
Hoe Ram	4	1
Jackhammer	2	0.5
Bulldozer	4	0.8
Excavator	2	0.3
Backhoe/bobcats	1	0.3
Loaded Trucks	4	1
Soldier Pile Drilling	4	1.1
Tieback Drilling	1	1
Vibratory roller	8	1.7

Note: [1] The Zone of Influence is the offset distance from the equipment/source at which ground vibration levels are estimated to be 5mm/s.
[2] The Zone of Influence is the offset distance from the equipment/source at which ground vibration levels are estimated to be 50mm/s.

The extent of the ZOI for the site during demolition, shoring, and vibration compaction are shown in **Figures 6 - 8**.

[2] From Chapter 633 of The City of Toronto Municipal Code

Based on the planned construction activities, the following is observed:

Demolition (Figure 6)

The ZOIs do not extend past the property line. No impacts are anticipated.

Shoring (Figure 7)

The ZOI's extend onto 2207 Fairview St to the west and onto the railway lands to the north. There are underground gasoline tanks located on the 2207 Fairview St near the southwest corner of the excavation. The current shoring plan calls for the use of tie-backs in this area and will need to be modified to include consideration of the tanks.

Continuous vibration monitoring is recommended in this location, during the duration of shoring and excavation.

Vibration levels at the rail tracks will be less than 50 mm/s, and much less than those produced by trains themselves as they travel over the tracks. Therefore adverse impacts on the rail line is not anticipated. Vibration monitoring is not required in this area.

Compaction (Figure 8)

The ZOI's extend onto 2207 Fairview St to the west and onto the railway lands to the north. There are underground gasoline tanks located on the 2207 Fairview St near the southwest corner of the excavation. Continuous vibration monitoring is recommended in this location.

Vibration levels at the rail tracks will be less than 50 mm/s, and much less than those produced by trains themselves as they travel over the tracks. Therefore adverse impacts on the rail line is not anticipated. Vibration monitoring is not required in this area.

Construction activity includes a small area close to Fairview St, where the Development will "tie in" to the City's underground municipal servicing/infrastructure. Given the nature and depth of the infrastructure, vibration impacts from surface compaction are not predicted. Vibration monitoring is not required in this area.

4. RECOMMENDATIONS

4.1 PRE-CONSTRUCTION INSPECTION OF ADJACENT BUILDINGS AND STRUCTURES

A Pre-Construction Survey was completed and is documented in the following report:

- "Pre-Construction Survey – 2243-2269 Fairview Street And 864 Drury Lane: Phase 1", dated July 13, 2022.

4.2 VIBRATION MONITORING REQUIREMENTS AND MITIGATION

Continuous vibration monitoring is recommended at 2207 Fairview Street, at the location of the underground gasoline tanks located near the property line. At a minimum, monitoring should be conducted during the period of shoring/excavation and vibratory compaction work.

The remote monitoring system should be equipped with real-time notification capabilities to alert the construction team when/if vibration levels approach the "Prohibited Vibration Levels" listed in Table 1 of By-law No. 514-2008. Alarm levels equivalent to 75% of the prohibited levels are recommended so that the contractor is notified in advance of exceedance of the limits.

Reports summarizing monitored vibration levels should be maintained on a monthly basis (as a minimum). The reports should include maximum measured vibrations and a discussion on compliance with the specified threshold limits.

Tiebacks are assumed to be conducted with standard drills and any impact or vibratory hammers should not be used. The contractor should exercise caution during excavation should any large boulders be encountered, with careful removal to avoid undue impacts that can generate high levels of vibration.

MONITORING EQUIPMENT

A seismograph shall be installed at the location of the underground gasoline tanks of 2207 Fairview St, at the closest possible setback to the shoring activity. The monitor shall be capable of recording continuous time traces of peak particle velocity (PPV) using a minimum sample frequency of 1024 Hz. Histograms of the maximum PPV value in 15-

minute intervals (or less) so that a continuous record of levels is generated. A minimum 5-second duration time trace of vibrations shall be recorded for further review/analysis for any events triggering the specified alarms levels.

The seismograph shall be armed with alarms that provide notification to all relevant stakeholders in the event the "Do Not Exceed" thresholds specified by the By-Law and DIN 4150-3 Standard thresholds are exceeded. The seismographs shall be configured to have continuous power throughout the monitoring period. A detailed description of the monitoring protocol is provided below.

MONITORING PROTOCOL

Vibration levels can be reviewed and monitored in accordance will thresholds published in City of Toronto's By-Law 514-2008 in **Table 2** and DIN 4150-3:1999 Structural vibration – Effects of vibration on structures in **Table 3**.

A cautionary limit of 5 mm/s is specified as a trigger level at the location of the building structure and 45 mm/s at the location of the underground gasoline tanks for download and review of the data. Should any vibration triggers exceed the threshold limits provided in **Tables 2 and 3**, onsite staff shall be notified to review and adjust their construction operational parameters or to cease operations. **Table 5** is a summary of the required Vibration Exceedance Protocol.

REPORTING

Reports summarizing monitored vibration levels should be submitted on a monthly basis and distributed to relevant stakeholders. The reports shall include maximum measured vibrations in each monitoring interval, and a discussion on compliance with the City of Toronto and DIN 4150-3 threshold limits. A summary discussion of events that exceed the By-Law and DIN4150-3 limits shall be included, together with a description of corrective measures taken to reduce vibrations to compliant levels.

