Vibration Monitoring Plan

325 King St, Niagara-on-the-Lake, Ontario

(Parliament Oak Hotel)

Date: 07/17/2025
Project No: M25-322

Prepared By:

Tarra Engineering & Structural Consultants Inc.

2800 14th Avenue, Suite 300, Markham, ON, L3R 0J9
Telephone: (905) 470-6952
Website: www.tarraeng.com; Email: admin@tarraeng.ca

Prepared For:

Solmar Development Corporation

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1.0 Introduction

Tarra Engineering and Structural Consultants Inc. was commissioned by Solmar Development Corporation to undertake a Vibration Monitoring program for the proposed development at 325 King Street, Niagara-on-the-Lake, Ontario. This vibration monitoring plan presents Tarra's methodology and work plan for the above-noted services.

No Vibration Monitoring Stations (VMS) will be installed throughout the entirety of the monitoring program. The vibration monitoring program will be carried out as per Section 01 57 19 – Environmental Controls and noise and vibration control by-laws.

2.0 Baseline Vibration Measurement

A baseline of vibration measurement will be taken before the commencement of construction/demolition activities. The baseline reading will be taken from the proposed locations around the construction site. Baseline locations will match the long-term monitoring locations. The entire process of instrumentation will be supervised by an experienced Vibration Technician/Engineer, along with inspection of the instruments. The field installation information of location map, date, instrument name, number, and other pertinent information, will be submitted with the monitoring baseline report.

3.0 Real-time Vibration Monitoring

Real-time Vibration Monitoring will be carried out as per Section 01 57 19 Environmental Controls, according to which, vibration shall be minimized in the work area in compliance with the requirement of the City of Toronto By-Law 514-2008 (Municipal Code Chapter 363-3.6).
Baseline vibration monitoring will be conducted in a continuous histogram mode. During the construction, vibration monitoring will be on continuous trigger mode, recording values continuously. All the vibration monitoring equipment will continue recording the vibration data during the construction activities.

City of Toronto By-Law 514 which regulates vibrations resulting from construction and demolition activities, provides limits of maximum allowable peak particle velocity (PPV) vibration levels as following (Table 1).

Table 1 - Prohibited Construction Vibrations adjacent to any structures

Frequency of Vibration (Hz)	Vibration Peak Particle Velocity (mm/sec)
Less than 4	8
4 to 10	15
Higher than 10	25

3.1. Cautionary Vibration Criteria as per By-Law

Some type of structures as shown in the table below, requires greater care as per the city by-law which should be exercised during the construction phase which includes a greater factor of safety. This is done to ensure that the prohibited vibration levels for cautionary conditions are not exceeded. In case of requirement for cautionary vibration criteria, the limitations of the table below considered during the monitoring of construction vibration.

The by-law leaves the identification of these levels and the selection of appropriate criteria to the Professional Engineer associated with the project.

Table 2 – Suggested Cautionary Vibration Criteria

Structure Type	Peak Particle Velocity (mm/sec)		
	< 4Hz	4 – 10 Hz	> 10 Hz
Sensitive or Heritage-Designated Buildings	2.4	4.5	7.5
Residential Buildings/Mixed-Use Buildings	4.8	9	15
Commercial Structures	6.4	12	20
Buried Services and Tunnels	6.4	12	20

3.2. Recommended Attended Vibration Monitoring Locations for Underground Utilities Adjacent to Construction Site

Underground utilities, including water and gas mains, typically have higher vibration tolerance limits than those used in the Zone of Influence assessment (calculated based on 5 mm per second). For example, the City of Toronto guideline (see Section 3.2 table 3) sets the vibration limit for modern water mains at 25 mm/s, regardless of frequency. As a result, applying the 5 mm/s criterion to

underground services would overestimate the ZOI extent. A more suitable threshold for identifying the ZOI around underground services is 15 mm/s, equivalent to 60% of water main damage (25mm per second).

It is recommended that vibration monitoring be carried out when caisson drilling or excavation occurs within 6 m of underground utilities. Given that the vibration estimates in this report are conservative, actual vibration levels are expected to be lower.

