# Appendix K: Noise Report

## 407 TRANSITWAY - KENNEDY ROAD TO BROCK ROAD

### MINISTRY OF TRANSPORTATION - CENTRAL REGION

ARCADIS Design & Consultancy for natural and built assets

Ontario Ministry of Transportation

# NOISE AND VIBRATION IMPACT ASSESSMENT

## Highway 407 Transitway: East of Kennedy Road to East of Brock Road

April 2016

# NOISE AND VIBRATION IMPACT ASSESSMENT

407 Transitway: East of Kennedy Road to East of Brock Road

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| dBA | A-weighted decibels |
| ETR | Express Toll Route |
| FHWA | Federal Highway Administration |
| FTA | Federal Transit Administration |
| km/hr | kilometers per hour |
| Leq | energy equivalent sound level |
| LRT | Light Rapid Transit |
| mm/s | millimetres per second |
| MOECC | Ontario Ministry of the Environment and Climate Change |
| MTO | Ontario Ministry of Transportation |
| NSA | Noise Sensitive Area |
| NVIA | Noise and Vibration Impact Assessment |
| OLA | Outdoor Living Area |
| POR | point of reception |
| PPV | peak particle velocity |
| TNM | Traffic Noise Model |
| TTC | Toronto Transit Commission |
| RMS | root mean square |

# EXECUTIVE SUMMARY

The Ministry of Transportation (MTO) is proposing a 18 km segment of a transitway facility along the Highway 407 corridor through York Region and Durham Region, from east of Kennedy Road in the City of Markham to east of Brock Road in the City of Pickering (407 Transitway). The 407 Transitway includes four stations, with the potential for two additional stations. Subject to the outcome of the study, the 407 Transitway will be implemented initially as bus rapid transit (BRT) facility with the opportunity to convert to light rail transit (LRT) in the future. The transitway will be a high-speed fully grade separated facility on a separate right-of-way running parallel, and crossing over or under Highway 407. This 18 km section includes four transit stations at Markham Road, 9th Line, Whites Road (Sideline 26), and Brock Road, and two potential additional stations at Donald Cousens Parkway/Reesor Road and Rossland Road (Sideline 22).

Arcadis Canada Inc. (formerly SENES Consultants Limited) was retained by LGL Limited (LGL), on behalf of the MTO, to complete a Noise and Vibration Impact Assessment (NVIA) in support of the Planning and Preliminary Design for the 407 Transitway project (the “Project”). The following potential impacts have been assessed in this study:

- Noise impacts at existing and proposed sensitive locations from buses and LRT operating on the proposed 407 Transitway, inclusive of changes to local topography;
- Ground-borne vibration impacts associated with buses and LRT operating on the 407 Transitway;
- Airborne vibration of house structure elements induced by sound levels from bus engines; and
- Noise and vibration considerations during construction of the Transitway.

As the Project is under the jurisdiction of the MTO, guidelines developed by the MTO were the primary reference for the assessment methodology and impact assessment criteria. Where no assessment guidance had been developed by the MTO for a potential project effect, relevant guidelines from the Ontario Ministry of the Environment and Climate Change (MOECC) and published literature were applied as appropriate.

The assessment methodology involved identifying the locations of Noise Sensitive Areas (NSAs) along the route, and selecting points of reception (POR) that are representative of each of these locations. Assessment scenarios were developed to estimate current and future sound levels associated with the Project. The difference in noise and vibration levels predicted between the future scenario that assumes the Project does not proceed (i.e., the future no-build, where no changes are assumed to current configurations and only traffic volumes are projected) and the future scenario where the Project does proceed (i.e., future build) is an indication of the impact of the Project. Traffic noise modelling of these scenarios was completed using methodology prescribed by the MTO (ORNAMENT or STAMINA), and compared to the adopted assessment criteria. In addition, potential noise and vibration impacts from construction were considered.

Analysis of the traffic noise modelling indicated that noise controls were to be considered at the NSA represented by POR13. An evaluation of the technical, economic and administrative feasibility was conducted for this group of homes, and it was found that a barrier located at the Transitway shoulder (i.e., within the right-of-way) of 3.5 m height and 550 m length is feasible. An exceedance of MTO criteria was also identified at POR24, which is a future area of development in the lands designated for the Seaton Community. The impact at this location was found to be due to the presence of the proposed parking lot at Brock Road. At this location, it was found that a 375 m long barrier of 5 m height along the south end of the parking lot would be feasible. A barrier in the 407 Transitway was not found to be technically feasible for the receptors represented by POR24.

No ground-borne or airborne vibration effects were predicted at any NSA for operations associated with the 407 Transitway. With regard to construction, the NVIA outlines the requirements of the municipal noise by-laws that would be applicable (Markham and Pickering), and sets out setback distances that would be required in order to avoid vibration impacts from construction. A series of best practices are also provided for consideration in construction planning from a noise and vibration control perspective.

# 1.0 INTRODUCTION

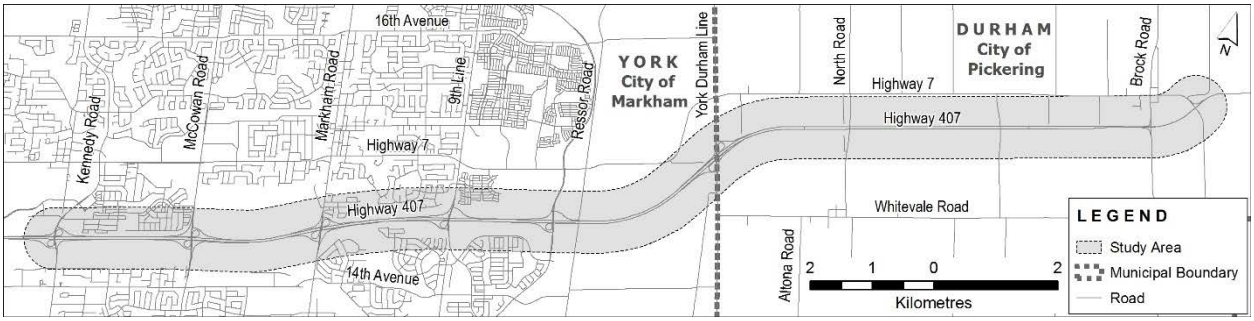
## 1.1 Project Description

The Ministry of Transportation (MTO) is proposing a 18 km segment of a transitway facility along the Highway 407 corridor through York Region and Durham Region, from east of Kennedy Road in the City of Markham to east of Brock Road in the City of Pickering (407 Transitway). The 407 Transitway includes four stations, with the potential for two additional stations. Subject to the outcome of the study, the 407 Transitway will be implemented initially as bus rapid transit (BRT) with the opportunity to convert to light rail transit (LRT) in the future.

This 18 km segment forms part of the 150 km long high-speed interregional facility planned to be ultimately constructed on a separate right-of-way that parallels Highway 407 from Burlington to Highway 35/115, with stations, parking and access connections. This transitway is a component of the official plans of the stakeholder municipalities and of the Province's commitment to support transit initiatives in the Greater Golden Horseshoe through the Metrolinx Regional Transportation Plan.

The transitway will be a high-speed fully grade separated facility on a separate right-of-way running parallel, and crossing over or under Highway 407. This 18 km section includes four transit stations at Markham Road, 9th Line, Whites Road (Sideline 26), and Brock Road, and two potential additional stations at Donald Cousens Parkway/Reesor Road and Rossland Road (Sideline 22). There is a possibility that the station at Rossland Road may be proposed for a bus garage. The station design will include bus access to and egress from the stations, bus platforms, layout of the access(es) to/from the arterial road, integration with local transit (bus platforms), parking spaces, Public Pick Up and Drop Off (PPUDO), shelters, building and other amenities. The transitway and the stations will initially be designed to support the busway service with provisions for future conversion to light-rail transit technology. The project limits are presented in Figure 1.

**Figure 1 Key Map of the Study Area**



The environmental impact of this transit project will be assessed according to the transit project assessment process as prescribed in Ontario Regulation 213/08, Transit Projects and Metrolinx Undertakings.

Arcadis Canada Inc. (formerly SENES Consultants Limited) was retained by LGL Limited (LGL), on behalf of the MTO, to complete a Noise and Vibration Impact Assessment (NVIA) in support of the Planning and Preliminary Design for the 407 Transitway project (the "Project"). A preliminary design of the 407 Transitway developed by Delcan, a Parsons Company was used for this NVIA.

## 1.2 Potential Noise and Vibration Impacts

Transportation projects in high density areas have the potential to impact the existing sound environment, and also introduce a potential source of vibration particularly when rail infrastructure is proposed. This NVIA assesses not only the noise and vibration impact associated with the use of the new transit alignment, but also the impact of the proposed changes to the local topography required to accommodate the new infrastructure, and secondary effects such as noise-induced vibration of house structure elements. The following potential impacts are addressed in this study:

- Noise impacts at existing and proposed sensitive locations from buses and LRT operating on the proposed 407 Transitway, inclusive of changes to local topography;
- Ground-borne vibration impacts associated with buses and LRT operating on the 407 Transitway;
- Airborne vibration of house structure elements induced by sound levels from bus engines; and
- Noise and vibration considerations during construction of the Transitway.

The assessment criteria that has been applied to identify noise and vibration impacts are discussed in section 3.0, inclusive of a summary of the local noise ordinances. The approaches to assessing the sound levels associated with the Project are discussed in section 4.0. The results of the noise and vibration impact assessments are discussed in sections 5.0 and 6.0, respectively.

# 2.0 STUDY AREA DESCRIPTION

The study area includes Highway 407 ETR (and its interchanges) and the proposed 407 Transitway alignment (including proposed stations and parking lots) between east of Kennedy Road in Markham and east of Brock Road in Durham. The west end of the study area is primarily comprised of high density residential and commercial properties, while the east end is largely undeveloped agricultural lands. It should be noted that the City of Pickering has approval from the Ontario government to begin development of a large community at the east end of the study area, called the Seaton Community. This NVIA accounts for the future occupation of these lands with noise-sensitive uses in the assessment scenarios for the horizon year of 2031, based on planning documents available from the City of Pickering.

# 3.0 ASSESSMENT CRITERIA

The following sections summarize the assessment criteria that has been applied in the evaluation of potential noise and vibration impacts related to the Project. As the Project is under the jurisdiction of the Ontario Ministry of Transportation, guidelines developed by the MTO were the primary reference for the assessment methodology and impact assessment criteria. Where no assessment guidance had been developed by the MTO for a potential project effect, relevant guidelines from the Ontario Ministry of the Environment and Climate Change (MOECC) and published literature were applied as appropriate. Relevant information from the municipal noise by-laws are also summarized with regard to construction activities herein.

## 3.1 Noise from Transportation Sources

The MTO has summarized its requirements for the assessment of noise impacts from projects under its jurisdiction in the *Environmental Guide for Noise* [1] and the *Environmental Reference for Highway Design* [2]. In addition to outlining requirements for the assessment documentation and qualifications of the assessors, these documents present the accepted procedures for identifying and inventorying noise sensitive points of reception, assessing and determining the significance of potential noise impacts at these locations, and evaluating the need for noise control measures where necessary.

The criteria for the assessment of noise impacts are applied at Noise Sensitive Areas (NSAs), which are to be identified at the outset of the assessment. NSAs generally include residential land uses, educational facilities, hospitals and commercial properties with overnight accommodations (i.e., hotels, motels, campgrounds). Refer to Appendix A for the full definition of an NSA. NSAs must have an associated Outdoor Living Area (OLA) to qualify for inclusion in the noise assessment by MTO standards. An OLA is a ground-level space adjacent to the building on an NSA that accommodates outdoor living activities (refer to Appendix A for the full definition). The impact assessment is completed at the most-exposed side of the unit with respect to the project, regardless of whether that is where the OLA is located. If an assessment of mitigation is required, then the point of reception is to be moved to the OLA if these locations differ.

The MTO procedures require that future sound levels (10 years after construction) at the identified NSAs be predicted both with and without the Project on a 24-hour energy equivalent basis. The difference between these sound levels provides an estimation of the degree to which the Project would be expected to increase sound levels at the NSAs compared to the case in which the Project does not proceed. These increments, as well as the predicted future sound levels at the NSAs, are used to assess whether there are likely to be any adverse noise effects associated with the Project using the assessment criteria summarized in Table 1.

**Table 1 MTO Noise Assessment Criteria**

| Change in Noise Level Above Ambient / Projected Noise Levels with Proposed Improvements | Mitigation Effort Required |
|---|---|
| < 5 dBA change; AND<br>< 65 dBA | None |
| ≥ 5 dBA change; OR<br>≥ 65 dBA | • Investigate noise control measures on right-of-way;<br>• Introduce noise control measures within right-of-way and mitigate to ambient if technically, economically and administratively feasible;<br>• Noise control measures, where introduced, should achieve a minimum of 5 dBA attenuation over first row receivers. |

The mitigation effort described in Table 1 identifies that noise control measures must be "technically, economically and administratively feasible". The different aspects of feasibility are detailed in Table 2 (from [1]).

**Table 2 MTO Feasibility Description**

| Feasibility Aspect | Descriptions |
|---|---|
| Technical Feasibility | Review the constructability of the noise mitigation (i.e., design of wall, roadside safety, shadow effect, topography, achieve a 5 dBA reduction, ability to provide a continuous barrier, etc.). |
| Economic Feasibility | Carry out a cost/benefit assessment of the noise mitigation (i.e., determine cost per benefited receiver). |
| Administrative Feasibility | Determine ability to locate the noise mitigation on lands within public ownership (i.e., provincial or municipal right-of-way). |

To comply with MTO assessment procedures, all predictions must be completed using calculation methods that are approved by the MTO and MOECC. These include the MOECC traffic noise prediction method ORNAMENT for simple geographical settings, and the United States Federal Highway Administration (FHWA) STAMINA 2.0 model for more complex scenarios where changes in topography and grade separated roads are involved.

## 3.2 Noise from Stationary Sources

The MTO *Environmental Guide for Noise* does not include a procedure for the assessment of noise impacts from stationary sources, instead outlining that the assessment of stationary sources is to follow the procedures developed by the MOECC in its Publication NPC-205. MOECC Publication NPC-205 has been superseded by Publication NPC-300: *Environmental Noise Guideline* [3]. It should be noted, however, that there are no stationary sources associated with the project design at this time. While the bus/LRT stations are stationary facilities, they are not considered to be stationary sources of noise according to MOECC definitions. The rationale for

excluding the stations and potential garage as stationary sources is discussed in the following paragraphs.