MITIGATION

In the event that the vibration thresholds are exceeded, the site contractor shall engage with a vibration consultant to review the activity and identify any required mitigation measures, such as gentler activity and the use of alternative equipment/ measures.

Table 4 Vibration Monitoring Protocol

Measured PPV (mm/s)	Notification	SLR Action	Required or Recommended Action for Contractor
<5 mm/s	None[1]	No action required	No action required
5 mm/s – 8 mm/s at building structure	Monitoring Consultant	• Monitoring Consultant to review vibration event to determine vibration frequency (Hz) and duration. • If appropriate, send notification email to stakeholders advising that vibration levels on site are approaching established limits	• Communication from Monitoring Consultant may be provided as a cautionary notice if vibration levels are established limits
8 mm/s to 25 mm/s at building structure	Monitoring Consultant	• Monitoring Consultant to review vibration event to determine if it has exceeded the limit. • Monitoring Consultant will contact selected stakeholders and site supervisor to advise whether limits are exceeded and if construction activities need to be stopped / changed. • A summary of all events exceeding 8 mm/s will be included in the monthly monitoring report	• Communication from Monitoring Consultant will be provided to alert stakeholders and site that the 8 mm/s PPV level has been exceeded. • If levels exceed the limits at the frequencies specified in **Table 1** changes to work methodology to reduce impacts will be required. • If levels do not exceed limits construction activity may continue but changes may be recommended to limit disruptions and potential complaints.
> 25 mm/s at building structure	Monitoring Consultant Site Supervisor Selected Stakeholders	• Monitoring Consultant will contact selected stakeholders and site supervisor to advise on required changes to construction activities • A summary of all events exceeding 8 mm/s will be included in the monthly monitoring report	• Contractor to stop all construction operation **immediately** at boundary of site. • Contact Monitoring Consultant directly via number provided in notification to confirm vibration level and discuss required changes to work methodology to reduce impacts at adjacent site.
45 mm/s at underground gasoline tanks	Monitoring Consultant	• Send notification email to stakeholders advising that vibration levels on site are approaching established limits	• Communication from Monitoring Consultant may be provided as a cautionary notice if vibration levels are established limits
> 50 mm/s at underground gasoline tanks	Monitoring Consultant Site Supervisor Selected Stakeholders	• Monitoring Consultant will contact selected stakeholders and site supervisor to advise on required changes to construction activities • A summary of all events exceeding 50 mm/s will be included in the monthly monitoring report	• Contractor to stop all construction operation **immediately** at boundary of site. • Contact Monitoring Consultant directly via number provided in notification to confirm vibration level and discuss required changes to work methodology to reduce impacts at adjacent site.

Note: Although vibrations may be below the applicable compliance thresholds, they may be perceptible to building occupants.

6.0 CONCLUSION

Should you have any questions or wish to discuss the recommendations outlined in this report, please contact us at your earliest convenience.

Yours sincerely,

SLR Consulting (Canada) Ltd.