As a result, short term in person monitoring of the adjacent underground utilities is necessary. If short-term monitoring confirms consistently low vibration levels from a specific activity, monitoring at that location (or further distances) may be discontinued.

Please note that this is the responsibility of the construction manager to inform us at least 3 days in advance before start of any drilling/construction for scheduling the live monitoring service of the existing underground utilities.

Table 3 –Vibration Limits at City of Toronto Structures

Structure Type	Maximum Allowable Vibration Levels During Construction, mm/s
Old Truck sewer/waterman	10
Modern truck sewer/waterman	25
Old bridge (Old construction methods/materials)	10
Modern bridge (Street, reinforced concrete)	25

4.0 Vibration Monitoring Baseline Report

a) Baseline vibration monitoring will be conducted at least 1 week before the construction activities start.
b) Baseline vibration monitoring will be conducted for a minimum of 24 hours.
c) Baseline vibration report will be submitted within 7 Days after baseline monitoring completion and before the start of the construction.

4.1. Monthly Vibration Report:

a) All vibration measurement events will be recorded 24/7.
b) Vibration results will be reported in terms of Peak Particle Velocity (PPV) in mm/s.

c) Any exceedance from the contract specific limits (if any) and more importantly the regulatory criteria as defined by The City of Toronto By-Law No.514, will be reported.
d) The vibration monitoring station includes a seismometer with a triaxial geophone with weather enclosure, cables & attachments.
e) Calibration tolerance for vibration monitoring system is ±0.01 mm/s PPV.

Monthly vibration monitoring reports will be submitted at the end of each month. However, if any trigger happens during the reporting period the construction site representatives will be informed immediately. Vibration monitoring will be measured and reported continuously until the completion of the construction. Vibration monitoring stations will remain active on the site for at least one week after the end of the construction.

5.0 Plan of Exceedances

Two vibration "action level" threshold values will be used to assess the potential vibration during pile drilling at the Site (Table 2). These levels will be evaluated at the ground surface by the maximum of the longitudinal, transverse, and vertical direction outside and near the foundations of potentially impacted structures, as practical. The distances at which action levels are to be assessed will be based on field logistics.

Tarra's monitoring team will notify the client if any reading exceeds the Review/Alert levels. If vibration readings exceed the Review Level, an onsite inspection will be conducted to measure the necessity of altering the construction method, rate, or sequence of construction to reduce vibration levels. If vibration alert is exceeded, the contractor should stop the work, make the site secure, and take necessary measures to mitigate vibration and assure the safety of work and the public.

Table 3- Vibration Action Levels

Action	Vibration Threshold Values (mm per second PPV)	Remarks
"Warning"	5 (Review Level)	The vibration "warning" threshold level is 5 mm per second PPV. If this level is exceeded, then the situation will be reviewed to identify the potential cause.
"Temporary Halt"	8 (Alert Level)	The vibration "stop work" threshold is 8 mm per second PPV. This threshold level is the City of Toronto By-Law 514 vibration criteria to avoid possible damages to structures with concrete foundations and timber framing. The potential causes of such vibration will be reviewed, and possible mitigation methods investigated.

6.0 Mitigation of Vibration During Construction/Demolition

There are many events that can cause vibrations during the process of construction/demolition. Below are some causes along with solutions to reduce the amount of vibration that occurs.

1. Vibration caused by falling debris during demolition can cause vibrations to the adjacent buildings. These vibrations can be mitigated through piecemeal demolition methods (grappling claws, pulverisers, saw cutting and grinding) to reduce the size of falling debris to a minimum. By reducing the size of falling debris, the rate of caused vibration will be reduced significantly.

2. Vibratory compaction is another cause of vibrations, especially when being doing near surrounding structures. To reduce the vibrations, the energy settings must be lowered, thinner lifts can be used, and using lighter equipment should be taken into consideration.

3. Drilling is another main cause of vibrations during construction. Drilling equipment that can twist liners in and out easily during the insertion/extraction of steel liners is recommended. This will minimize the vibrations to surrounding structures compared to pile driving of the liners. Vibratory/ Hammer driving piles must be eliminated or being used by extreme caution.

4. While excavating, there could be obstructions (boulders, old foundation elements, etc.) that need to be demolished. These obstructions should be moved away from surrounding buildings before getting demolished, if this is not an option, consider saw cutting or grinding them.