The planned stations will consist of a canopied platform with staircases and elevators to provide pedestrian access from street level, bus/LRT access to and from the platform, car parking facilities and designated PPUDO sites. Based on these open concept design plans, the stations are not anticipated to have any significant stationary noise sources associated with them (e.g., building ventilation, HVAC sources, etc.). The dominant sources of noise at the stations are anticipated to be associated with the transitway vehicles entering and exiting the station, and the vehicular activity in the parking/PPUDO areas, which are not considered stationary sources by the MOECC. The definition of a "stationary source" is provided in Part A of NPC-300. Section 5 of this definition outlines sources that are not considered as "stationary sources", including *transportation corridors (i.e., railways and roadways)*, and *commuter parking lots* [3]. The access/egress of vehicles from the stations and vehicular activity in the parking lot area have each been included in the assessment of noise from transportation sources as outlined in section 3.1 for comparison to the criteria outlined in Table 1.

The potential bus garage at Rossland Road is being discussed as a potential alternative to a station at this location. The Rossland site will require access from the Seaton Development and from Highway 407 ETR to become suited for a station or any other Transitway facility. Due to uncertainties regarding the construction of the Rossland Road Extension through the Seaton Development lands and the interchange that would connect the Rossland Road Extension to Highway 407 ETR, it was concluded that no station or any other 407 Transitway facility (e.g., bus garage) would be proposed at this site for this study. However, if plans for the bus garage were to proceed at some point in the future, the facility would require a detailed noise assessment as part of the MOECC approvals process prior to operating. As such, any potential noise impacts from the facility would be addressed at that time.

## 3.3 Vibration from Transportation Sources

The MTO *Environmental Guide for Noise* was developed for the assessment of highway projects, which are not typically associated with significant ground-borne vibrations. As such, the MTO guide does not include an assessment methodology for operations-related ground-borne vibration. However, since the Project includes a provision for future LRT operations on the 407 Transitway, it was important to establish ground-borne vibration criteria for application to this assessment.

Ground-borne vibration criteria from the MOECC and United States Federal Transit Administration (FTA) are discussed in the following sections. The MOECC vibration criteria summarized in section 3.3.1 is for application to residential properties only; however, the Project study area includes institutional lands as well as land uses that are potentially more sensitive to vibrations due to the nature of interior operations (i.e., instrumentation associated with health-

care). Applicable criteria from the U.S. FTA literature was adopted to accommodate the assessment of these additional land use types, summarized in section 3.3.2.

While ground-borne vibrations are not anticipated to be significant at NSAs from rubber-tired vehicles operating on a smooth surface (i.e., buses), there is potential for airborne vibration due to bus engine noise in the low frequency range. Such vibrations may result in rattling of windows or other structural elements, depending on the magnitude of the sound produced. Thresholds for noise-induced vibration of building elements have been summarized in section 3.3.3 to provide a basis by which to assess the potential for airborne vibrations from bus pass-by events on the 407 Transitway.

### 3.3.1 MOECC Guidelines for Transit Projects

The MOECC has historically developed guidelines specifically for use in the assessment of noise and vibration from the operation of public transit systems, in conjunction with public transit agencies such as the Toronto Transit Commission (TTC) and GO Transit. Vibration assessment methodologies and criteria from the MOE / TTC Protocols have been considered in this assessment, as the vibration criteria is more relevant to the operation of LRT systems.

Under the MOE / TTC Protocols, vibration levels are assessed in terms of root-mean-square (RMS) vibration velocity in millimeters per second (mm/s) at outdoor locations on a residential property that are at least 15 m from the track centerline. Where vibration levels are predicted to exceed 0.1 mm/s, mitigation measures are to be applied where technically, economically and administratively feasible [4].

### 3.3.2 U.S. Federal Transit Administration (FTA)

The U.S. FTA has published a manual specifically for use in assessing noise and vibration from transit projects such as the implementation of LRT systems. The *Transit Noise and Vibration Impact Assessment* [5] report includes a summary of basic noise and vibration concepts, noise and vibration criteria, and prediction methodologies for various transit project types. In addition to residential lands, the vibration criteria that is presented in this report includes institutional lands and land usages with increased sensitivity to vibration effects, such buildings containing delicate equipment (e.g., hospitals, research centres). Vibration criteria recommended by the FTA for various land uses are summarized in Table 3.

**Table 3 U.S. FTA Ground-Borne Vibration Impact Criteria**

| Land Use Category | Ground-Borne Vibration Impact Levels (RMS, mm/s) | | |
|---|---|---|---|
| | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] |
| Category 1: *Buildings where vibration would interfere with interior operations*[4] | 0.05 | 0.05 | 0.05 |
| Category 2: *Residences and buildings where people normally sleep* | 0.10 | 0.14 | 0.25 |
| Category 3: *Institutional land uses with primarily daytime use* | 0.14 | 0.20 | 0.36 |

Notes:

1: "Frequent Events" is defined as more than 70 vibration events of the same source per day.

2: "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day.

3: "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day.

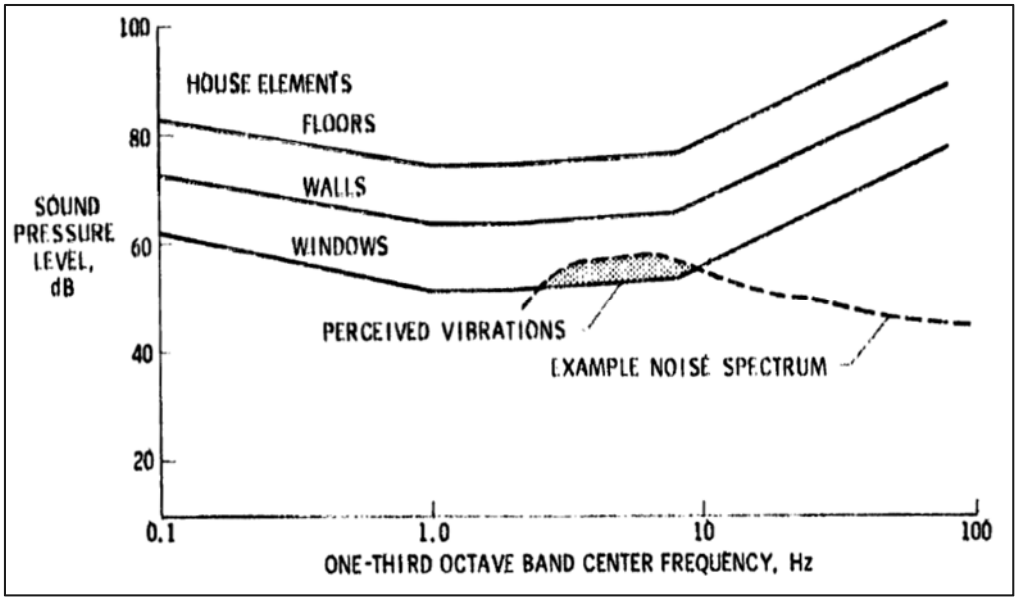
4: This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.

The applicable limits for the Project are those for "Frequent Events", and it should be noted that the criterion for residences (Category 2) is identical to the MOECC vibration limit for residential lands that was presented in section 3.3.1.

### 3.3.3 Thresholds for Noise-Induced Vibrations

NASA conducted research in the 1980s to assist in the siting of large wind turbines, which included the investigation of source characteristics, sound propagation characteristics and the effect of exposure at the receiver location. The research was summarized in a technical memorandum titled *Guide to the evaluation of human exposure to noise from large wind turbines* [6]. In the evaluation of noise effects at the receiver location, this technical memorandum summarized research into the magnitude of sound pressure required to excite building components such as windows, walls and floors. The results are presented in Figure 2. These frequency-based thresholds have been applied to predictions of maximum expected sound levels of bus pass-by events, to evaluate the potential for noise-induced vibrations due to operations on the 407 Transitway.

**Figure 2 Thresholds for Perceptible Vibration of House Structure Elements (from [6])**




## 3.4 Noise from Construction

The MTO Environmental Guide for Noise outlines that construction must be conducted in a manner that minimizes noise and abides by the municipal by-laws. A procedure by which to address noise complaints must be in place as part of the contract documents. Such procedures involve responding to persistent complaints by completing sound testing of the construction equipment to ensure operating sound levels are within those recommended by the MOECC. The following sections summarize MOECC construction equipment guideline limits, and relevant requirements of the applicable municipalities with regard to construction noise.

### 3.4.1 MOECC NPC Guidelines

Construction activities are not considered to be “stationary sources” by the MOECC (per the definition of Stationary Source in Part A of Publication NPC-300), and are therefore not required to meet the sound level limits outlined in Publication NPC-300. The MOECC does not currently prescribe sound level limits for the cumulative impact of construction operations. In Publication NPC-115, the MOECC has instead outlined a series of equipment-specific sound level limits that must be met by individual pieces of construction equipment, depending on the location of use and date of manufacture [7]. The sound level limits for construction equipment manufactured after January 1st, 1981 are summarized in Table 4.

In addition, any heavy vehicle (motorized conveyance with a gross weight >4,500 kg) with a diesel engine that is associated with a construction activity would be subject to the sound level limits prescribed in MOECC Publication NPC-118 [8]. For vehicles manufactured after 1979, the maximum allowable sound level is 95 dBA at a distance of 15 m.

**Table 4 MOECC NPC-115 Construction Equipment Sound Level Limits**

| Equipment | Standard | Measurement Distance (m) | Maximum Sound Level (dBA) |
|---|---|---|---|
| Excavator, Dozer, Loader, Backhoe, Other | Quiet Zone | 15 | Power Rating <75 kW: 83 dBA<br>Power Rating >75 kW: 85 dBA |
| | Residential Zone | | Power Rating <75 kW: 83 dBA<br>Power Rating >75 kW: 85 dBA |
| Pneumatic Pavement Breaker | Quiet Zone | 7 | 85 dBA |
| | Residential Zone | | 85 dBA |
| Portable Air Compressor | Quiet Zone | 7 | 70 dBA |
| | Residential Zone | | 76 dBA |
| Tracked Drills | Quiet Zone | 15 | 100 dBA |
| | Residential Zone | | 100 dBA |

### 3.4.2 City of Markham Noise By-Law

The Town of Markham (now City of Markham) By-Law No. 2003-137 *A By-Law to Regulate Noise Within the Town of Markham* [9] includes a number of provisions that are intended to control noise from construction activities. Relevant excerpts from the by-law are discussed below, and the full document is provided in Appendix B. Similar to NPC-115 [7], the Noise by-law references Quiet Zones and Residential Zones which are defined in the Town of Markham Zoning By-law.

Section 3(1) of the by-law references the General Prohibitions of the by-law, of which the most relevant is "the operation of any item of construction equipment without effective muffling devices in good working order and in constant operation." Other General Prohibitions that may be applicable to the construction phase include excessive vehicle idling and excessive use of horns.

Section 3(2) of the by-law references activities that are prohibited by time and place, which includes "*the operation of any equipment in connection with construction*" (item #16 in Schedule 2). Construction activities are prohibited during the following times in both Quiet Zones and Residential Zones:

- All day Sundays and Statutory Holidays; and
- 19:00 one day to 07:00 next day.

During periods when construction is allowed, sections 4(1) and 4(2) of the by-law sets limits on where construction equipment may be operated in Residential Zones and Quiet Zones, respectively. Equipment that is to be operated at a work site that is within 600 m of a Residential Zone, or within a Quiet Zone, must display a label affixed by the manufacturer or distributor that shows the date of manufacture and confirmation that the equipment complies with the applicable sound level limit from NPC-115 [7] (refer to section 3.4.1). Similarly, and motorized conveyance as defined in NPC-118 [8] must comply with the applicable sound level limits from NPC-118 (refer to section 3.4.1).

The Markham Noise by-law includes a provision for obtaining a permit that would grant exemptions to requirements of the by-law. This requires a written request to the Town and submittal of an exemption request fee. Upon receipt, Council will decide whether to approve of the request. There are no specific exemptions for projects under the jurisdiction of provincial agencies.

### 3.4.3 City of Pickering Noise By-Law

The City of Pickering By-law No. 6834/08 *A by-law to prohibit and regulate noise* [10] includes control noise from construction activities through the use of Time Prohibitions. Construction activities are prohibited during the following periods:

- 7:00 pm to 7:00 am; and
- All day on Sundays and statutory holidays.

An exemption to these requirements may be applied for by providing a written request to the City Clerk. Only where deemed appropriate will the requested exemption be granted, and the exemption may include conditions which if breached would render the exemption null and void.

The full City of Pickering Noise by-law is provided in Appendix C.

## 3.5 Vibration from Construction

The MTO does not provide limits for vibrations from construction activities. In section NPC-207 of the Ontario Model Municipal By-law [11], the MOECC recommends limits for impulse vibration, which may be applicable to some construction activities such as pile driving. Other types of construction equipment have potential to be sources of non-impulsive vibration, such as vibratory compaction. Construction vibration limits from the U.S. FTA have therefore also been considered [5].

Construction vibrations are generally assessed in terms of peak particle velocities (PPV) rather than RMS levels, since public concerns are generally related more to the potential for building damage than perceptibility during construction [5]. The MOECC outlines the limits presented in Table 5 for impulse vibration, which vary depending on the frequency of occurrence [11].

**Table 5 MOECC NPC-207 Impulse Vibration Limits**

| Time Required to Observe 20 Impulses (minutes) | Limit on the Average Peak Vibration Velocity (mm/s) | |
|---|---|---|
| | Daytime (07:00-23:00) | Night-time (23:00-07:00) |
| 20 minutes or less | 0.30 | 0.30 |
| Less or equal to 60 minutes but more than 20 minutes | 0.60 | 0.30 |
| Less or equal to 120 minutes but more than 60 minutes | 1.00 | 0.30 |
| 120 minutes | 10.00 | 0.30 |

The U.S. FTA provides a series of criteria that vary depending on details of the building that is receiving the vibration, and are set to protect against building damage [5]. These criteria are summarized in Table 6. As a conservative measure, the vibration analysis in this assessment utilizes the Category III criteria of 5.1 mm/s.

**Table 6 Construction Vibration Damage Criteria**

| Building Category | | PPV (mm/s) |
|---|---|---|
| I. | Reinforced concrete, steel, or timber (no plaster) | 12.7 |
| II. | Engineered concrete and masonry (no plaster) | 7.6 |
| III. | Non-engineered timber and masonry buildings | 5.1 |
| IV. | Buildings extremely susceptible to vibration damage | 3.0 |

## 3.6 Summary of Assessment Criteria

The assessment criteria that has been adopted for each aspect of the Project is summarized in Table 7.