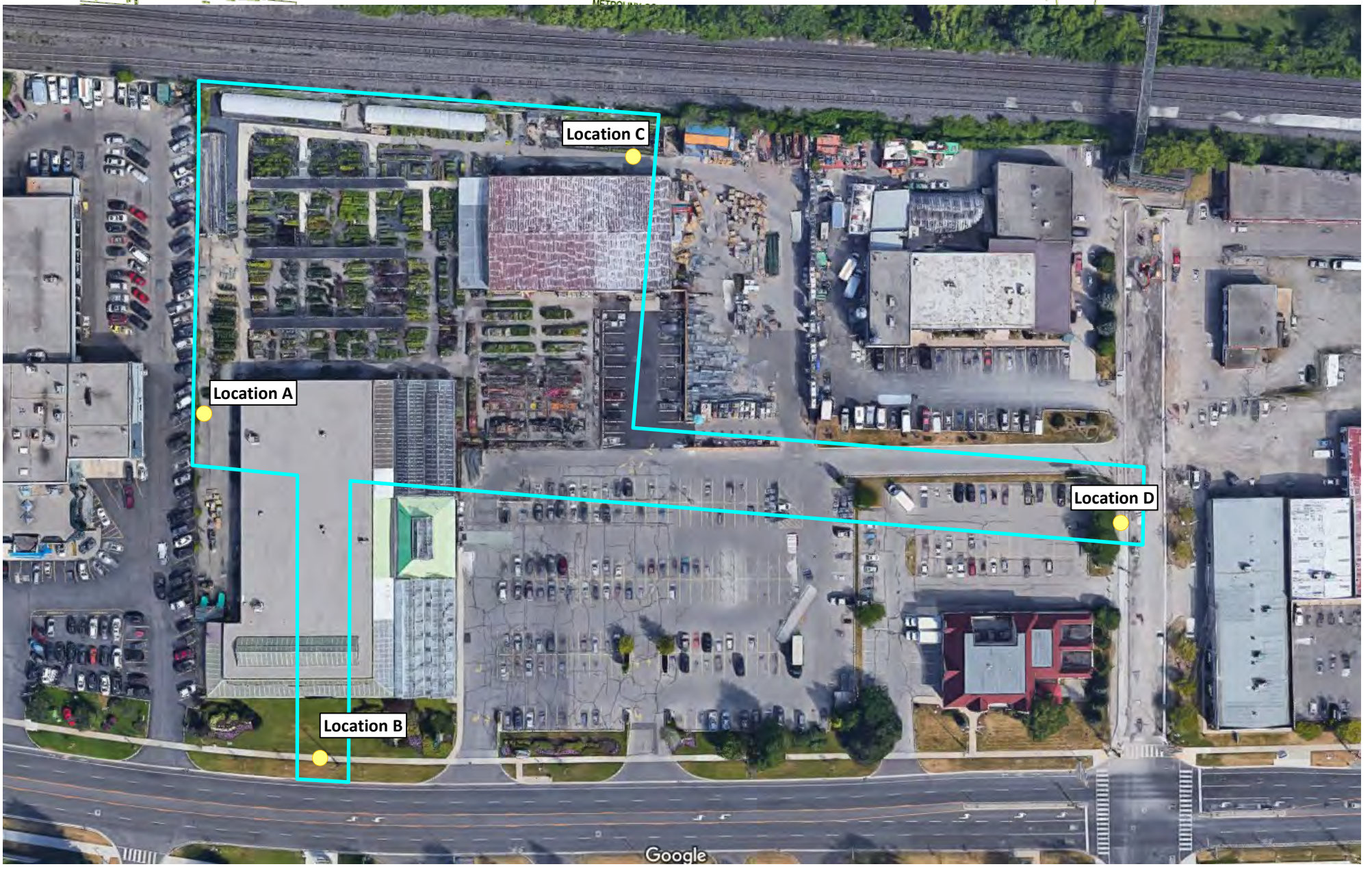


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FIGURES

Construction Vibration Control Study
2243-2269 Fairview Street & 864 Drury Lane
SLR Project No.: 241.18239.00000

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Phase 1 Construction Area

Figure No. **1**

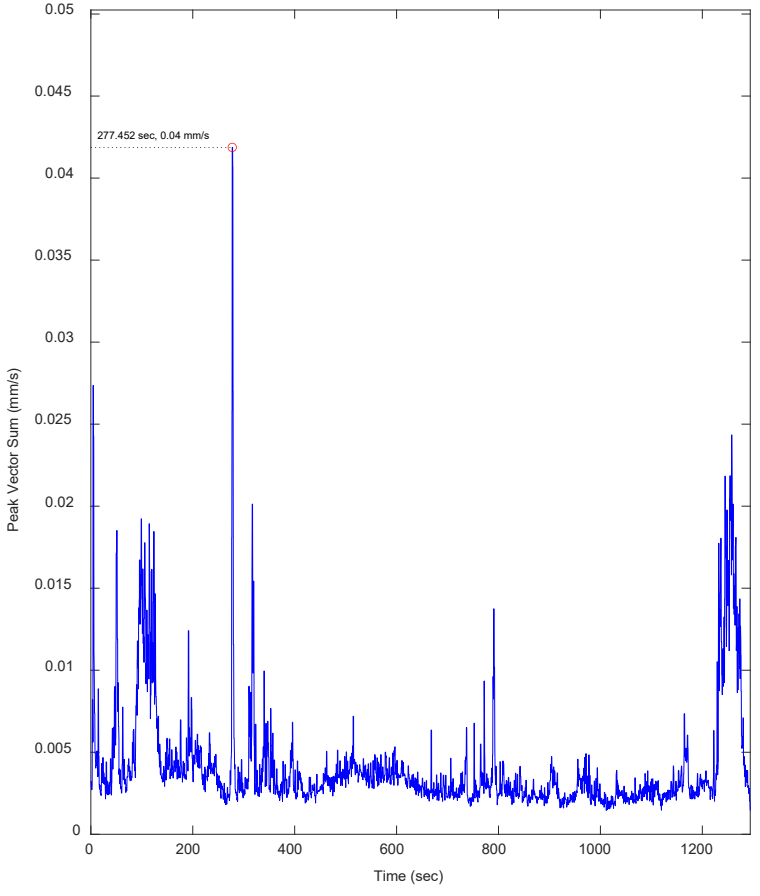
Baseline Vibration Measurement Locations