Below is a summary of mitigation measures (that should be considered but not limited to):

- Locate construction staging and laydown areas to minimize potential impacts on sensitive receptors, where feasible.
- Use construction equipment that emits low levels of vibration, where possible.
- Prefabricate components off-site to reduce construction activities near sensitive areas.
- Limit construction activities to daytime hours where feasible. If night-time work is necessary, schedule high-vibration tasks during daytime hours whenever possible.
- Reassess vibration impacts based on finalized construction staging plans, equipment selection, and nearby building locations prior to construction, if required.
- Maintain smooth travel surfaces for trucks to reduce vibration.
- Where possible, route heavily loaded trucks away from vibration-sensitive locations.
- Operate machinery using lower vibration settings when available.
- Maximize the distance between operating equipment and sensitive receptors, where feasible.
- Establish and implement project-specific vibration criteria.
- Use alternative methods or equipment with lower vibration emissions or power settings if needed to remain within allowable limits.
- Develop a communication plan that includes procedures for timely resolution of vibration-related complaints.

7.0 Calculation of Zone of influence

Ground-borne vibration can be produced by various common construction activities, including caisson drilling, pile driving, and soil compaction. In extreme cases, such vibration produced at a construction site has the potential to damage buildings or structures outside the limits of the site; at the very least, it creates an annoyance or nuisance in nearby buildings. A clear understanding of the potential hazard is important. In 2008, Toronto enacted its Vibration Control Bylaw 514-2008, Chapter 363, "Building Construction and Demolition," of the city's municipal code. It requires those applying for permits for construction or demolition to assess and, in some cases, monitor the potential vibration impact of the construction activities. The purpose is to avoid the potential for adverse vibration impact.

Vibration causes soil particles to move back and forth (*i.e.* oscillate) from their at-rest position. Two characteristics of the vibration are important (Figure 1):

- how long a particle took to complete one oscillation; and
- the maximum velocity that the particle experienced during its oscillation.

The first item defines the frequency of the oscillation, usually referred to in Hertz (Hz) or cycles per second. The second item is the 'peak particle velocity (PPV),' or the maximum velocity (in mm/s) experienced by the particle as it oscillates back and forth in response to the excitation (*i.e.* construction activity).

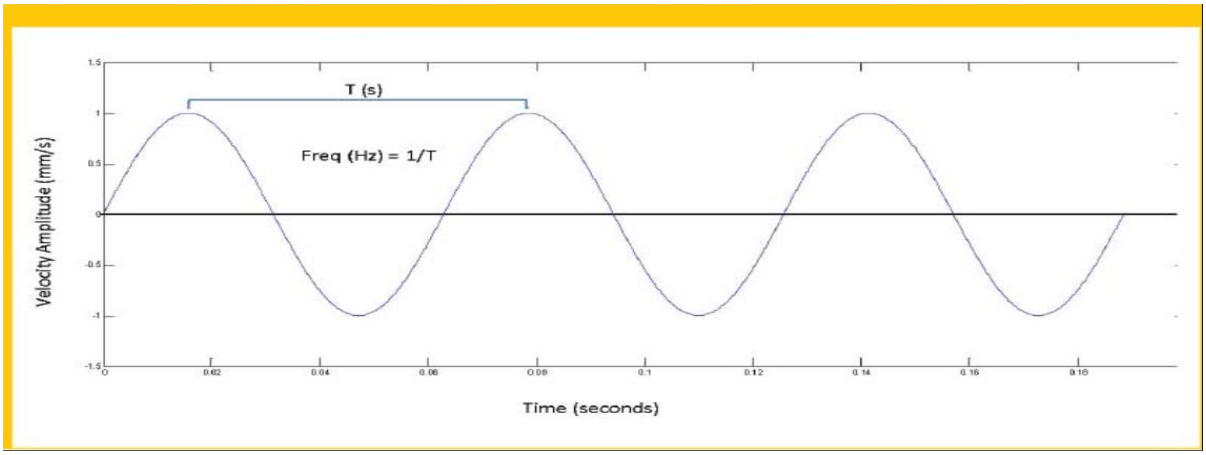

Figure 1: Particle oscillation.