**Table 7 Summary of Assessment Criteria**

| Project Aspect | Effects Pathway | Criteria | Reference |
|---|---|---|---|
| Operations [Transportation Sources] | Noise | ≥ 5 dBA change; OR ≥ 65 dBA | MTO [1] |
| | Vibration [Ground-borne] | 0.1 mm/s | MOECC [4], U.S. FTA [5] (Category 2) |
| | | 0.05 mm/s | U.S. FTA [5] (Category 1) |
| | | 0.14 mm/s | U.S. FTA [5] (Category 3) |
| | Vibration [Airborne] | Frequency-based | NASA [6] |
| Operations [Stationary Sources] | Noise | N/A | N/A |
| | Vibration | N/A | N/A |
| Construction | Noise | Equipment-dependent | MOECC [7], City of Markham [9] |
| | | Time and Place Restrictions | City of Markham [9]; City of Pickering [10] |
| | Vibration | 0.3 mm/s [impulse sources] | MOECC [11] |
| | | 5.1 mm/s [steady sources] | U.S. FTA [5] |

# 4.0 ASSESSMENT METHODOLOGY

## 4.1 Identification of NSAs

Existing NSAs were identified using recent aerial photography and confirmed during a field investigation on June 3rd, 2015. Key points of reception (POR) were identified to represent groups of NSAs with similar exposure to the 407 Transitway. The receptors and number of dwellings represented are summarized in Table 8 and illustrated in Figure 5 (located in the Figures section at the end of this report). For each NSA, the side of the building that is most exposed to the transitway was assessed, per MTO guidelines.

**Table 8 Summary of NSAs Included in NVIA**

| ID | No. of Units Represented | Type of Unit[1] | Segment |
|---|---|---|---|
| POR1 | 10 | Residential | Kennedy Rd. to McCowan Rd. |
| POR2 | 2 | Residential | Kennedy Rd. to McCowan Rd. |
| POR3 | 46 | Residential | Kennedy Rd. to McCowan Rd. |
| POR4 | 40 | Residential | Kennedy Rd. to McCowan Rd. |
| POR5 | 65 | Residential | Kennedy Rd. to McCowan Rd. |
| POR6 | 58 | Residential | Kennedy Rd. to McCowan Rd. |
| POR7 | 21 | Residential | Markham Rd. to Ninth Line |
| POR8 | 43 | Residential | Markham Rd. to Ninth Line |
| POR9 | 13 | Residential | Markham Rd. to Ninth Line |
| POR10 | 10 | Residential | Markham Rd. to Ninth Line |
| POR11 | 9 | Residential | Markham Rd. to Ninth Line |
| POR12 | 47 | Residential | Markham Rd. to Ninth Line |
| POR13 | 14 | Residential | Markham Rd. to Ninth Line |
| POR14 | 14 | Residential | Markham Rd. to Ninth Line |
| POR15 | 1 | Health Care | Ninth Line to Donald Cousens Pkwy. |
| POR16 | 1 | Senior Res. (F) | Ninth Line to Donald Cousens Pkwy. |
| POR17 | 33 | Residential | Ninth Line to Donald Cousens Pkwy. |
| POR18 | 2 | Residential | Donald Cousens Pkwy. to York-Durham Line |
| POR18a | 1 | Residential | Donald Cousens Pkwy. to York-Durham Line |
| POR19 | 1 | Residential | Donald Cousens Pkwy. to York-Durham Line |
| POR20 | 52 | Residential (F) | York-Durham Line to Whites Road |
| POR21 | 41 | School (F) | York-Durham Line to Whites Road |
| POR22 | 1 | Residential (F) | Whites Road to Brock Road |
| POR23 | 98 | Residential (F) | Whites Road to Brock Road |
| POR24 | 63 | Residential (F) | Whites Road to Brock Road |

1: (F) denotes a future receptor, based on current development plans.

It should be noted that several of the receptors to the east end of the study area are representative of future receptors associated with the proposed Seaton community in the City of Pickering. Representative locations for residential properties and schools were based on the draft Neighbourhood Plans that have been developed by the City of Pickering [12] as part of an amendment to the Pickering Official Plan and Seaton Zoning By-law 7364/14 [13].

## 4.2 Description of Assessment Scenarios

The potential noise and vibration impacts associated with the Project were assessed by predicting noise and vibration conditions at the nearest NSAs under three operating scenarios: existing conditions (2015), future conditions (2031) assuming that the project *does not* proceed (future no-build), and future conditions (2031) assuming that the project *does* proceed (future build). Each of these scenarios are described in more detail in the following sections.

### 4.2.1 Existing Conditions (2015)

The 407 Transitway will be constructed in a major traffic corridor, parallel to Highway 407 ETR and within 100 m of Highway 407 ETR for most of the route under assessment. Existing sound levels at the nearest sensitive receptors are currently dominated by traffic on Highway 407 ETR and the arterial roads that connect to it. In order to put the results for the future scenarios into perspective, it is important to first establish the noise and vibration conditions that nearby sensitive receptors are currently exposed to (i.e., prior to implementation of the Project).

The existing sound environment at the NSAs was established through predictive modelling of traffic noise from current usage of Highway 407 ETR and its interchanges, based on traffic count data provided by IBI Group. The predictions of current sound levels account for local topography, including any berms adjacent to the highway that may act as obstructions to sound propagation. Details of the traffic noise modelling are provided in section 4.3.1.

Existing vibration conditions were not modelled as part of this assessment, as ground-borne vibration is typically negligible for rubber-tired vehicles operating on smooth surfaces. Validation for this assertion is provided in the assessment of ground-borne vibration from the 407 Transitway in section 6.1.1, which concludes that ground-borne vibration from rubber-tired vehicles travelling at 100 km/hr would not be perceptible beyond 24 m from the road alignment.

### 4.2.2 Future No-Build (2031)

In order to assess the impacts associated with full operations on the Transitway at the future horizon year of 2031, conditions must first be established for the same year in the absence of the Transitway. This scenario, termed the future no-build or future ambient scenario, provides a baseline condition for assessing the potential impacts associated with the Project.

In the future no-build scenario, it has been assumed that existing traffic volumes on the Highway 407 ETR will increase with population growth in the area. Projected traffic volumes were calculated based on annual growth rates provided by IBI Group, and modelled in the same manner as the existing traffic scenario (discussed in section 4.3.1) to describe a future ambient condition at the NSAs. This represents the future condition that the NSAs would otherwise be exposed to if the Project were not to proceed, accounting only for traffic increases associated with population growth and no changes to existing transportation infrastructure.

### 4.2.3 Future Build (2031)

The future-build scenario represents future conditions in the same year as the future no-build year, but inclusive of the 407 Transitway. For traffic on the 407 ETR, the assessment of this scenario utilizes the same projected traffic data as was used in the assessment of future no-build conditions with the exception that public transit vehicles are utilizing the 407 Transitway, resulting in less cars utilizing the 407 ETR. IBI Group estimated that there would be an approximate 3% reduction in cars utilizing the 407 ETR as a result of the implementation of the Transitway.

Projected noise levels at the NSAs in the future-build scenario were estimated through predictive modelling (discussed in section 4.3.1), in the same manner as for the future no-build scenario. Modelling of the future build scenario accounts for any changes to local topography that will be required to accommodate the 407 Transitway, and also accounts for the planned vertical profile of the 407 Transitway (i.e., at-grade sections and overpasses). Also included in the future build scenario is a proposed berm at the south end of Ninth Line station parking area, which affects sound levels at POR14. It should be noted that this is not a noise mitigation measure that was found to be necessary through this assessment, and so a feasibility study (i.e., technical, economic and administrative feasibility) was not completed. This berm is primarily proposed to address local concerns raised by the community, and will serve as a visual screen to block sight-lines to the parking lot.

As future plans for the 407 Transitway involve potential operations using LRT, ground-borne vibration levels due to LRT pass-by events were predicted using methodology developed by the U.S. FTA [5], discussed further in section 4.4.1.1. The analysis also includes an assessment of ground-borne vibration from buses to confirm that levels would not be perceptible at the NSAs.

Potential vibration effects associated with bus pass-by events are more likely to be associated with airborne vibration caused by engine noise rather than ground-borne vibration. The potential for airborne (noise-induced) vibration from bus pass-by events was estimated using algorithms from the U.S. FHWA Traffic Noise Model (TNM) version 2.5 [14], discussed further in section 4.4.1.2.

## 4.3 Noise Modelling

### 4.3.1 Noise from Transportation Sources

The MTO requires that sound level predictions completed in support of transportation noise assessments be completed using either the MOECC ORNAMENT calculation method, or the STAMINA 2.0 model [14]. The ORNAMENT calculation method is to be applied in situations with relatively straight roads, where the surrounding topography and vertical road profile are relatively flat. For scenarios with complex geometry, such as roads featuring grade separations or below grade sections, irregular topography or complex horizontal alignments, the more rigorous STAMINA model may be used. The STAMINA model is based on algorithms from the U.S. FHWA. The most recent version of STAMINA is implemented in the FHWA TNM program. As per MTO requirements, all sound levels were assessed as 24-hour $L_{eq}$'s at a height of 1.2 m from the ground at the most exposed side or OLA of each identified NSA [1].

#### 4.3.1.1 ORNAMENT/STAMSON

Sound levels in ORNAMENT are calculated based on the specific exposure of a given point of reception to the road(s) under assessment. As the road source geometry is considered from the specific point of view of the receptor, only one receptor may be modelled at a time and the results are applicable only to that receptor and those with a reasonably similar exposure to the road.

The ORNAMENT method is summarized in a Technical Document prepared in 1989 [15], and is based on reference sound level data for three classes of vehicles: cars, medium trucks (inclusive of buses) and heavy trucks. A series of adjustments are then applied to the reference data based on site-specific variables, including the actual volume of each vehicle type, the speed of travel, distance between the road and receptor, road length and pavement type, road gradient, intervening ground surface, and obstacles to noise propagation (i.e., barriers, houses, dense foliage).

The ORNAMENT calculations were completed in the software program STAMSON (also developed by the MOECC). Sound level predictions were completed using STAMSON for any receptors located in areas with relatively flat terrain and simple road alignments. Based on aerial photography and site observations, the surrounding ground surface was set to absorptive. Vehicles were assumed to be operating at the posted speed limit, per MOECC procedures outlined in the ORNAMENT Technical Document [15].

#### 4.3.1.2 FHWA STAMINA/TNM

TNM version 2.5 was developed by the FHWA for the assessment and analysis of highway traffic noise, and to assist in the design of noise barriers for highway projects [14]. The model utilizes 1/3-octave band reference sound level data for several vehicle types operating on a variety of pavement surfaces. The vehicle types that may be modelled include: automobiles, medium

trucks, heavy trucks, buses and motorcycles. In this program, the user plots the road alignment and sensitive receptor locations of interest, and assigns the traffic mix to each plotted road segment as appropriate. The model accounts for the speed of each vehicle type, the pavement surface type, the separation distance between the road and receptor, as well as the effect of intervening distance, ground type, topography and absorption of sound by the atmosphere. TNM allows for the simultaneous calculation of multiple receptor points in a single run, as opposed to ORNAMENT, for which each run is receptor-specific.

TNM version 2.5 was applied in the assessment of traffic noise impacts at most of the receptors in this assessment, as the 407 Transitway involves many above grade sections in order to pass over the interchanges that connect with the 407 ETR. Furthermore, the horizontal alignment of some existing and proposed road infrastructure is curved (e.g., on/off ramps, flyovers), which does not lend well to the use of ORNAMENT.

The existing road infrastructure was input to TNM based on plan drawings and topographical plots provided by Parsons. The volumes of the various vehicle types were input based on the existing and projected future traffic data, and speeds were assigned based on the posted speed limits of the associated roads. The selected representative receptors discussed in section 4.1 were plotted and assigned a height of 1.2 m per MTO requirements. It was assumed that the vehicles travel on an average pavement type, and that the surrounding area is grassed (based on observations and aerial photography). The 407 Transitway infrastructure was input based on plan and profile drawings, and typical cross-sectional drawings provided by Parsons.

#### 4.3.1.3 FTA Algorithms

As neither the ORNAMENT nor the FHWA models include LRT sources, the impact of LRT operating on the 407 Transitway was assessed separately, using equations from the U.S. FTA transit manual [5] to calculate an energy equivalent sound level for use in modelling. The FTA manual provides reference data for rail transit vehicles, which may be scaled based on the actual travel speed of the vehicle being assessed. Track-side energy equivalent sound levels were calculated based on LRT vehicles operating at 40 km/hr (through stations) and 100 km/hr (between stations). These emission levels were applied as inputs to the FTA modelling module in the noise modelling software Cadna-A. The model was configured using the same assumptions as applied in the FHWA and ORNAMENT modelling described previously (e.g., receptor locations, heights, ground absorption, etc.). The resulting sound levels were substituted in place of the bus contributions in the future build scenario to arrive at predictions for the LRT scenario.

### 4.3.2 Noise from Construction

As noted in section 3.4.1, the sound level limits recommended by the MOECC for construction noise have been developed on a per-unit basis rather than a cumulative basis. As such, there are no applicable criteria values for the simultaneous operation of multiple pieces of construction equipment. The City of Markham requires that all construction equipment that is to be used within

600 m of a Residential Area be affixed with a label from the manufacturer confirming that the sound level limits from MOECC Publication NPC-115 are met [9]. Noise modelling of individual pieces of construction equipment to confirm compliance with the NPC-115 limits has therefore not been undertaken for this assessment, as it is assumed that the equipment supplier will ensure that all equipment meets the applicable NPC-115 limits.

## 4.4 Vibration Modelling

### 4.4.1 Vibration from Transportation Sources

Rail infrastructure is a known source of ground-borne vibration, caused by the transfer of energy along the vertical axis from the rolling vehicle to the track system, and subsequently from the track system to the ground where it may propagate towards nearby structures. Ground-borne vibration impacts are less common from rubber-tired vehicles when operating on a smooth surface. The U.S. FTA has developed a procedure for the prediction of ground-borne vibration (RMS velocity) with distance from the centerline of a transit alignment, based on the type of vehicle [5]. This procedure was applied in reverse for LRT and buses, using the vibration criteria discussed in section 3.3.1 and 3.3.2 to determine the separation distances beyond which no vibration impacts would be predicted for each receptor type.