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

True North

Date: 21/10/07
File No.:
Drawn By: AA

SLR



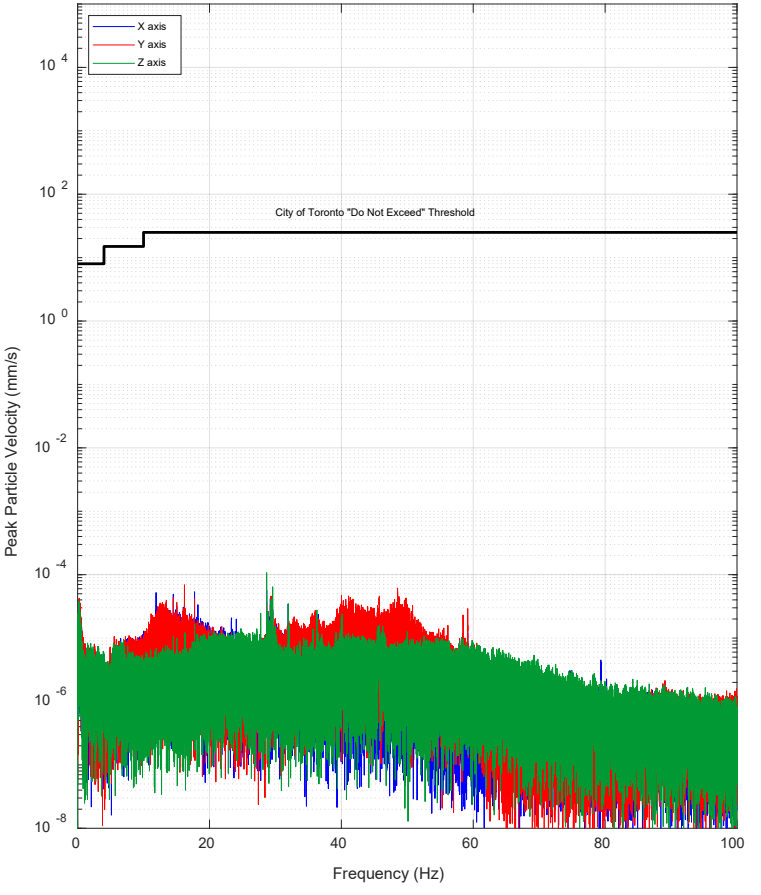


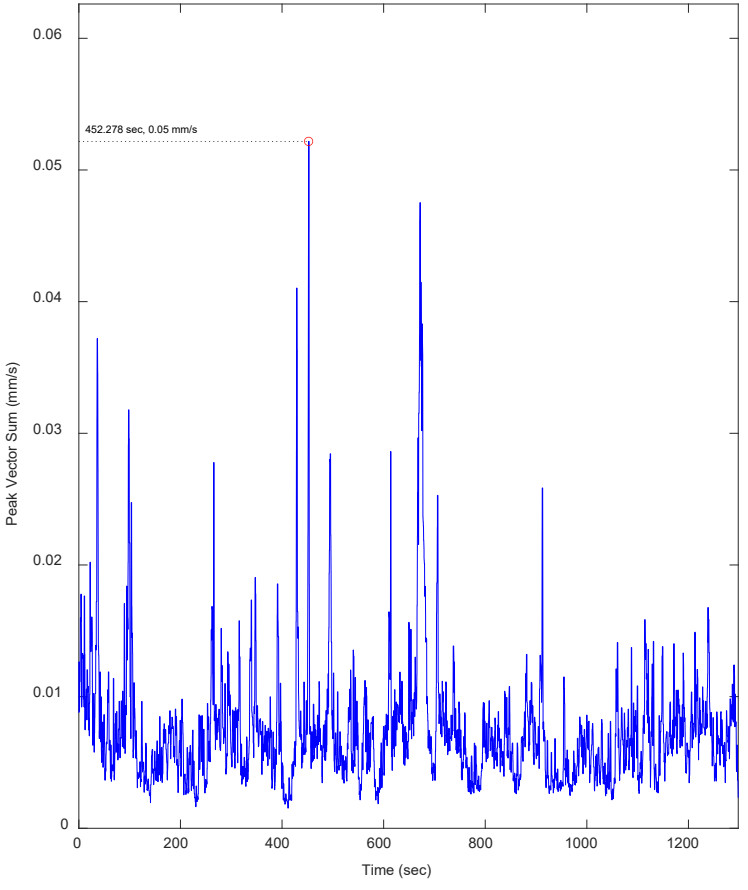
Figure No. **2**

Baseline Vibration Levels
Location A

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Date: 21/10/07
File No.:
Drawn By: AA