The risk of potential damage to a structure is correlated with PPV. For any given value of PPV, the total particle displacement (*i.e.* distance traveled) is greater if the oscillation frequency is lower. Thus, the vibration criteria (in terms of PPV) are frequency-dependent and more stringent at lower frequencies.

7.1 By-law particulars:

The Toronto bylaw provides vibration limits at neighboring properties, applicable to the use of construction equipment on a construction/demolition site (Figure 2). However, there is also a provision for the professional engineer making submissions under the bylaw to identify more stringent requirements if necessary. The bylaw requires an application for a permit for construction (*i.e.* building permit) or demolition to be accompanied by a vibration control form. This form (Section C of the bylaw) provides a

roadmap for the overall application and approval process. The form itself is divided into sections and follows an 'if–then' format.

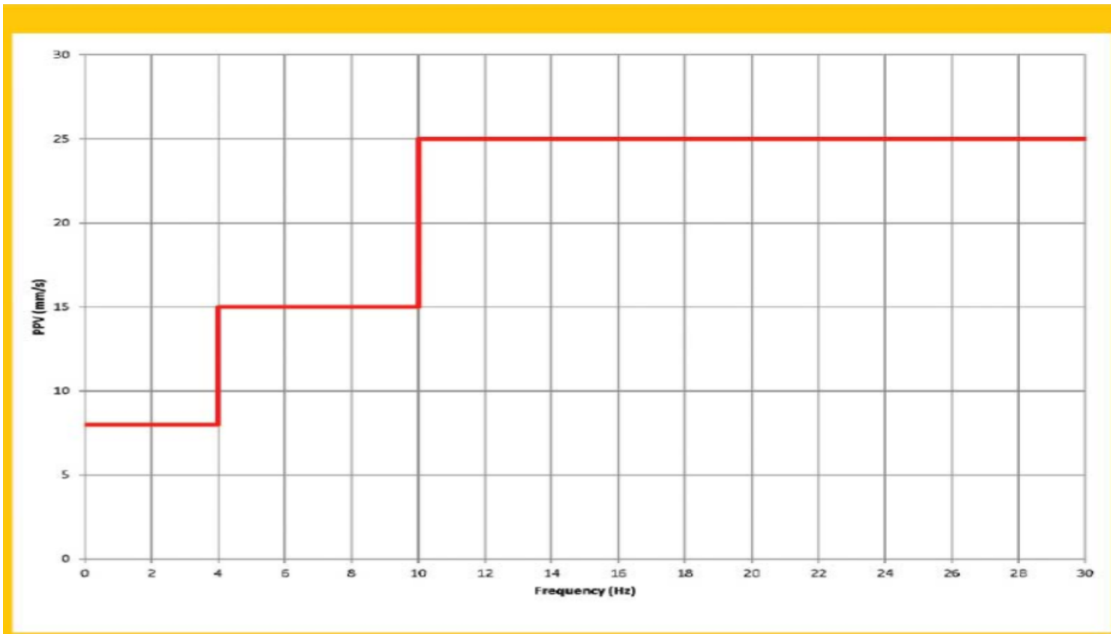

Figure 2: Bylaw vibration criteria

7.2 Section A—Section C (2) of bylaw:

The applicant must declare whether certain activities will occur as part of the construction/demolition process. Specifically, the list includes:

- Blasting.
- Deep foundations.
- Drilled caissons.
- Large-scale soil compaction.
- Construction within the water table; and
- Any other construction activity or method that has the potential to cause vibrations that may impact buildings or structures outside the construction site.

It is important to note the last bullet item is a 'catch-all,' leaving the actual scope of the work to the discretion and responsibility of the engineer completing the form.

7.3 Section B—Section C (3) of By-Law:

Per section C (3) of the By-Law; any activity listed in Section C (3) is to be conducted, a preliminary study is required to evaluate the potential impact of the project on the nearby neighbors. The study must include a plan showing the construction site, along with adjacent land and buildings, that identifies the zone of influence (ZOI) of vibrations.

It must also show whether the ZOI extends beyond the legal boundaries of the construction site that is the subject of the permit application. Further, it needs to show any buildings designated under the *Ontario Heritage Act* located within the zone.