The assessment procedures for evaluating potential ground-borne and airborne vibration levels are discussed in the following sections.

#### 4.4.1.1 Ground-borne Vibration

Approximate ground-borne vibration levels from rubber-tired vehicles and LRT vehicles travelling at 100 km/hr were estimated at various distances using the methodology developed by the U.S. FTA [5]. The FTA provides reference curves that are used to predict vibration levels at a given distance, based on a reference speed of travel. A series of adjustments are then applied to tailor the prediction to the site-specific conditions, including:

- actual travel speed;
- vehicle condition (e.g., stiff suspension, resilient wheels, worn wheels);
- track/road condition (e.g., worn/corrugated track, special trackwork, jointed track, uneven roads);
- track treatments (e.g., floating slab trackbed, ballast mats, high resilience fasteners);
- type of tie system;
- track configuration (e.g., at-grade, elevated);
- ground type between transit alignment and receptor.

The U.S. FTA procedure outlines additional variables for inclusion in the calculations, such as to account for the building foundation material, and transfer of vibration between floors; however, since the adopted criteria applies at an outdoor location, these factors were not considered in the calculations. The following key assumptions were applied in the predictions completed for this assessment:

- Applied RMS velocity versus distance curve for Rapid Transit Vehicles to estimate vibration due to LRT traffic;
- LRT and buses are operating at 40 km/hr in the vicinity of stations, and 100 km/hr between stations;
- The pavement surface will be regularly maintained such that buses are operating on a smooth surface;
- LRT vehicle wheels and suspensions and LRT track will be regularly maintained (i.e., no wheel flats, stiff suspensions or worn tracks);
- No special trackwork or track treatments, and normal tie system;
- Separate runs were completed for at-grade segments and elevated segments (i.e., overpasses).

The above assumptions were applied to develop adjusted curves depicting vibration velocity with distance for the 407 Transitway. The curves were then applied in reverse, using the vibration criteria from section 3.3 to determine a setback distance beyond which the criteria would not be exceeded. Separation distances were calculated for an at-grade configuration, elevated configuration and in the vicinity of a station. The results of the ground-borne vibration assessment are discussed in section 6.1.1.

#### 4.4.1.2 Airborne Vibration

Noise from heavy vehicles operating in close vicinity to receptors has the potential to induce vibration in building components such as windows, walls and floors. To evaluate whether the buses operating on the 407 Transitway would be expected to cause airborne vibration of building components, it was necessary to derive octave band sound level data for a bus pass-by event for comparison to the frequency-dependent criteria summarized in section 3.3.3. As described in section 4.3.1.2, the FHWA TNM 2.5 is based on 1/3-octave band reference data for various types of vehicle, including buses. The reference data for each vehicle type is descriptive of a single vehicle pass-by at a known distance and speed.

The TNM 2.5 model outputs overall A-weighted receptor sound levels based on all user inputs; however, it is possible to calculate the reference sound levels based on information provided in the Technical Manual for the model [14]. The calculation is based on the vehicle type, pavement type, throttle setting, travel speed and 17 constants provided in the manual. The calculation results in a maximum pass-by sound level for the associated vehicle at 15 m from the road.

For purposes of this calculation, it was assumed that the bus is travelling on average pavement, at 100 km/hr and full throttle. The closest receptor to the 407 Transitway is located at 35 m from the centerline, and so the reference sound level was projected to this distance using line source attenuation and assuming full 180$^{o}$ exposure to the road. The resulting octave band sound level due to a bus pass-by was plotted with the frequency-based criteria discussed in section 3.3.3 to determine whether the any of the thresholds are exceeded. The results of the assessment are discussed in section 0.

### 4.4.2 Vibration from Construction

The operation of construction equipment may result in perceptible ground vibrations in the vicinity of the construction site. As detailed construction plans are not available at this time, the potential for vibration impacts has been assessed on a setback basis by typical equipment type. Measurement data from literature have been used in conjunction with the construction vibration criteria in section 3.5 to define the minimum separation distance required for each type of construction equipment that may be used in construction.

The U.S. FTA has compiled vibration measurement data for various sources from literature, and summarized each source in terms of a reference PPV vibration level (in/sec) at a distance of 25 ft [5]. The following equation is provided to extrapolate the reference level to further distances.

$$PPV_{equip} = PPV_{ref}\left(\frac{25}{D}\right)^{1.5}$$

Where:

$PPV_{equip}$ = peak particle velocity of the equipment in in/sec of the equipment, adjusted for distance;

$PPV_{ref}$ = reference vibration level in in/sec at 25 ft from the equipment; and

D = the distance from the equipment to the receiver (ft).

The above equation was rearranged to solve for D with the $PPV_{equip}$ variable being set to the applicable criteria value from section 3.5. The solution to the resulting equation provides the minimum distance required between each type of equipment and the receiver to achieve the applicable criteria. The results of the construction vibration impact assessment are discussed in section 6.2.

# 5.0 NOISE IMPACT ASSESSMENT

## 5.1 Noise from Transportation Sources

### 5.1.1 Impact Assessment

The full results of the noise modelling for transportation sources are summarized in Table 9. The predictions indicate that future build sound levels are projected to remain under the MTO absolute sound level limit of 65 dBA at all representative receptor locations for operations both as a busway and LRT system. The incremental impacts are less than the MTO criteria of +5 dBA at all but two (2) locations (POR13 and POR24).

Receptor POR13 represents 14 residential houses between Markham Road and Ninth Line, on the south side of Highway 407 ETR. The predicted incremental sound level at POR13 is +6.8 dBA when buses are operating on the 407 Transitway, and +9.9 dBA when LRT is operating. The proposed centerline of the 407 Transitway is approximately 30 m from POR13, and an existing earthen berm is to be removed in order to accommodate the 407 Transitway. This berm currently acts to obstruct noise from the 407 ETR at the receptors represented by POR13, and its presence therefore also benefits the receptors in the future no-build scenario (which assumes no changes to the existing configuration). The removal of the berm to accommodate the 407 Transitway results in a higher contribution of traffic noise from the 407 ETR at these receptors compared to the no-build scenario. Therefore, in addition to the incremental noise attributable to the operation of the 407 Transitway in the future build scenario, the receptors represented by POR13 will also be subject to increased noise from the 407 ETR. As the assessment resulted in a predicted exceedance of the MTO criteria at this location, an assessment of noise mitigation was completed to determine whether the MTO feasibility requirements for control measures could be achieved.

An exceedance of the MTO incremental criteria was also predicted at POR24, which is representative of future residences located within the Seaton Community in the vicinity of the proposed Brock Road Station. The predicted increment at this location was +6.3 dBA for bus operations, and +6.8 dBA for LRT operations. This was primarily due to a relatively low predicted future no-build sound level of 43.4 dBA, as the area is currently undeveloped and set back approximately 500 m from the 407 ETR. The 407 Transitway is proposed to be located approximately 250 m from this location; however, these proposed homes also about the proposed Brock Station parking lot. As a result, sound levels are projected to increase to 49.7 dBA. As both the 407 Transitway right-of-way and Brock Road Station will be MTO property, the assessment of noise mitigation considered the feasibility of noise barriers in each location.

**Table 9 Summary of Noise Impacts from BRT and LRT Operations on the 407 Transitway**

| ID | Segment | No. of Units Represented | Type of Units | Sound Level Predictions (dBA) | | | | Increment (dBA) | | Impact Assessment | | | | Prediction Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Existing (2015) | Future No-Build (2031) | Future Build (2031) | | | | Absolute ≥65 dBA | | Increment ≥5 dBA | | |
| | | | | | | BRT | LRT | BRT | LRT | BRT | LRT | BRT | LRT | |
| POR1 | Kennedy Rd. to McCowan Rd. | 10 | Residential | 51.6 | 52.9 | 53.4 | 54.1 | 0.5 | 1.2 | No | No | No | No | FHWA TNM 2.5 |
| POR2 | Kennedy Rd. to McCowan Rd. | 2 | Residential | 56.0 | 57.3 | 57.7 | 58.4 | 0.4 | 1.1 | No | No | No | No | FHWA TNM 2.5 |
| POR3 | Kennedy Rd. to McCowan Rd. | 46 | Residential | 56.5 | 57.8 | 57.8 | 58.1 | 0.0 | 0.3 | No | No | No | No | FHWA TNM 2.5 |
| POR4 | Kennedy Rd. to McCowan Rd. | 40 | Residential | 48.3 | 49.6 | 50.8 | 51.2 | 1.2 | 1.6 | No | No | No | No | FHWA TNM 2.5 |
| POR5 | Kennedy Rd. to McCowan Rd. | 65 | Residential | 54.6 | 55.9 | 55.9 | 55.8 | 0.0 | -0.1 | No | No | No | No | ORNAMENT |
| POR6 | Kennedy Rd. to McCowan Rd. | 58 | Residential | 53.8 | 55.1 | 55.2 | 55.1 | 0.1 | 0.0 | No | No | No | No | ORNAMENT |
| POR7 | Markham Rd. to Ninth Line | 21 | Residential | 56.7 | 57.8 | 58.2 | 58.4 | 0.4 | 0.6 | No | No | No | No | FHWA TNM 2.5 |
| POR8 | Markham Rd. to Ninth Line | 43 | Residential | 57.1 | 58.4 | 58.4 | 58.6 | 0.0 | 0.2 | No | No | No | No | FHWA TNM 2.5 |
| POR9 | Markham Rd. to Ninth Line | 13 | Residential | 53.7 | 55.0 | 54.5 | 55.2 | -0.5 | 0.2 | No | No | No | No | FHWA TNM 2.5 |
| POR10 | Markham Rd. to Ninth Line | 10 | Residential | 57.9 | 59.2 | 58.4 | 58.8 | -0.8 | -0.4 | No | No | No | No | FHWA TNM 2.5 |
| POR11 | Markham Rd. to Ninth Line | 9 | Residential | 57.3 | 58.6 | 59.5 | 61.2 | 0.9 | 2.6 | No | No | No | No | FHWA TNM 2.5 |
| POR12 | Markham Rd. to Ninth Line | 47 | Residential | 57.4 | 58.7 | 58.7 | 58.9 | 0.0 | 0.2 | No | No | No | No | FHWA TNM 2.5 |
| POR13 | Markham Rd. to Ninth Line | 14 | Residential | 51.4 | 52.8 | 59.6 | 62.7 | 6.8 | 9.9 | No | No | Yes | Yes | FHWA TNM 2.5 |
| POR14 | Markham Rd. to Ninth Line | 14 | Residential | 47.7 | 49.0 | 49.9 | 49.9 | 0.9 | 0.9 | No | No | No | No | FHWA TNM 2.5 |
| POR15 | Ninth Line to Donald Cousens Pkwy. | 1 | Health Care | 53.5 | 54.8 | 55.4 | 56.4 | 0.6 | 1.6 | No | No | No | No | FHWA TNM 2.5 |
| POR16 | Ninth Line to Donald Cousens Pkwy. | 1 | Senior Res. (F) | N/A | 59.8 | 60.5 | 61.3 | 0.7 | 1.5 | No | No | No | No | FHWA TNM 2.5 |
| POR17 | Ninth Line to Donald Cousens Pkwy. | 33 | Residential | 52.2 | 53.5 | 53.9 | 54.7 | 0.4 | 1.2 | No | No | No | No | FHWA TNM 2.5 |
| POR18 | Donald Cousens Pkwy. to York-Durham Line | 2 | Residential | 46.5 | 47.9 | 51.4 | 51.9 | 3.5 | 4.0 | No | No | No | No | FHWA TNM 2.5 |
| POR18a | Donald Cousens Pkwy. to York-Durham Line | 1 | Residential | 54.3 | 56.1 | 55.7 | 56.4 | -0.4 | 0.3 | No | No | No | No | FHWA TNM 2.5 |
| POR19 | Donald Cousens Pkwy. to York-Durham Line | 1 | Residential | 58.0 | 58.4 | 58.5 | 58.7 | 0.1 | 0.3 | No | No | No | No | FHWA TNM 2.5 |
| POR20 | York-Durham Line to Whites Road | 52 | Residential (F) | N/A | 47.8 | 48.1 | 48.3 | 0.3 | 0.5 | No | No | No | No | ORNAMENT |
| POR21 | York-Durham Line to Whites Road | 41 | School (F) | N/A | 47.2 | 50.6 | 50.6 | 3.4 | 3.4 | No | No | No | No | FHWA TNM 2.5 |
| POR22 | Whites Road to Brock Road | 1 | Residential (F) | N/A | 44.2 | 43.8 | 44.4 | -0.4 | 0.2 | No | No | No | No | FHWA TNM 2.5 |
| POR23 | Whites Road to Brock Road | 98 | Residential (F) | N/A | 43.4 | 43.6 | 46.2 | 0.2 | 2.8 | No | No | No | No | FHWA TNM 2.5 |
| POR24 | Whites Road to Brock Road | 63 | Residential (F) | N/A | 43.4 | 49.7 | 50.2 | 6.3 | 6.8 | No | No | Yes | Yes | FHWA TNM 2.5 |

### 5.1.2 Assessment of Noise Controls

According to cross-section drawings provided by Parsons, where necessary, a noise barrier of 3.34 m height would be installed directly adjacent to the 407 Transitway. The noise barrier is proposed within the right-of-way at the shoulder of the 407 Transitway, offset approximately 6 m from the 407 Transitway centreline. As the MTO prefers to have noise barriers assessed in incremental heights of 0.5 m, the proposed noise barrier was assessed at 3 m and 3.5 m to evaluate the effectiveness (i.e., to bound the height proposed by Parsons). Additional heights were evaluated depending on the results of these noise model runs.

#### 5.1.2.1 Receptor POR13 Area

Additional points of reception were considered in the analysis of the noise barrier in the area of POR13. As per MTO guidelines, a minimum of one point of reception for every three houses is required in barrier analysis [2]. A point of reception was included for every second home in this analysis, as shown in Figure 17 (in the Figures section at the end of this report). A total of fourteen (14) locations were assessed, and include those associated with POR11 as these also currently benefit from the existing berm. The receptors represented by POR11 are front-facing (i.e., the fronts of the residences face the 407 Transitway alignment), while those represented by POR13 are rear-facing. According the MTO guideline, analysis of mitigation is to be assessed at the OLA, which may not necessarily be the most exposed side of the NSA. The OLA is typically interpreted as the rear yard. As such, the receptors represented by POR11 benefit from sound attenuation due to the house structures, while those represented by POR13 do not.