SLR



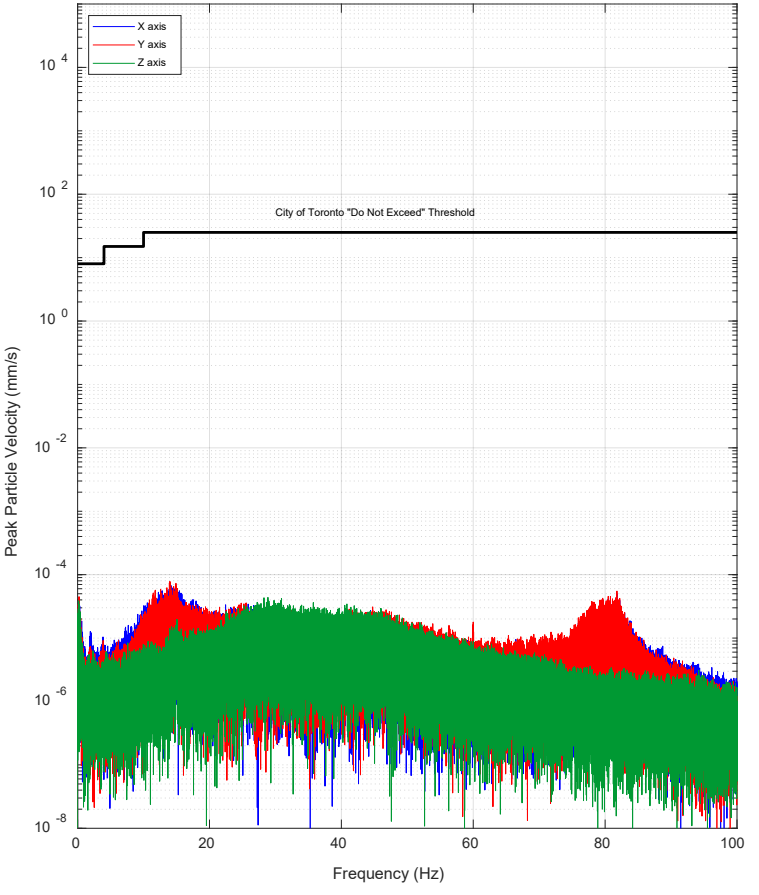


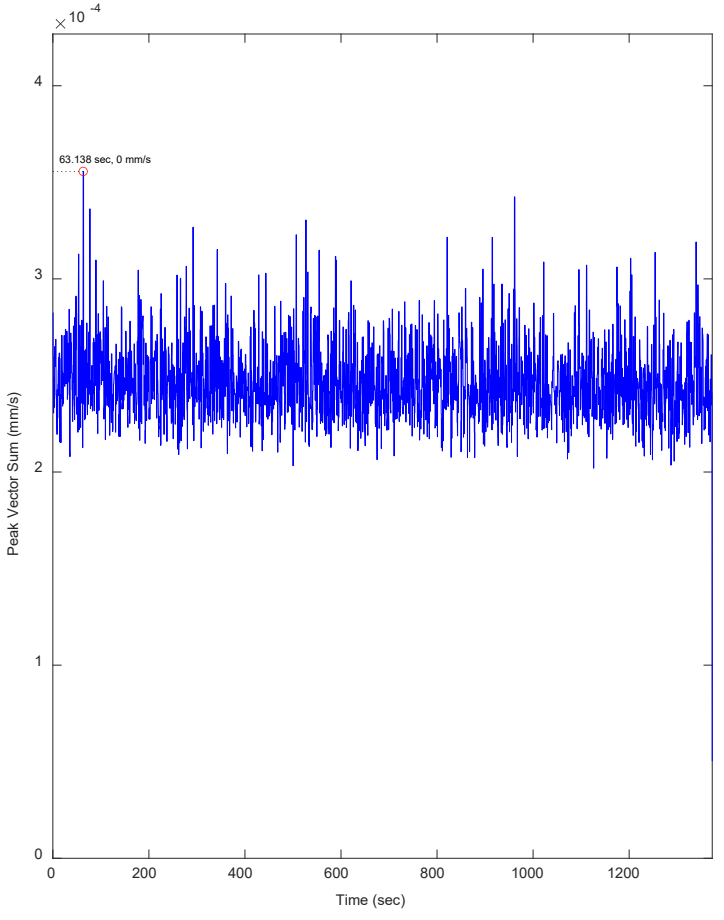
Figure No. **3**

Baseline Vibration Levels
Location B

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Date: 21/10/07
File No.:
Drawn By: AA