The ZOI defined in the bylaw is the area of land within or adjacent to a construction site—including any buildings or structures—that potentially may be impacted by vibrations steaming from a construction activity where the PPV at the point of reception would be equal to or greater than 5 mm/s (0.20 in./s) at any frequency.

7.4 Section C—Section D of bylaw:

In accordance with Section C of the City By-law and in compliance with Municipal Code 363-3.6, if the Zone of Influence extends beyond the legal boundaries of the construction site, then the following tasks shall be taken to comply with Section C (and Section D):

- Pre-construction condition survey of the properties within the ZOI.
- Pre-construction measurement of background (*i.e.* ambient) vibration.
- Pre-construction inspection of adjacent buildings and structures within the ZOI.
- identification of vibration mitigation measures.
- A vibration monitoring program.

7.5 ZOI at the Site:

Currently, there are piles on the proposed site to be drilled. Pile tie-back drilling and construction are anticipated for the proposed new development. As the PPV of 5 mm/s criterion for the ZOI is more stringent

than the vibration limits, the ZOI is intended to cast a somewhat wide net in determining the existence of nearby structures that could be impacted by the activity on the construction site.

According to Transportation and Construction Vibration Guidance Manual (2013)[1], Equation 1 is used to calculate PPV resulting from different types of pile driving and drilling based on a reference PPV value as presented in Table 3. The piling at the Site is to be implemented through drilling. Accordingly, a reference PPV value of 0.089 in/sec.

$$PPV_{equipment} = PPV_{reference}\ (25/D)^{n}$$ **Equation 1**

Where:

PPV reference: Reference PPV at 25 feet

D: Distance (ft)

n: *1.1, the value related to the attenuation rate through ground*. The suggested value for "*n*" is 1.1.

Table 4 - Reference PPV values for different piling equipment

Equipment	Reference PPV at 25 ft. (in/sec)
Vibratory roller	0.210
Large bulldozer	0.089
Caisson drilling	0.089
Loaded trucks	0.076
Jackhammer	0.035
Small bulldozer	0.003
Crack-and-seat operations	2.4

As such, using Equation 1 and assuming a conservative attenuation rate (n) of 1.1, as graphically shown in Figure 3, the ZOI is estimated to be approximately **4.5** meters measured from the construction lines considering the regulatory criterion of 5 mm/sec as the PPV.

By considering the safety factor of **2** for the above calculation, the total ZOI will be **9 meters** from the construction lines.

Please Note: In case of using soil vibratory roller, the Zone of Influence can conservatively increase to **12 meters.**

We did not receive any information about the demolition procedure/plan. If the demolition will take place by using typical equipment (concrete pulverizes, grapple or bucket) generally won't cause any high level of vibration. We consider a safety factor (shown above) in case of falling some material to the ground which will result in some degree of vibration plus the additional level of vibration as a result of compaction that might occur on the construction site.

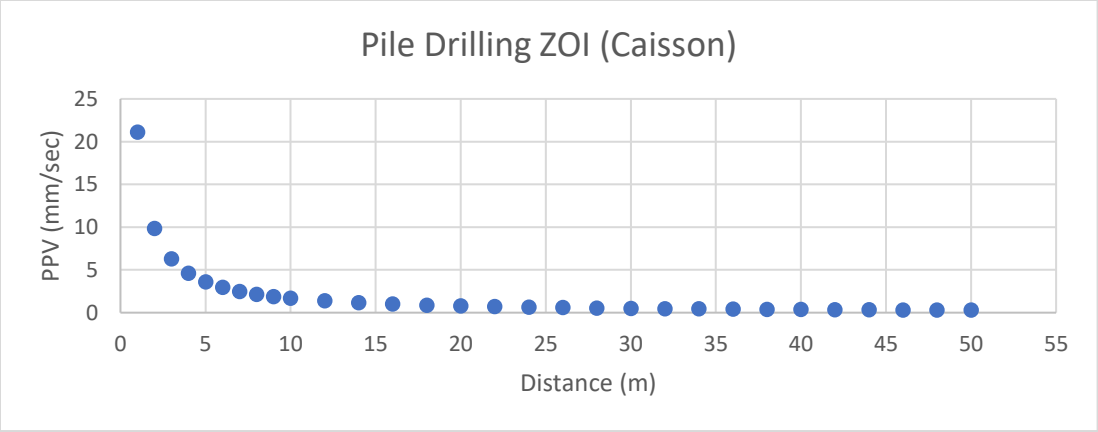

Figure 3- Graphical presentation of Equation 1 for calculating ZOI resulting from pile drilling

There are no buildings located inside the zone of influence for 325 King Street, Niagara-on-the-Lake, Ontario.