The future no-build scenario was re-run at these 14 locations, and iterations of the future build runs were completed at the noted heights. The barrier was plotted in TNM 2.5 at the offset of 6 m from the 407 Transitway centreline as specified by Parsons. The minimum required barrier length was found to be 400 m. However, a 550 m barrier is recommended in order to provide shielding for all receptors that currently benefit from the existing berm.

In terms of **technical feasibility**, the MTO requires that the proposed barrier be able to achieve a minimum of 5 dBA of attenuation averaged over first row receptors. The results of the barrier analysis for the 400 m (minimum) barrier are provided in Table 10, and for the 550 m (recommended) barrier in Table 11. It was found that barriers of both lengths are technically feasible at both modelled heights (3 m and 3.5 m). Due to the sensitivity around the removal of the existing berm, it is our recommendation that the 550 m barrier at the 3.5 m height be considered in the Detail Design stage.

In terms of **economic feasibility**, the MTO currently requires that the cost of the barrier per protected receiver be less than $100,000. On average, the construction of a noise barrier typically costs approximately $500 per $m^2$. A barrier of 550 m length and 3.5 m height would cost approximately $962,500, and there are 26 first row receivers that would be protected by the proposed barrier. As such, the cost per benefited receiver would be approximately $37,020,

which is within the MTO requirement for economic feasibility. If the shorter barrier were to be considered, at 400 m length and 3.5 m height the estimated cost would be $700,000. A total of 16 receptors would be protected by this barrier, resulting in a cost per benefited receiver of $43,750, which is also economically feasible. Our recommendation is to consider the 550 m barrier at a height of 3.5 m, in order to reduce the potential for noise complaints. At the Detail Design stage, the MTO may wish to consider the economic feasibility of a barrier as high as 5 m in the right-of-way (the maximum offered by the MTO) in order to provide maximum reduction in sound level.

In terms of **administrative feasibility**, the MTO requires that there be public lands available for the construction of the barrier. As the barrier is proposed for installation within the right-of-way, and the cross-section of the 407 Transitway has been designed to accommodate the presence of a barrier where necessary, the proposed berm is considered to be administratively feasible.

**Table 10 Summary of Barrier Analysis (POR13 Area; 400 m barrier)**

| ID | Future No-Build (dBA) | Pre-Mitigation | | Barrier (h = 3 m) | | Barrier (h = 3.5 m) | |
|---|---|---|---|---|---|---|---|
| | | Future Build (dBA) | Increment (dBA) | Future Build (dBA) | Attenuation (dBA) | Future Build (dBA) | Increment (dBA) |
| | | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT |
| BA_POR1 | 59.5 | 60.6 / 62.0 | 1.1 / 2.6 | 56.0 / 56.4 | -0.2 / -0.1 | 55.9 / 56.4 | -0.2 / -0.2 |
| BA_POR2 | 56.8 | 59.7 / 61.4 | 2.9 / 4.6 | 54.3 / 54.5 | 0.0 / 0.0 | 54.3 / 54.5 | -0.1 / 0.0 |
| BA_POR3 | 55.4 | 59.0 / 61.0 | 3.6 / 5.6 | 53.4 / 53.7 | -0.7 / -0.6 | 53.4 / 53.2 | -0.7 / -1.1 |
| BA_POR4 | 54.2 | 58.6 / 60.7 | 4.3 / 6.5 | 52.7 / 52.9 | -0.7 / -0.6 | 52.7 / 52.9 | -0.7 / -0.6 |
| BA_POR5 | 53.4 | 58.3 / 60.6 | 4.9 / 7.2 | 52.4 / 52.8 | -1.5 / -1.3 | 52.3 / 52.7 | -1.6 / -1.4 |
| BA_POR6 | 52.7 | 60.1 / 62.6 | 7.4 / 9.9 | 55.8 / 56.9 | -4.3 / -5.7 | 55.4 / 56.6 | -4.7 / -6.0 |
| BA_POR7 | 52.4 | 60.0 / 62.4 | 7.6 / 10 | 54.9 / 55.9 | -5.1 / -6.5 | 54.4 / 55.6 | -5.6 / -6.9 |
| BA_POR8 | 52.5 | 59.7 / 62.1 | 7.3 / 9.7 | 54.8 / 55.7 | -5.0 / -6.4 | 54.4 / 55.4 | -5.4 / -6.7 |
| BA_POR9 | 53.0 | 60.1 / 62.7 | 7.1 / 9.7 | 55.3 / 56.1 | -4.8 / -6.6 | 54.8 / 55.7 | -5.3 / -7.0 |
| BA_POR10 | 52.7 | 59.9 / 62.5 | 7.3 / 9.8 | 54.5 / 55.2 | -5.5 / -7.3 | 54.0 / 54.8 | -6.0 / -7.7 |
| BA_POR11 | 52.8 | 60.0 / 62.5 | 7.2 / 9.7 | 54.6 / 55.2 | -5.5 / -7.3 | 54.0 / 54.8 | -6.0 / -7.7 |
| BA_POR12 | 52.9 | 60.1 / 62.6 | 7.2 / 9.7 | 54.5 / 55.2 | -5.6 / -7.4 | 54.0 / 54.8 | -6.1 / -7.8 |
| BA_POR13 | 53.5 | 61.2 / 63.5 | 7.6 / 10.0 | 54.9 / 55.6 | -6.3 / -7.9 | 54.2 / 55.2 | -6.9 / -8.3 |
| BA_POR14 | 53.7 | 60.4 / 62.8 | 6.7 / 9.0 | 54.9 / 55.7 | -5.5 / -7.0 | 54.4 / 55.3 | -6 / -7.5 |
| *Average Attenuation (POR6-POR14):* | | -- | -- | -- | *-5.3 / -6.9* | -- | *-5.8 / -7.3* |

**Table 11 Summary of Barrier Analysis (POR13 Area; 550 m barrier)**

| ID | Future No-Build (dBA) | Pre-Mitigation | | Barrier (h = 3 m) | | Barrier (h = 3.5 m) | |
|---|---|---|---|---|---|---|---|
| | | Future Build (dBA) | Increment (dBA) | Future Build (dBA) | Attenuation (dBA) | Future Build (dBA) | Increment (dBA) |
| | | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT |
| BA_POR1 | 59.5 | 60.6 / 62.0 | 1.1 / 2.6 | 54.7 / 55.4 | -1.4 / -1.1 | 54.6 / 55.3 | -1.3 / -1.1 |
| BA_POR2 | 56.8 | 59.7 / 61.4 | 2.9 / 4.6 | 53.1 / 53.5 | -1.2 / -1.0 | 53.0 / 53.4 | -1.3 / -1.1 |
| BA_POR3 | 55.4 | 59.0 / 61.0 | 3.6 / 5.6 | 52.0 / 52.6 | -2.0 / -1.7 | 52.0 / 52.6 | -1.4 / -1.1 |
| BA_POR4 | 54.2 | 58.6 / 60.7 | 4.3 / 6.5 | 51.1 / 51.5 | -2.3 / -2.0 | 51.0 / 51.4 | -1.8 / -1.5 |
| BA_POR5 | 53.4 | 58.3 / 60.6 | 4.9 / 7.2 | 51.7 / 52.1 | -2.2 / -2.0 | 51.4 / 51.9 | -1.0 / -0.9 |
| BA_POR6 | 52.7 | 60.1 / 62.6 | 7.4 / 9.9 | 54.3 / 55.0 | -5.8 / -7.6 | 53.8 / 54.6 | -6.3 / -8.0 |
| BA_POR7 | 52.4 | 60.0 / 62.4 | 7.6 / 10 | 54.0 / 54.7 | -6.0 / -7.8 | 53.4 / 54.2 | -6.6 / -8.2 |
| BA_POR8 | 52.5 | 59.7 / 62.1 | 7.3 / 9.7 | 53.9 / 54.6 | -5.8 / -7.6 | 53.4 / 54.2 | -6.3 / -7.9 |
| BA_POR9 | 53.0 | 60.1 / 62.7 | 7.1 / 9.7 | 54.5 / 55.2 | -5.5 / -7.5 | 54.0 / 54.7 | -6.1 / -8.0 |
| BA_POR10 | 52.7 | 59.9 / 62.5 | 7.3 / 9.8 | 53.9 / 54.6 | -6.1 / -7.9 | 53.3 / 54.2 | -6.6 / -8.3 |
| BA_POR11 | 52.8 | 60.0 / 62.5 | 7.2 / 9.7 | 54.0 / 54.7 | -6.0 / -7.8 | 53.4 / 54.3 | -6.6 / -8.2 |
| BA_POR12 | 52.9 | 60.1 / 62.6 | 7.2 / 9.7 | 54.0 / 54.7 | -6.1 / -7.9 | 53.4 / 54.4 | -6.7 / -8.2 |
| BA_POR13 | 53.5 | 61.2 / 63.5 | 7.6 / 10.0 | 54.5 / 55.3 | -6.7 / -8.2 | 53.8 / 54.8 | -7.3 / -8.7 |
| BA_POR14 | 53.7 | 60.4 / 62.8 | 6.7 / 9.0 | 54.5 / 55.3 | -5.9 / -7.5 | 54.0 / 54.9 | -6.4 / -7.9 |
| *Average Attenuation (POR6-POR14):* | | -- | -- | -- | *-6.0 / -7.8* | -- | *-6.6 / -8.1* |

#### 5.1.2.2 Receptor POR24 Area

Additional points of reception were considered in the analysis of the potential noise barrier in the area of POR24. As per MTO guidelines, a minimum of one point of reception for every three houses is required in barrier analysis [2]. This area is a proposed residential area in the Seaton Community, and so there are currently no houses for use in selecting points of reception. As such, points were placed at a spacing representing approximately every second home, as shown in Figure 18 (in the Figures section at the end of this report). A total of thirty-two (32) receptors were assessed (BA24_POR1 to BA24_POR32). The receptors have been assumed to have an OLA facing the 407 Transitway.

The future no-build and future build (pre-mitigation) scenarios were re-run for these thirty-two receptors, and the results were used to determine the extent of the proposed barrier by identifying the receptors at which an increase of greater than 5 dBA was predicted. It was found that the proposed mitigation should be designed to reduce sound levels at receptors BA24_POR11 to BA24_POR25. A barrier was assessed in the 407 Transitway right-of-way, as per MTO guidelines. Due to the distance between the receptors and the 407 Transitway at this location (approximately 250 m), the barrier was modelled at the maximum height of 5 m to determine the impact as it was expected that the distance would reduce the efficiency of the barrier. As detailed in the discussion below, this option was not found to be feasible. Barriers of varying height were therefore also assessed at the south end of the proposed Brock Road parking lot, as it was expected that parking lot traffic was a dominant source of noise at these locations. Barrier heights of 3.5 m to 5 m were modelled in 0.5 m increments. The results of the feasibility analysis are discussed below.

In terms of **technical feasibility**, the MTO requires that the proposed barrier be able to achieve a minimum of 5 dBA of attenuation averaged over first row receptors. There were fifteen (15) receptors with predicted incremental increases of greater than 5 dBA. The 5 m barrier wall in the right-of-way was predicted to achieve an average attenuation of 2.6 dBA with buses operating, and 2.5 dBA with LRT operating. As such, the right-of-way barrier is not considered technically feasible. The performance of the barrier that was assessed at the south end of the Brock Road parking lot varied by height. A total of four (4) heights were assessed: 3.5 m, 4 m, 4.5 m and 5 m. The barrier was found to be technically feasible for both bus and LRT operations only at a height of 5 m. The full results of the technical feasibility analysis are provided in Table 12 and Table 13.

The **economic feasibility** was assessed only for the 5 m barrier at the south end of the Brock Road parking lot, as this was the only option that was found to be technically feasible. As noted above, the MTO requires that the barrier cost per protected receptor be less than $100,000. It was found that a barrier of approximate 375 m length would be required to provide shielding for the fifteen (15) identified receptors. Assuming an average construction cost for a noise barrier of $500 per $m^2$, a 5 m high barrier of this length would cost approximately $937,500. As each receptor represents two homes, the cost per protected receptor (30) would be $31,250, which is within the MTO requirements for economic feasibility.

As the MTO will own the lands on which the Brock Road station is constructed, the barrier is considered to be **administrative feasible**.