SLR



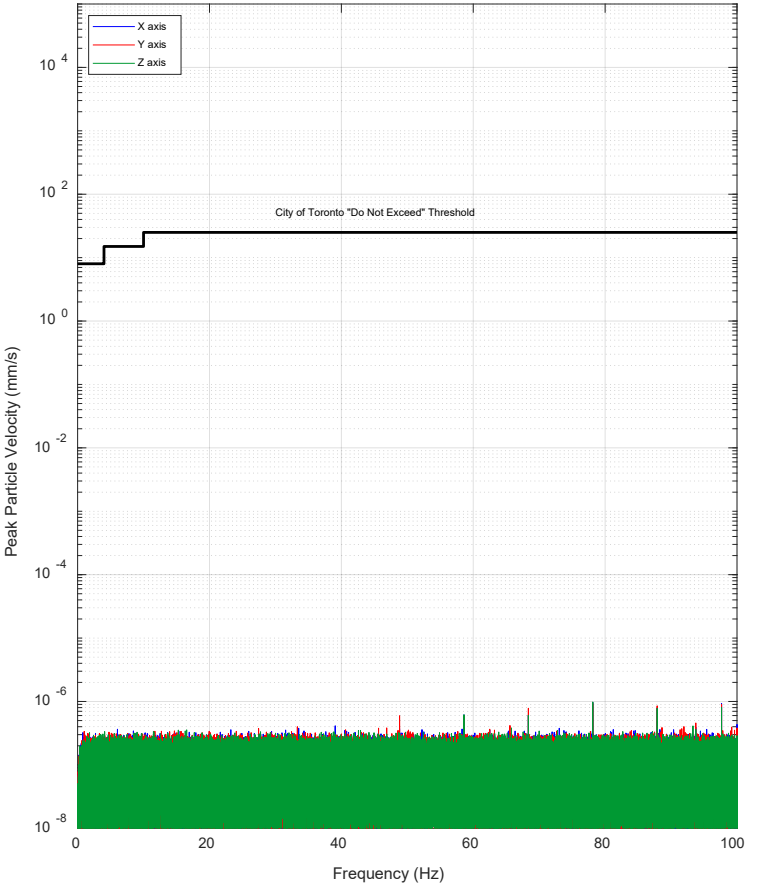


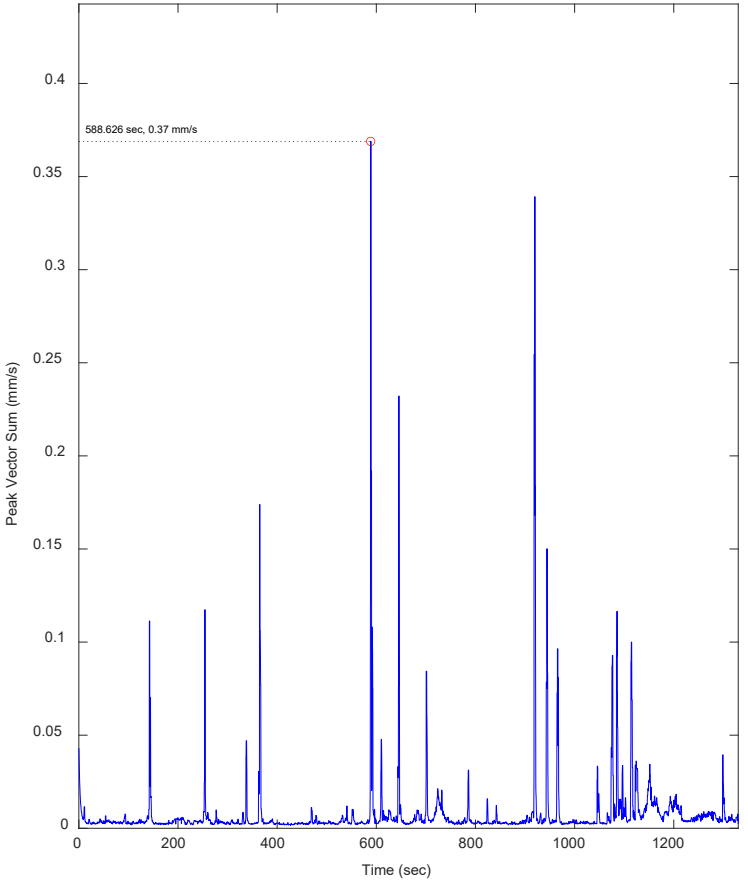
Figure No. **4**

Baseline Vibration Levels
Location C

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Date: 21/10/07
File No.:
Drawn By: AA

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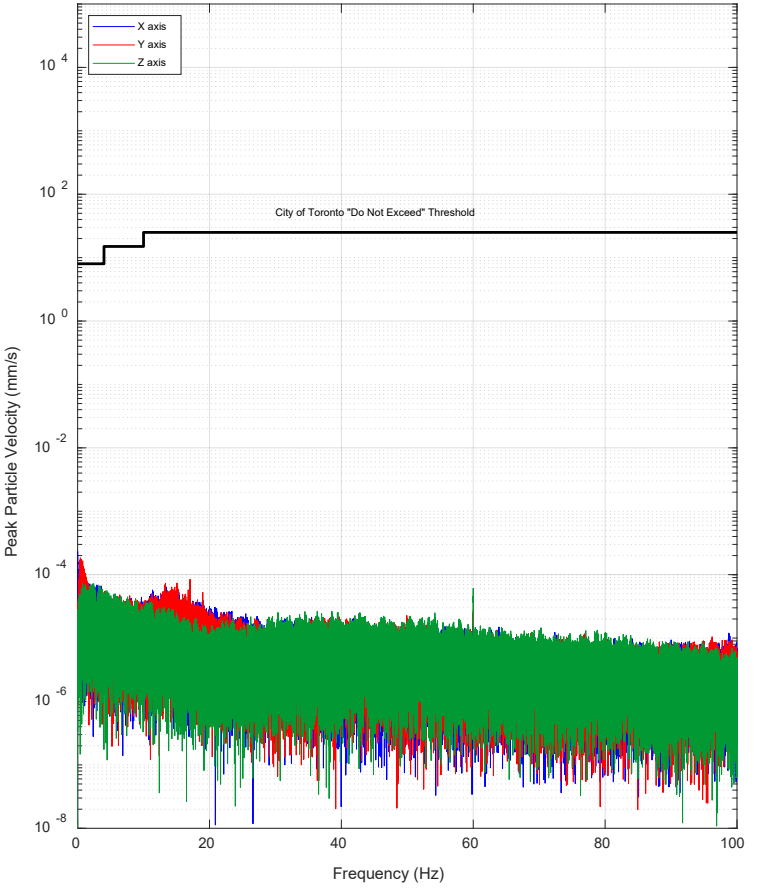