Figure 4 shows the ZOI at the Site which indicates that the ZOI extends beyond the site boundaries into the municipal right of way.

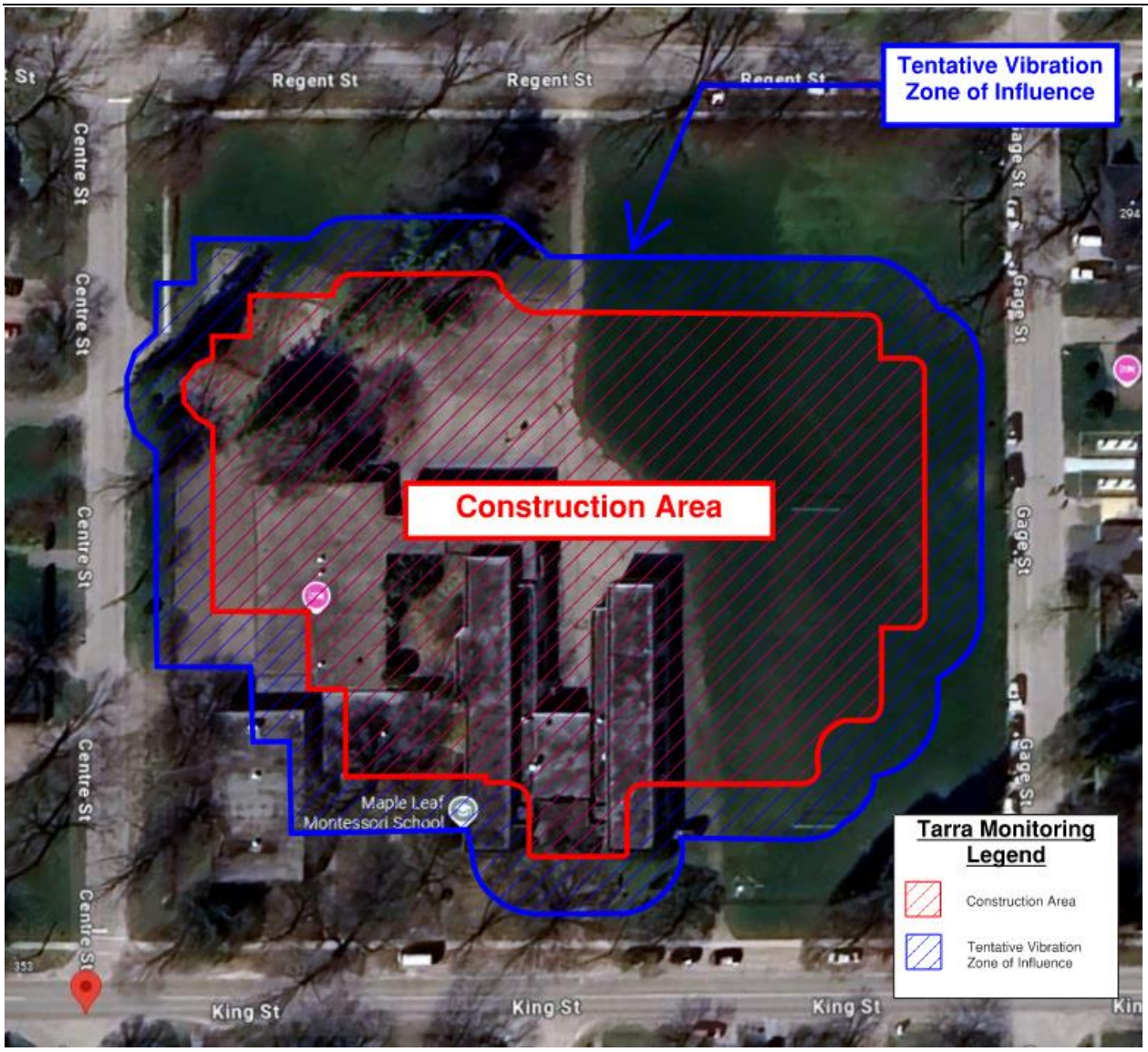

Figure 4- ZOI boundaries resulting from pile drilling at the Site

8.0 Pre and Post Construction Survey

The projected Zone of Influence extends beyond the legal boundaries of the site.

Per the vibration control requirements, the following steps should be considered to take place:

Pre-construction survey of the following properties/roads or structures:

- N/A

9.0 Closure

We trust the above information will satisfy your requirements. If there are any further questions, please do not hesitate to contact us.

Regards,
Tarra Engineering & Structural Consultants Inc.

Prepared by:
Stanley Liang
Field Technician Inspector
Stanley Liang

Approved by:
Ali Bayat Mokhtari (M.Eng, P.Eng)
Project Manager

APPENDIX A

VIBRATION ZONE OF INFLUENCE SKETCH

REGENT STREET

Tentative Vibration Zone of Influence

Construction Area

CENTRE STREET

GAGE STREET

KING STREET

KEY PLAN

LEGEND

000.00	TOP OF SHORING/ GRADE
000.00	BASE OF EXCAVATION/ FOUNDATION
	SHORING PILES & PILE NUMBER
	SHORING & STRUCTURAL CAISSONS (CONCRETE STRENGTH –SEE STRUCTURAL)
EX.	EXISTING SHORING
OR	PROPOSED BUILDING
	EXISTING BUILDING
EX.STORM	EXISTING UTILITIES
BH–	BORE HOLE LOCATIONS
	INCLINOMETER LOCATIONS
EX. STRUCTURE OR	REQUESTED TEST PIT LOCATIONS TO VERIFY EXISTING BUILDING OR FOUNDATION (IF REQUIRED)
TP	TIEBACK PERFORMANCE TEST
	STRUCTURAL CAISSONS DRILLED FROM DRILLING PLATFORM PRIOR TO EXCAVATION – SEE STRUCTURAL

Tarra Monitoring Legend

Construction Area

Tentative Vibration Zone of Influence

325 KING ST., NIAGARA-ON-THE-LAKE

SHORING KEY PLAN

SCALE 1:200