**Table 12 Summary of Barrier Analysis (POR24 Area, Barrier in ROW)**

| ID | Future No-Build (dBA) | Pre-Mitigation | | ROW Barrier (h = 5 m) | |
|---|---|---|---|---|---|
| | | Future Build (dBA) | Increment (dBA) | Future Build (dBA) | Attenuation (dBA) |
| | | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT |
| BA24_POR01 | 45.9 | 46.8 / 47.2 | 0.9 / 1.3 | 44.9 / 45.5 | -1.9 / -1.8 |
| BA24_POR02 | 45.1 | 47.8 / 48.2 | 2.6 / 3.1 | 45.6 / 46.2 | -2.2 / -2.0 |
| BA24_POR03 | 45.2 | 48.5 / 49.0 | 3.3 / 3.8 | 46.8 / 47.3 | -1.7 / -1.6 |
| BA24_POR04 | 44.3 | 46.6 / 47.7 | 2.4 / 3.4 | 43.9 / 45.1 | -2.8 / -2.6 |
| BA24_POR05 | 44.1 | 46.5 / 47.5 | 2.4 / 3.4 | 43.8 / 44.9 | -2.7 / -2.6 |
| BA24_POR06 | 44.0 | 46.9 / 47.8 | 2.9 / 3.8 | 43.8 / 44.9 | -3.1 / -2.9 |
| BA24_POR07 | 43.9 | 46.1 / 47.1 | 2.3 / 3.3 | 43.8 / 44.8 | -2.4 / -2.3 |
| BA24_POR08 | 43.7 | 46.1 / 47.1 | 2.5 / 3.5 | 43.9 / 44.9 | -2.3 / -2.2 |
| BA24_POR09 | 43.6 | 46.3 / 47.3 | 2.7 / 3.7 | 44.2 / 45.1 | -2.1 / -2.2 |
| BA24_POR10 | 43.5 | 47.2 / 47.9 | 3.8 / 4.4 | 45.0 / 45.6 | -2.3 / -2.3 |
| BA24_POR11 | 43.8 | 48.5 / 48.9 | 4.7 / 5.1 | 46.2 / 46.6 | -2.3 / -2.3 |
| BA24_POR12 | 43.6 | 49.0 / 49.2 | 5.4 / 5.6 | 46.7 / 47.1 | -2.3 / -2.1 |
| BA24_POR13 | 43.6 | 49.1 / 49.4 | 5.6 / 5.8 | 47.1 / 47.4 | -2.1 / -1.9 |
| BA24_POR14 | 43.5 | 49.2 / 49.4 | 5.7 / 6.0 | 47.2 / 47.5 | -2.0 / -2.0 |
| BA24_POR15 | 43.6 | 49.2 / 49.5 | 5.6 / 5.9 | 47.4 / 47.7 | -1.8 / -1.8 |
| BA24_POR16 | 43.5 | 49.7 / 49.9 | 6.2 / 6.4 | 47.3 / 47.6 | -2.3 / -2.3 |
| BA24_POR17 | 44.1 | 49.8 / 50.1 | 5.7 / 5.9 | 47.3 / 47.6 | -2.5 / -2.5 |
| BA24_POR18 | 44.1 | 49.8 / 50.2 | 5.7 / 6.0 | 47.4 / 47.7 | -2.4 / -2.4 |
| BA24_POR19 | 44.2 | 49.9 / 50.3 | 5.7 / 6.1 | 47.4 / 47.8 | -2.4 / -2.5 |
| BA24_POR20 | 44.9 | 49.9 / 50.4 | 5.0 / 5.5 | 47.4 / 47.8 | -2.5 / -2.6 |
| BA24_POR21 | 45.0 | 49.9 / 50.4 | 4.9 / 5.4 | 47.3 / 47.7 | -2.6 / -2.7 |
| BA24_POR22 | 44.9 | 49.6 / 50.0 | 4.7 / 5.1 | 46.7 / 47.2 | -3.0 / -2.9 |
| BA24_POR23 | 44.9 | 49.8 / 49.9 | 4.9 / 5.0 | 46.1 / 46.6 | -3.7 / -3.4 |
| BA24_POR24 | 44.6 | 49.6 / 49.6 | 5.0 / 5.0 | 45.9 / 46.2 | -3.8 / -3.4 |
| BA24_POR25 | 44.6 | 49.7 / 49.6 | 5.1 / 5.0 | 46 / 46.3 | -3.7 / -3.2 |
| BA24_POR26 | 44.7 | 49.4 / 49.2 | 4.7 / 4.4 | 45.5 / 45.8 | -3.9 / -3.4 |
| BA24_POR27 | 44.3 | 48.7 / 48.4 | 4.4 / 4.1 | 44.6 / 44.8 | -4.1 / -3.6 |
| BA24_POR28 | 43.8 | 48.3 / 47.9 | 4.5 / 4.1 | 44.4 / 44.5 | -3.9 / -3.4 |
| BA24_POR29 | 43.2 | 47.8 / 47.4 | 4.6 / 4.2 | 44.4 / 44.5 | -3.5 / -3.0 |
| BA24_POR30 | 42.7 | 47.4 / 46.8 | 4.7 / 4.1 | 43.8 / 43.8 | -3.6 / -3.0 |
| BA24_POR31 | 42.4 | 46.8 / 46.3 | 4.4 / 3.8 | 43.4 / 43.3 | -3.4 / -2.9 |
| BA24_POR32 | 41.9 | 46.3 / 45.7 | 4.5 / 3.8 | 42.7 / 42.7 | -3.6 / -3.0 |
| | *Average Attenuation:* | -- | -- | -- | *-2.6 / -2.5* |

**Table 13 Summary of Barrier Analysis (POR24 Area, Barrier in Parking Lot)**

| Receptor ID | Future No-Build | Pre-Mitigation | | Parking Lot Barrier (h=3.5 m) | | Parking Lot Barrier (h=4 m) | | Parking Lot Barrier (h=4.5 m) | | Parking Lot Barrier (h=5 m) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Future Build (dBA) | Increment (dBA) | Future Build (dBA) | Attenuation (dBA) | Future Build (dBA) | Attenuation (dBA) | Future Build (dBA) | Attenuation (dBA) | Future Build (dBA) | Attenuation (dBA) |
| | | BRT / LRT | BRT / LRT | BRT / LRT | BRT / LRT | | | | | | |
| BA24_POR01 | 45.9 | 46.8 / 47.2 | 0.9 / 1.3 | 46.8 / 47.2 | 0.0 / 0.0 | 46.8 / 47.2 | 0.0 / 0.0 | 46.8 / 47.2 | 0.0 / 0.0 | 46.8 / 47.2 | 0.0 / 0.0 |
| BA24_POR02 | 45.1 | 47.8 / 48.2 | 2.6 / 3.1 | 47.8 / 48.2 | 0.0 / 0.0 | 47.8 / 48.2 | 0.0 / 0.0 | 47.8 / 48.2 | 0.0 / 0.0 | 47.8 / 48.2 | 0.0 / 0.0 |
| BA24_POR03 | 45.2 | 48.5 / 49.0 | 3.3 / 3.8 | 48.5 / 49.0 | 0.0 / 0.0 | 48.5 / 49.0 | 0.0 / 0.0 | 48.5 / 49.0 | 0.0 / 0.0 | 48.5 / 49.0 | 0.0 / 0.0 |
| BA24_POR04 | 44.3 | 46.6 / 47.7 | 2.4 / 3.4 | 46.6 / 47.7 | 0.0 / 0.0 | 46.6 / 47.7 | 0.0 / 0.0 | 46.6 / 47.7 | 0.0 / 0.0 | 46.6 / 47.7 | 0.0 / 0.0 |
| BA24_POR05 | 44.1 | 46.5 / 47.5 | 2.4 / 3.4 | 46.5 / 47.5 | 0.0 / 0.0 | 46.5 / 47.5 | 0.0 / 0.0 | 46.5 / 47.5 | 0.0 / 0.0 | 46.5 / 47.5 | 0.0 / 0.0 |
| BA24_POR06 | 44.0 | 46.9 / 47.8 | 2.9 / 3.8 | 46.9 / 47.8 | 0.0 / 0.0 | 46.9 / 47.8 | 0.0 / 0.0 | 46.9 / 47.8 | 0.0 / 0.0 | 46.9 / 47.8 | 0.0 / 0.0 |
| BA24_POR07 | 43.9 | 46.1 / 47.1 | 2.3 / 3.3 | 46.1 / 47.1 | 0.0 / 0.0 | 46.1 / 47.1 | 0.0 / 0.0 | 46.1 / 47.1 | 0.0 / 0.0 | 46.1 / 47.1 | 0.0 / 0.0 |
| BA24_POR08 | 43.7 | 46.1 / 47.1 | 2.5 / 3.5 | 46.1 / 47.1 | 0.0 / 0.0 | 46.1 / 47.1 | 0.0 / 0.0 | 46.1 / 47.1 | 0.0 / 0.0 | 46.1 / 47.1 | 0.0 / 0.0 |
| BA24_POR09 | 43.6 | 46.3 / 47.3 | 2.7 / 3.7 | 46.3 / 47.3 | 0.0 / 0.0 | 46.3 / 47.3 | 0.0 / 0.0 | 46.3 / 47.3 | 0.0 / 0.0 | 46.3 / 47.3 | 0.0 / 0.0 |
| BA24_POR10 | 43.5 | 47.2 / 47.9 | 3.8 / 4.4 | 47.1 / 47.8 | -0.2 / -0.1 | 47.1 / 47.8 | -0.2 / -0.1 | 47.1 / 47.8 | -0.2 / -0.1 | 47.1 / 47.8 | -0.2 / -0.1 |
| BA24_POR11 | 43.8 | 48.5 / 48.9 | 4.7 / 5.1 | 48.0 / 48.6 | -0.5 / -0.3 | 48.0 / 48.6 | -0.5 / -0.3 | 48.0 / 48.6 | -0.5 / -0.3 | 48.0 / 48.6 | -0.5 / -0.3 |
| BA24_POR12 | 43.6 | 49.0 / 49.2 | 5.4 / 5.6 | 46.0 / 46.8 | -3.0 / -2.4 | 45.9 / 46.7 | -3.1 / -2.5 | 45.9 / 46.7 | -3.2 / -2.6 | 45.8 / 46.7 | -3.2 / -2.6 |
| BA24_POR13 | 43.6 | 49.1 / 49.4 | 5.6 / 5.8 | 43.9 / 44.4 | -5.3 / -4.9 | 43.6 / 44.2 | -5.5 / -5.2 | 43.3 / 44.0 | -5.8 / -5.4 | 43.1 / 43.8 | -6.0 / -5.6 |
| BA24_POR14 | 43.5 | 49.2 / 49.4 | 5.7 / 6.0 | 42.8 / 43.2 | -6.4 / -6.2 | 42.2 / 42.8 | -7.0 / -6.7 | 41.7 / 42.3 | -7.5 / -7.1 | 41.3 / 41.9 | -7.9 / -7.5 |
| BA24_POR15 | 43.6 | 49.2 / 49.5 | 5.6 / 5.9 | 43.6 / 43.9 | -5.6 / -5.6 | 43.0 / 43.3 | -6.2 / -6.2 | 42.5 / 42.8 | -6.7 / -6.7 | 42.0 / 42.4 | -7.2 / -7.1 |
| BA24_POR16 | 43.5 | 49.7 / 49.9 | 6.2 / 6.4 | 44.3 / 44.5 | -5.4 / -5.5 | 43.5 / 43.7 | -6.1 / -6.2 | 42.9 / 43.1 | -6.7 / -6.8 | 42.5 / 42.7 | -7.1 / -7.2 |
| BA24_POR17 | 44.1 | 49.8 / 50.1 | 5.7 / 5.9 | 44.8 / 44.8 | -5.0 / -5.2 | 44.1 / 44.1 | -5.7 / -5.9 | 43.3 / 43.3 | -6.5 / -6.8 | 42.8 / 42.8 | -7.0 / -7.3 |
| BA24_POR18 | 44.1 | 49.8 / 50.2 | 5.7 / 6.0 | 45.6 / 45.5 | -4.2 / -4.6 | 44.8 / 44.7 | -5.0 / -5.4 | 44.1 / 44.0 | -5.7 / -6.1 | 43.4 / 43.3 | -6.4 / -6.8 |
| BA24_POR19 | 44.2 | 49.9 / 50.3 | 5.7 / 6.1 | 46.5 / 46.3 | -3.4 / -4.0 | 45.5 / 45.3 | -4.4 / -5.0 | 44.5 / 44.4 | -5.3 / -5.9 | 43.7 / 43.5 | -6.2 / -6.8 |
| BA24_POR20 | 44.9 | 49.9 / 50.4 | 5.0 / 5.5 | 48.1 / 47.6 | -1.8 / -2.8 | 46.1 / 45.8 | -3.8 / -4.6 | 45.2 / 44.8 | -4.7 / -5.5 | 44.5 / 44.1 | -5.4 / -6.3 |
| BA24_POR21 | 45.0 | 49.9 / 50.4 | 4.9 / 5.4 | 48.9 / 48.6 | -0.9 / -1.8 | 46.7 / 46.3 | -3.1 / -4.1 | 45.8 / 45.2 | -4.1 / -5.2 | 44.8 / 44.2 | -5.0 / -6.2 |
| BA24_POR22 | 44.9 | 49.6 / 50.0 | 4.7 / 5.1 | 48.8 / 48.6 | -0.8 / -1.5 | 47.0 / 46.5 | -2.6 / -3.5 | 46.0 / 45.3 | -3.7 / -4.8 | 45.2 / 44.4 | -4.5 / -5.6 |
| BA24_POR23 | 44.9 | 49.8 / 49.9 | 4.9 / 5.0 | 47.4 / 47.0 | -2.4 / -3.0 | 46.5 / 45.9 | -3.3 / -4.1 | 45.9 / 45.2 | -3.9 / -4.7 | 45.1 / 44.5 | -4.6 / -5.5 |
| BA24_POR24 | 44.6 | 49.6 / 49.6 | 5.0 / 5.0 | 46.5 / 46.0 | -3.1 / -3.6 | 46.0 / 45.6 | -3.6 / -4.0 | 45.5 / 45.0 | -4.2 / -4.6 | 45.0 / 44.6 | -4.6 / -5.0 |
| BA24_POR25 | 44.6 | 49.7 / 49.6 | 5.1 / 5.0 | 46.5 / 46.1 | -3.1 / -3.5 | 45.9 / 45.5 | -3.7 / -4.1 | 45.6 / 45.2 | -4.1 / -4.4 | 45.2 / 44.8 | -4.5 / -4.7 |
| BA24_POR26 | 44.7 | 49.4 / 49.2 | 4.7 / 4.4 | 46.6 / 46.1 | -2.8 / -3.0 | 46.1 / 45.6 | -3.3 / -3.6 | 45.7 / 45.3 | -3.7 / -3.9 | 45.3 / 45.0 | -4.1 / -4.2 |
| BA24_POR27 | 44.3 | 48.7 / 48.4 | 4.4 / 4.1 | 46.7 / 46.3 | -2.0 / -2.2 | 46.5 / 46.1 | -2.2 / -2.3 | 46.4 / 46.0 | -2.4 / -2.4 | 46.3 / 45.9 | -2.5 / -2.5 |
| BA24_POR28 | 43.8 | 48.3 / 47.9 | 4.5 / 4.1 | 46.5 / 46.0 | -1.8 / -1.9 | 46.3 / 45.8 | -2.0 / -2.1 | 46.2 / 45.8 | -2.1 / -2.2 | 46.0 / 45.7 | -2.2 / -2.2 |
| BA24_POR29 | 43.2 | 47.8 / 47.4 | 4.6 / 4.2 | 46.2 / 45.7 | -1.6 / -1.7 | 46.1 / 45.7 | -1.7 / -1.8 | 46.0 / 45.6 | -1.8 / -1.8 | 45.8 / 45.5 | -2.0 / -1.9 |
| BA24_POR30 | 42.7 | 47.4 / 46.8 | 4.7 / 4.1 | 45.9 / 45.3 | -1.5 / -1.5 | 45.8 / 45.3 | -1.6 / -1.6 | 45.7 / 45.2 | -1.7 / -1.7 | 45.6 / 45.1 | -1.8 / -1.7 |
| BA24_POR31 | 42.4 | 46.8 / 46.3 | 4.4 / 3.8 | 45.6 / 45.0 | -1.3 / -1.3 | 45.4 / 44.9 | -1.4 / -1.4 | 45.4 / 44.8 | -1.5 / -1.4 | 45.3 / 44.8 | -1.6 / -1.5 |
| BA24_POR32 | 41.9 | 46.3 / 45.7 | 4.5 / 3.8 | 45.0 / 44.4 | -1.3 / -1.3 | 44.9 / 44.3 | -1.5 / -1.4 | 44.8 / 44.3 | -1.6 / -1.4 | 44.7 / 44.2 | -1.6 / -1.5 |
| *Average Attenuation:* | | -- | -- | -- | *-3.4 -3.7* | -- | *-4.2 -4.5* | -- | *-4.8 -5.1* | -- | *-5.4 -5.6* |

## 5.2 Noise from Construction

### 5.2.1 Impact Assessment

As noted in section 3.4.1, the sound level limits recommended by the MOECC for construction noise have been developed on a per-unit basis rather than a cumulative basis. As such, there are no applicable criteria values for the simultaneous operation of multiple pieces of construction equipment. The City of Markham requires that all construction equipment that is to be used within 600 m of a Residential Area be affixed with a label from the manufacturer confirming that the sound level limits from MOECC Publication NPC-115 are met [9]. Noise modelling of individual pieces of construction equipment to confirm compliance with the NPC-115 limits has therefore not been undertaken for this assessment, as it is assumed that the equipment supplier will ensure that all equipment meets the applicable NPC-115 limits.