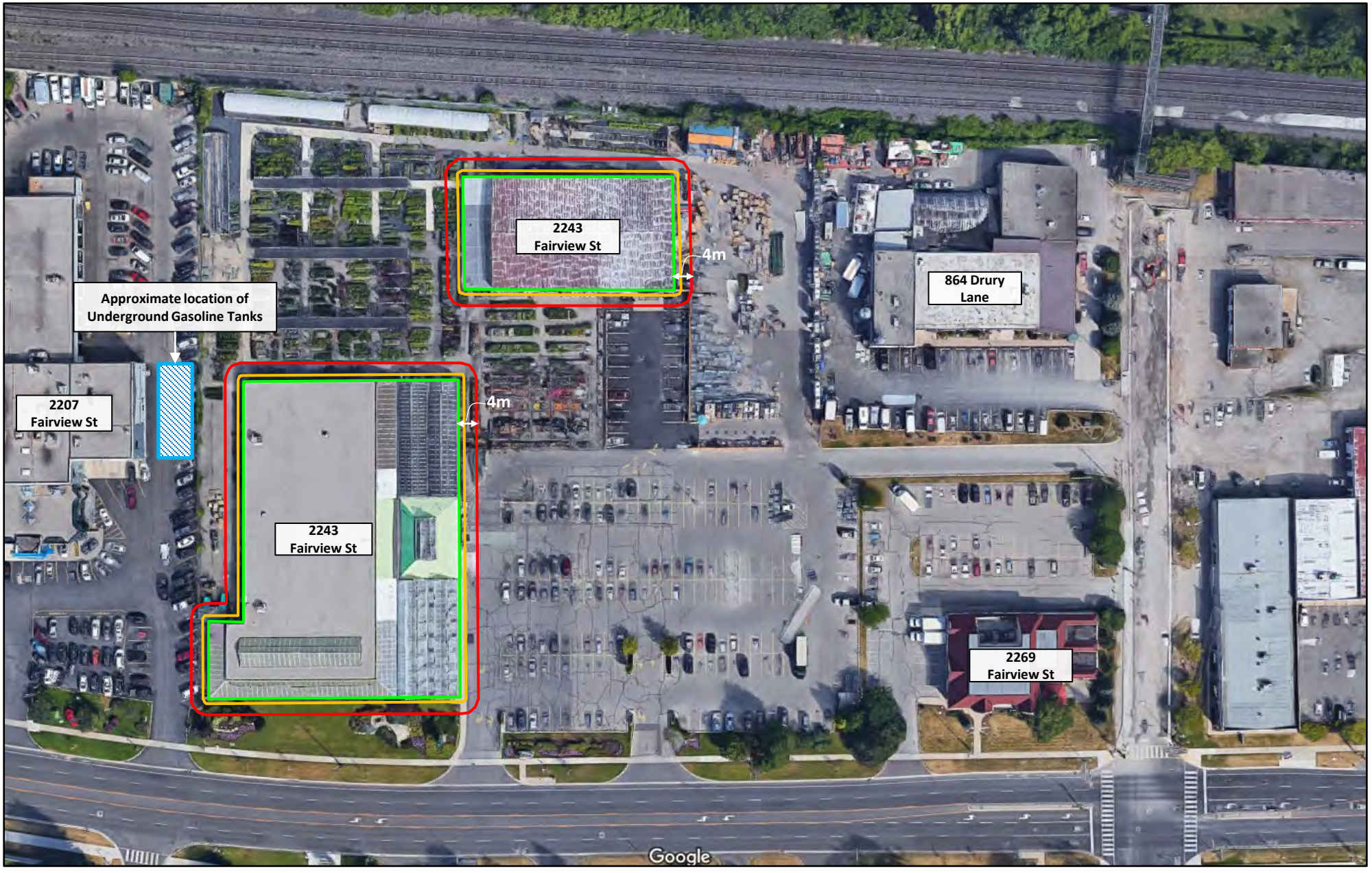
Figure No. **5**

Baseline Vibration Levels
Location D

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Date: 21/10/07
File No.:
Drawn By: AA

SLR



Demolition Activity

ZOI (5mm/s threshold contour)

ZOI (50mm/s threshold contour)

Figure No. **6**

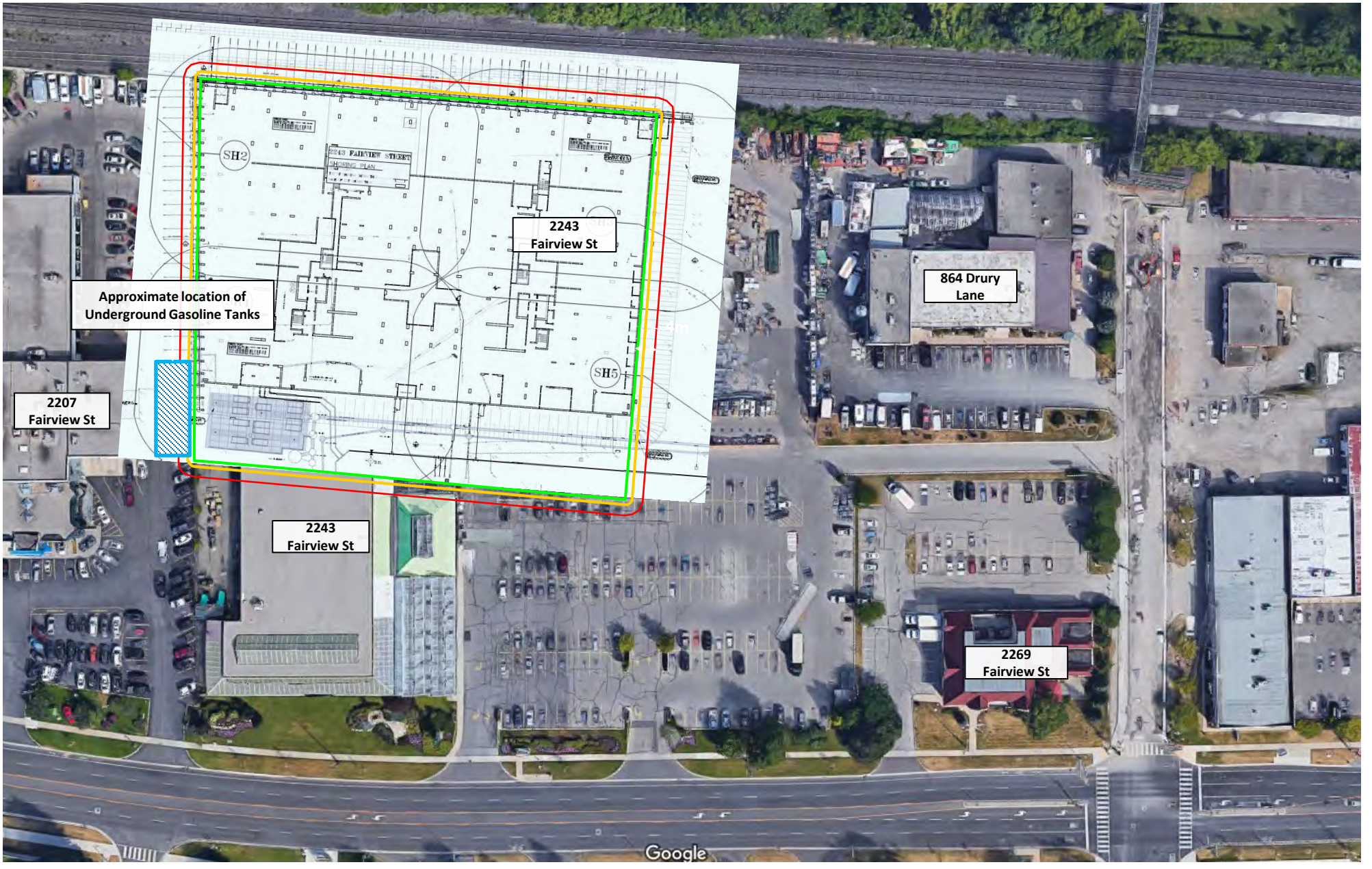
Zone of Influence (ZOI)
Proposed Demolition Activity: Phase 1