TOP OF SHORING SHOWN THUS .....

BASE OF CUT SHOWN THUS .....

NOT FOR CONSTRUCTION

No.	DESCRIPTION	Date
1	ISSUED FOR PERMIT	DEC. 17, 2024

REVISION

NOTES

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Client: SOLMAR DEVELOPMENT CORP.

CONCORD

Consultant: tarra

Tarra Engineering & Structural Consultants Inc.
2800 - 14th Ave., Suite 300
Markham, ON L3R 0E4
Tel: (905) 470 - 6962
Fax: (905) 470 - 5126

Project: PARLIAMENT OAK HOTEL

NIAGARA-ON-THE-LAKE ONTARIO

Drawing Title: EXCAVATION SHORING KEY PLAN

Designed: W.L.	Drawn: W.L.	Scale: AS INDICATED	
Checked: S.H / G.G.		Date: DEC 2024	
Project NO. 24102		Drawing NO. SH1	

APPENDIX B

LIMITATION AND USE OF THE REPORT

Limitation and Use of Report

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Tarra Engineering and Structural Consultants Inc. at the time of preparation. Unless otherwise agreed in writing by Tarra, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and/or recommendations given in this report are based on the information determined during the survey. The benchmark and elevations used in this report are primarily to establish relative elevation differences between locations and should not be used for other purposes, such as grading, excavating, planning, development, etc. Professional judgement was exercised in gathering and analyzing data and formulation of recommendations using current industry guidelines and standards. Similar to all professional persons rendering advice, Tarra cannot act as absolute insurer of the data presented and conclusion we have reached. No additional warranty or representation, expressed or implied, is included or intended in this report other than stated herein the report.

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