### 5.2.2 Noise Control Recommendations

The implementation of the following measures will help to mitigate potential noise impacts during construction:

- Limit construction to the time periods allowed by the Town of Markham and City of Pickering noise by-laws, as summarized in section 0 and 3.4.3, respectively.
- Should there be a need to complete work outside of the hours allowed in the applicable noise by-laws, the Contractor is to seek any required exemptions and permits directly from the applicable jurisdiction, in advance of any work performed outside of the allowable time periods. If an exemption cannot be obtained, then construction will proceed in accordance with the requirements of the noise by-laws.
- The Contractor is expected to comply with all applicable requirements of the contract and local noise by-laws. Enforcement of noise control by-laws is the responsibility of the Municipality for all work.
- Contracts shall include explicit indication that all construction equipment used on the project is to meet the sound level criteria from NPC-115 and NPC-118, and be well maintained and operating with effective muffling devices that are in good working order. Note that demonstrated compliance with NPC-115 is a requirement of the Town of Markham noise by-law.
- The separation distance between construction staging areas and nearby sensitive receptors is to be maximized to the extent possible to reduce noise impacts.
- Any temporary roads for construction vehicle access are to be well maintained and free of pot-holes and ruts to avoid excessive noise from heavy vehicles travelling on uneven surfaces.
- A complaints protocol is to be established for receiving, investigating and addressing construction noise complaints from the public, including a plan for how the public is to be notified of their options for lodging a complaint.

- A noise complaint will trigger an investigation to verify whether the noise mitigation has been implemented, including verification of construction equipment sound levels per NPC-115 and NPC-118.
- In the presence of persistent complaints and subject to the results of a field investigation, alternative noise control measures may be required, where reasonably available. In selecting appropriate noise control and mitigation measures, consideration will be given to the technical, administrative and economic feasibility of the various alternatives.

# 6.0 VIBRATION IMPACT ASSESSMENT

## 6.1 Vibration from Transportation Sources

### 6.1.1 Ground-borne Vibration

As noted in section 4.4.1, the potential for ground-borne vibration impacts was assessed using an evaluation approach developed by the FTA [5]. The FTA provides a reference curve depicting how vibration velocity levels (RMS) typically change with distance for various vehicle types. A series of adjustment factors are provided to tailor the assessment approach to the specific scenario being modelled. To complete this assessment, the total adjustment for each vehicle type (rubber-tired or LRT for this assessment) was added to the reference values from the original curve, resulting in site specific curve for the three modelling scenarios: at-grade alignment, elevated alignment and in the vicinity of stations. An example of the adjusted curves (for at-grade segments) is presented in Figure 3. These curves were then used to determine the setback distance required to achieve compliance with the vibration criteria. All receptors beyond this distance would therefore not be impacted.

**Figure 3 Adjusted Ground-borne Vibration Curves for At-Grade Section**


The minimum separation distance for each scenario are presented in Table 14. The largest setbacks (i.e., the most likely to encompass an NSA) are associated with the at-grade scenario. Category 1 receptors are classified as commercial or industrial properties that house equipment that may be sensitive to vibrations. The nearest receptor that may house such equipment was identified as the Boxgrove Medical Arts Centre (POR15), which is 120 m from the proposed alignment of the 407 Transitway, and therefore well outside of the Category 1 setbacks identified in Table 14.

Category 2 receptors are residential locations, or any locations where people may be sleeping. The closest such receptor was identified as being 35 m from the proposed 407 Transitway alignment (POR13). As ground-borne vibrations are predicted to be negligible beyond 10 m from the Transitway when operating buses, and 19 m when operating LRT, no vibration impacts are expected at residential locations.

Category 3 receptors are institutional lands with primarily daytime use. The nearest such receptor was identified as the proposed Seaton Community high school (POR21), at 350 m from the proposed 407 Transitway alignment. This location is well outside of the Category 3 setbacks identified in Table 14.

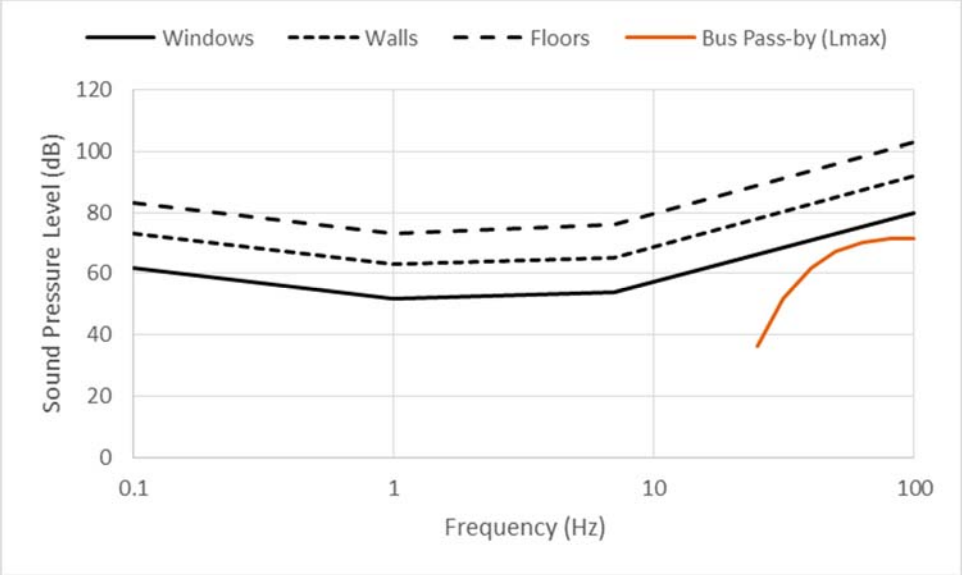
**Table 14 Minimum Setback Distances for Ground-Borne Vibration Impacts**

| Category | Criteria (mm/s) | Minimum Setback Distance Required (m) | | | | | |
|---|---|---|---|---|---|---|---|
| | | At-Grade | | Elevated | | Station | |
| | | Bus | LRT | Bus | LRT | Bus | LRT |
| Category 1 [sensitive equipment] | 0.05 | 24 | 47 | 8 | 13 | 9 | 17 |
| Category 2 [residential] | 0.10 | 10 | 19 | 4 | 6 | 5 | 7 |
| Category 3 [institutional] | 0.14 | 8 | 13 | 3 | 4 | 3 | 5 |

### 6.1.2 Airborne Vibration

As noted in section 4.4.1.2, FHWA algorithms were used to develop an estimate of the maximum bus pass-by noise in 1/3 octave bands. This sound level spectrum was then projected to the receptor location nearest to the 407 Transitway (POR13) in order to estimate whether the low frequency noise levels have potential to cause vibration of building components based on sound pressure thresholds developed by NASA [6]. The results of the assessment are depicted in Figure 4, which shows that the anticipated maximum bus pass-by levels are not expected to be of sufficient magnitude to cause excitation of building components.

**Figure 4 Assessment of Peak Bus Pass-by Noise at Nearest Receptor**




## 6.2 Vibration from Construction

### 6.2.1 Impact Assessment

As noted in section 4.4.2, detailed construction plans are not available at this stage of the project. As such, it is not known which types of construction equipment are likely to be operated, and where they may be situated in relation to receptors. As such, the potential vibration impacts from individual common types of construction equipment were assessed on a setback basis, using the construction vibration criteria presented in section 3.5. Reference curves from literature that depict vibration level with distance were used in conjunction with the identified criteria to identify the appropriate setback distance to consider when planning construction activities. The results of the assessment are provided in Table 15.

**Table 15 Minimum Setback Distances for Construction Equipment**

| Equipment Type | $PPV_{ref}$ | | Criteria | Setback |
|---|---|---|---|---|
| | (in/s) | (mm/s) | (mm/s) | (m) |
| Pile Driver (impact) | 1.52 / 0.64 | 38.6 / 16.4 | 0.3 | 194 / 110 |
| Pile Driver (sonic) | 0.73 / 0.17 | 18.6 / 4.3 | 0.3 | 120 / 45 |
| Vibratory Roller | 0.210 | 5.3 | 5.1 | 8 |
| Small Bulldozer | 0.003 | 0.1 | 5.1 | 1 |
| Large Bulldozer | 0.089 | 2.3 | 5.1 | 4 |
| Loaded Trucks | 0.076 | 1.9 | 5.1 | 4 |
| Jackhammer | 0.035 | 0.9 | 5.1 | 2 |

### 6.2.2 Vibration Control Recommendations

The implementation of the following measures will help to mitigate potential vibration impacts during construction:

- For work that is to occur outside of regular hours, the Contractor will be responsible for identifying the implications of the vibration generated, and to make construction work plans available for review.
- For work that has a high potential for vibration impacts (e.g., pile driving), the Contractor will be responsible for identifying the implications of the vibration generated, and to make construction work plans available for review.
- Construction equipment with potential to cause off-site vibrations should be operated as far away from vibration-sensitive sites as possible.
- Where possible, activities that have potential to cause off-site vibrations should be phased such that as few as possible are occurring simultaneously.
- Construction activities that have potential to cause off-site vibration during the night-time hours should be avoided.
- A complaints protocol is to be established for this project for receiving, investigating and addressing construction vibration complaints received from the public.
- The Contract documents shall contain a provision that any initial vibration complaint will trigger verification that any general vibration control measures agreed to are in effect.
- In the presence of persistent vibration complaints, the MTO and its Contractor shall consider implementing a measurement program to evaluate the vibration impacts.
- In the presence of persistent complaints and subject to the results of a field investigation, alternative vibration control measures may be required, where reasonably available. In selecting appropriate vibration control measures, consideration will be given to the technical, administrative and economic feasibility of the various alternatives.

# 7.0 CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Conclusions

The NVIA for the 407 Transitway extension from east of Kennedy Road to Brock Road included an assessment of the following potential impacts at existing and proposed future sensitive locations:

- Noise impacts at existing and proposed sensitive locations from buses and LRT operating on the proposed 407 Transitway, inclusive of changes to local topography;
- Ground-borne vibration impacts associated with buses and LRT operating on the 407 Transitway;
- Airborne vibration of house structure elements induced by sound levels from bus engines; and
- Noise and vibration considerations during construction of the Transitway.

The following key conclusions may be drawn from the assessment:

- An increment of greater than 5 dBA was predicted at POR11/POR13, and is attributable not only to the addition of the 407 Transitway, but also to the removal of the existing berm that currently mitigates noise from the 407 ETR to an extent.
- A 3.5 m high barrier wall installed on the right-of-way (south side) is predicted to be technically, economically and administratively feasible for first row receptors in the area of POR13. A barrier of 3.5 m height meets the minimum MTO feasibility requirements.
- An increment of greater than 5 dBA was predicted at POR24, and was found to be primarily attributable to the presence of traffic at the proposed Brock Road station parking lot.
- Barriers were assessed in the POR24 area, both in the Transitway right-of-way and at the south end of the Brock Station parking lot. It was predicted that a 5 m barrier at the south end of the Brock Station parking lot would be technically, economically and administratively feasible.
- No ground-borne vibration impacts were predicted for operations on the 407 Transitway.
- No airborne vibration effects (i.e., rattling of house structure elements) due to bus engine pass-by noise were predicted.

The noise by-laws for the associated jurisdictions include time and place prohibitions on construction activities, and the Markham noise by-law specifically requires all construction equipment to comply with NPC-115 and NPC-118.

## 7.2 Recommendations

Construction noise and vibration recommendations have been provided in sections 5.2.2 and 6.2.2, respectively.

As noted in the discussion in section 5.1.2.1, barriers in the area of POR11/POR13 were evaluated assuming that front-facing receptors have OLAs in the front-yard (exposed to the Transitway) and the backyard (shielded by the house structure). While OLAs in barrier analysis are often placed in the backyard, it is our recommendation to base the barrier design on front-yard OLAs in this scenario. There is anticipated to be sensitivity around the removal of the existing berm, which currently shields noise from the 407 ETR at these locations. A barrier designed based on front-yard OLAs would provide shielding for all receptors that currently benefit from this berm, and reduce the potential for noise complaints in this area.

As noted in the conclusions above, a 3.5 m barrier in the area of POR11/13 was found to meet the minimum MTO feasibility requirements. It is recommended that a barrier height up to 5 m be evaluated during the Detail Design stage, to determine whether further a greater reduction in sound level can be accommodated while remaining economically feasible.

It should be noted that if plans for the potential bus garage on the lands designated for Rossland Road station proceed, the facility will require an Environmental Compliance Approval (ECA) prior to operating. A detailed noise assessment will be required to support the ECA application. It is recommended that an Acoustic Assessment Report be undertaken during the detailed design stage such that any required noise controls can be accounted for in the final design.

# 8.0 REFERENCES

[1] Ontario Ministry of Transportation, "Environmental Guide for Noise (version 1.1)," Provincial and Environmental Planning Office, Ministry of Transportation, St. Catharines, Ontario, 2006.

[2] Ontario Ministry of Transportation, "Environmental Reference for Highway Design, Section 3.4: Noise," Provincial and Environmental Planning Office, St. Catharines, Ontario, 2006.