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Project North

Date: 22/07/13
File No.:
Drawn By: NV

SLR



Shoring Activity

ZOI (5mm/s threshold contour)

ZOI (50mm/s threshold contour)

Figure No. **7**

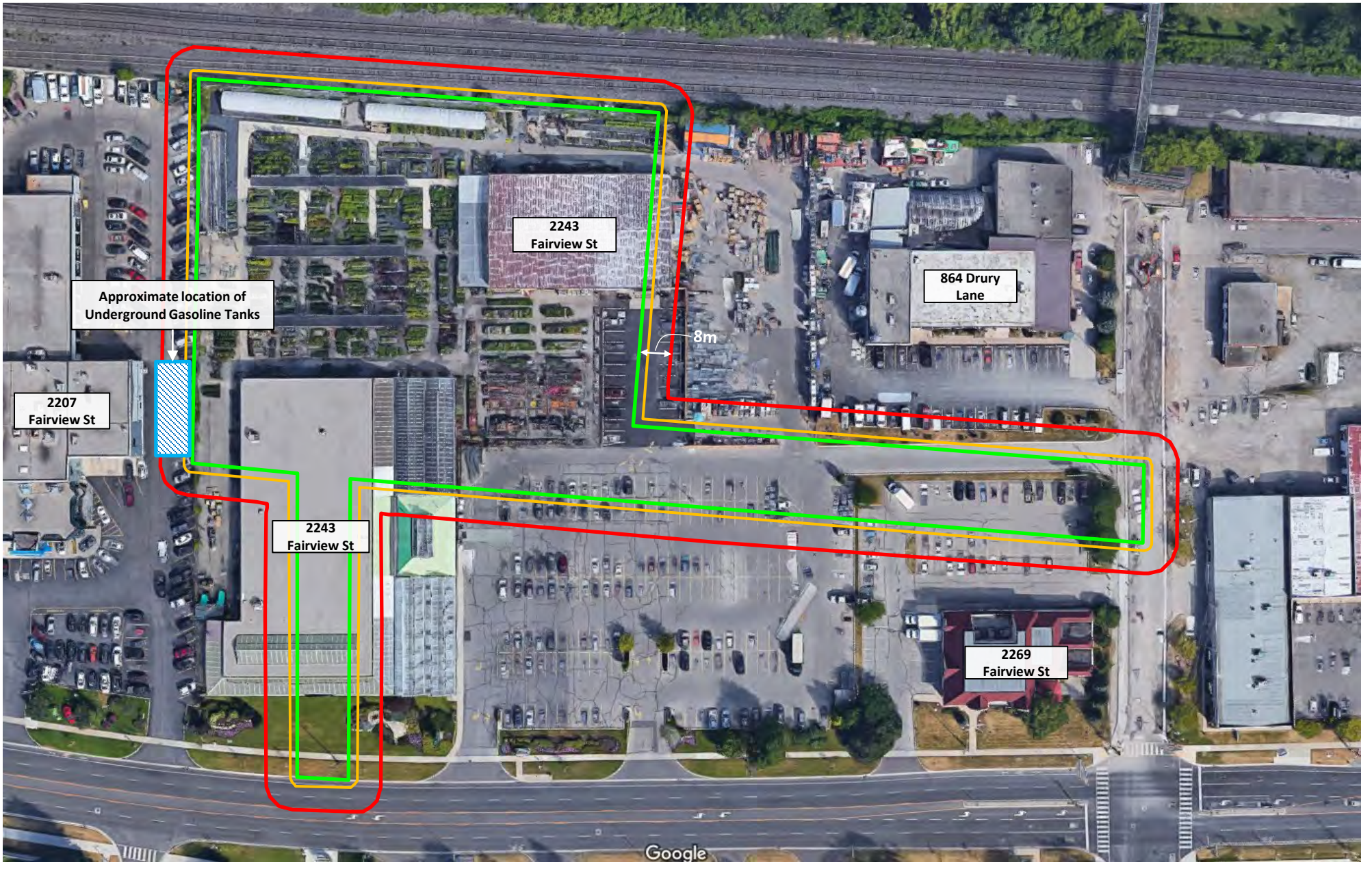
Zone of Influence (ZOI)
Proposed Shoring Activity

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Project North

Date: 22/07/13
File No.:
Drawn By: NV

SLR



Compaction Activity

ZOI (5mm/s threshold contour)

ZOI (50mm/s threshold contour)

Figure No. **8**

Zone of Influence (ZOI)
Proposed Compacting Activity

2243-2269 Fairview St and 864 Drury Lane
Burlington, Ontario

Project North

Date: 22/07/13

File No.:

Drawn By: NV

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