[3] Ontario Ministry of the Environment, "Environmental Noise Guideline: Stationary and Transportation Sources - Approval and Planning Publication NPC-300," Queen's Printer for Ontario, 2013.

[4] Ontario Ministry of the Environment, "MOEE/TTC Draft Protocol for Noise and Vibration Assessment for the Proposed Scarborough Rapid Transit Extension," 1993.

[5] Federal Transit Administration, "Transit Noise and Vibration Impact Assessment," U.S. Department of Transportation, Washington, D.C., 2006.

[6] D. G. Stephens, K. P. Shepherd, H. H. Hubbard and F. W. Gosveld, "NASA Technical Memorandum 83288 Guide to the Evaluation of Human Exposure to Noise from Large Wind Turbines," NASA Langley Research Center, Hampton, Virginia, 1982.

[7] Ontario Ministry of the Environment, "Model Municipal Noise Control By-law, Publication NPC-115: Construction," 1977.

[8] Ontario Ministry of the Environment, "Model Municipal Noise Control By-law, Publication NPC-118: Motorized Conveyances," 1977.

[9] Town of Markham, "By-Law No. 2003-137: A by-law to regulate noise within the Town of Markham," Council of the Town of Markham, Markham, Ontario, 2003.

[10] City of Pickering, "By-Law No. 6834/08: A by-law to prohibit and regulate noise," The Corporation of the City of Pickering, Pickering, Ontario, 2008.

[11] Ontario Ministry of the Environment, "Model Municipal Noise Control By-Law; Publication NPC-207: Impulse Vibration in Residential Buildings," 1983.

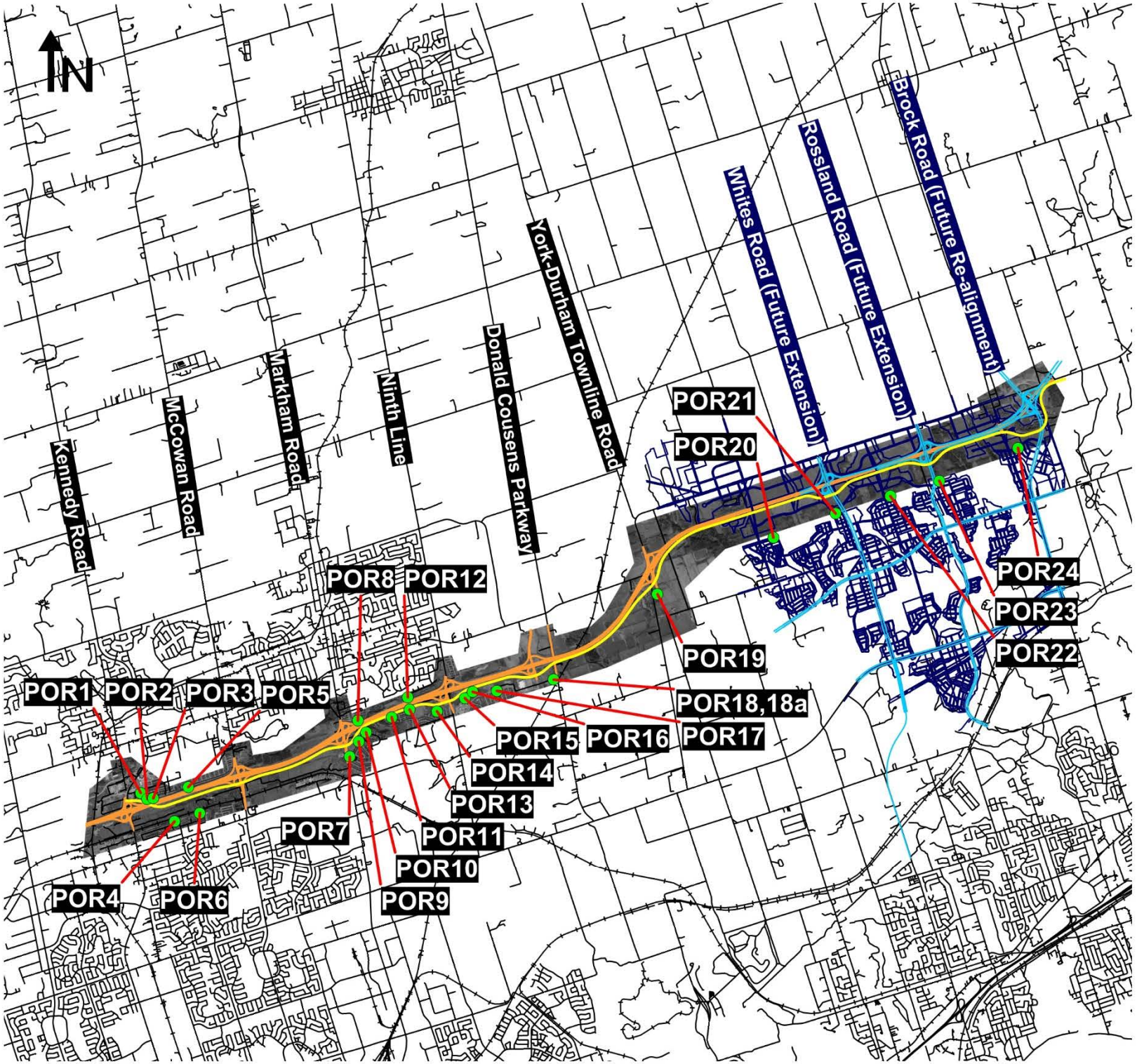
[12] City of Pickering, "Seaton Community Neighbourhood Plans," City of Pickering, January 2013. [Online]. Available: https://www.pickering.ca/en/cityhall/neighbourhoodplans.asp. [Accessed 13 August 2015].

[13] City of Pickering, "Zoning By-law 7364/14: Seaton Zoning By-law," City of Pickering, Pickering, 2014.

[14] Federal Highway Administration, "FHWA Traffic Noise Model Tecnical Manual," U.S. Department of Transportation, Washington, D.C., 1998.

[15] Ontario Ministry of the Environment, "Ontario Road Noise Analysis Method for Environment and Transportation: Technical Document," 1989.

# FIGURES




**LEGEND:**

- Existing Roads
- Proposed Future Roads (Seaton Community)
- 407 ETR Alignment
- 407 Transitway Alignment
- Proposed Future Interchanges
- Point of Reception

**NOTES:**

**SCALE:**

0 km 2 km 4 km

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**REFERENCE:**

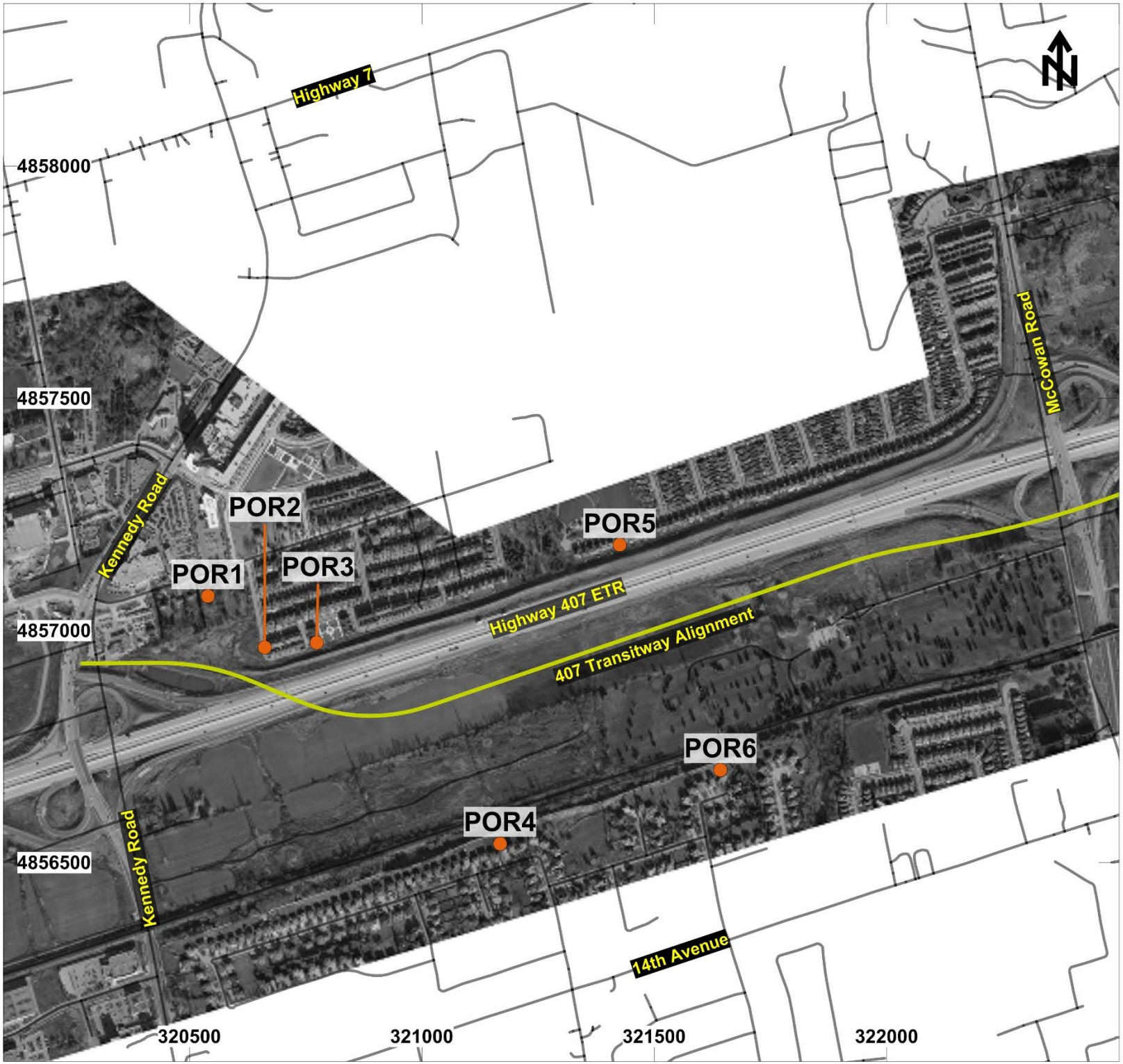
ARCADIS

Ontario Ministry of Transportation

**Summary of Points of Reception**

407 Transitway
Kennedy Road to Brock Road

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 5 |
| Date: Aug. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route

**NOTES:**

**SCALE:**

0 m 250 m 500 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

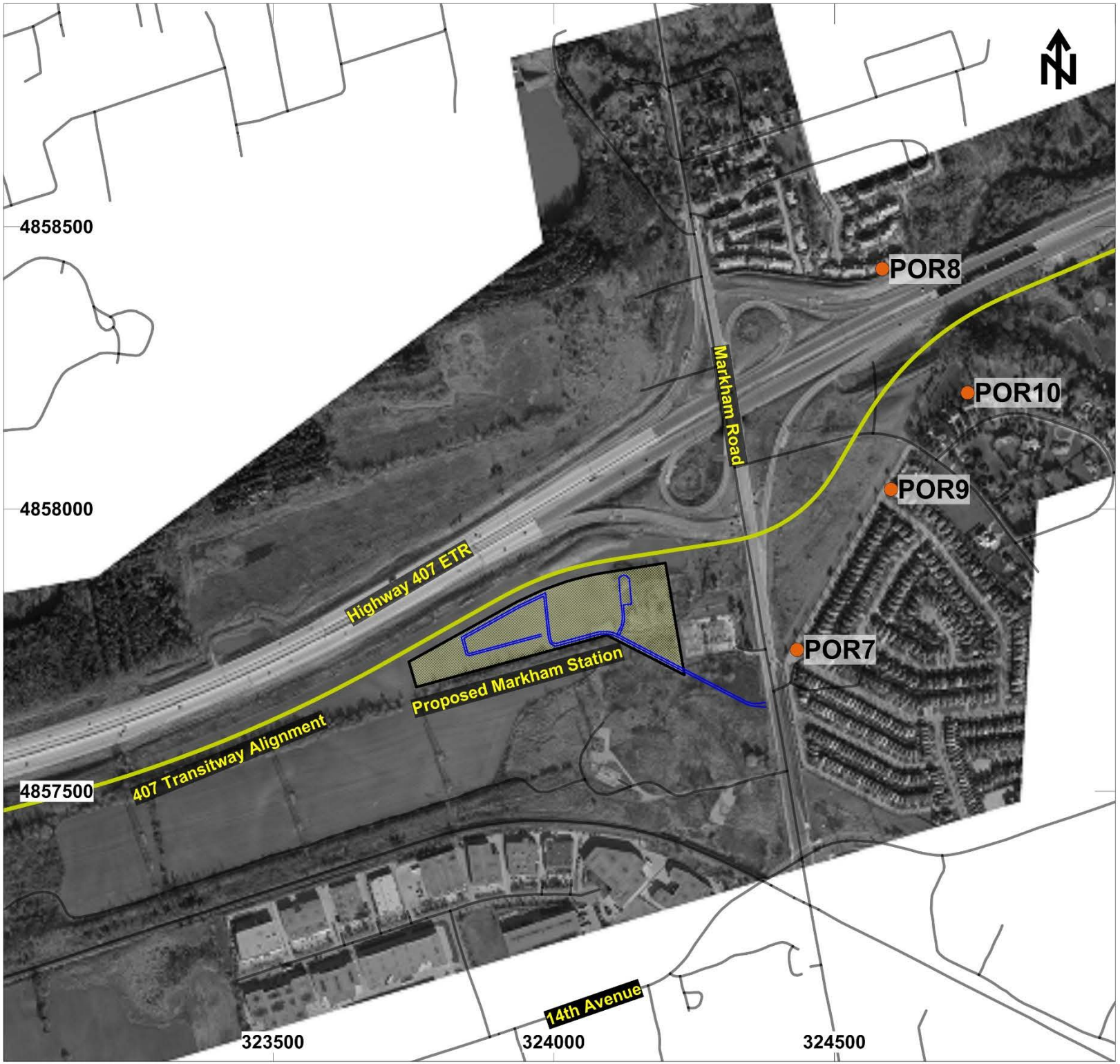
ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**Kennedy Rd. to McCowan Rd.**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 6 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Station Traffic (modelled routes)
- Approximate Station Footprint

**NOTES:**

**SCALE:**

0 m 200 m 400 m

**REVISIONS:**

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|---|---|---|---|
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

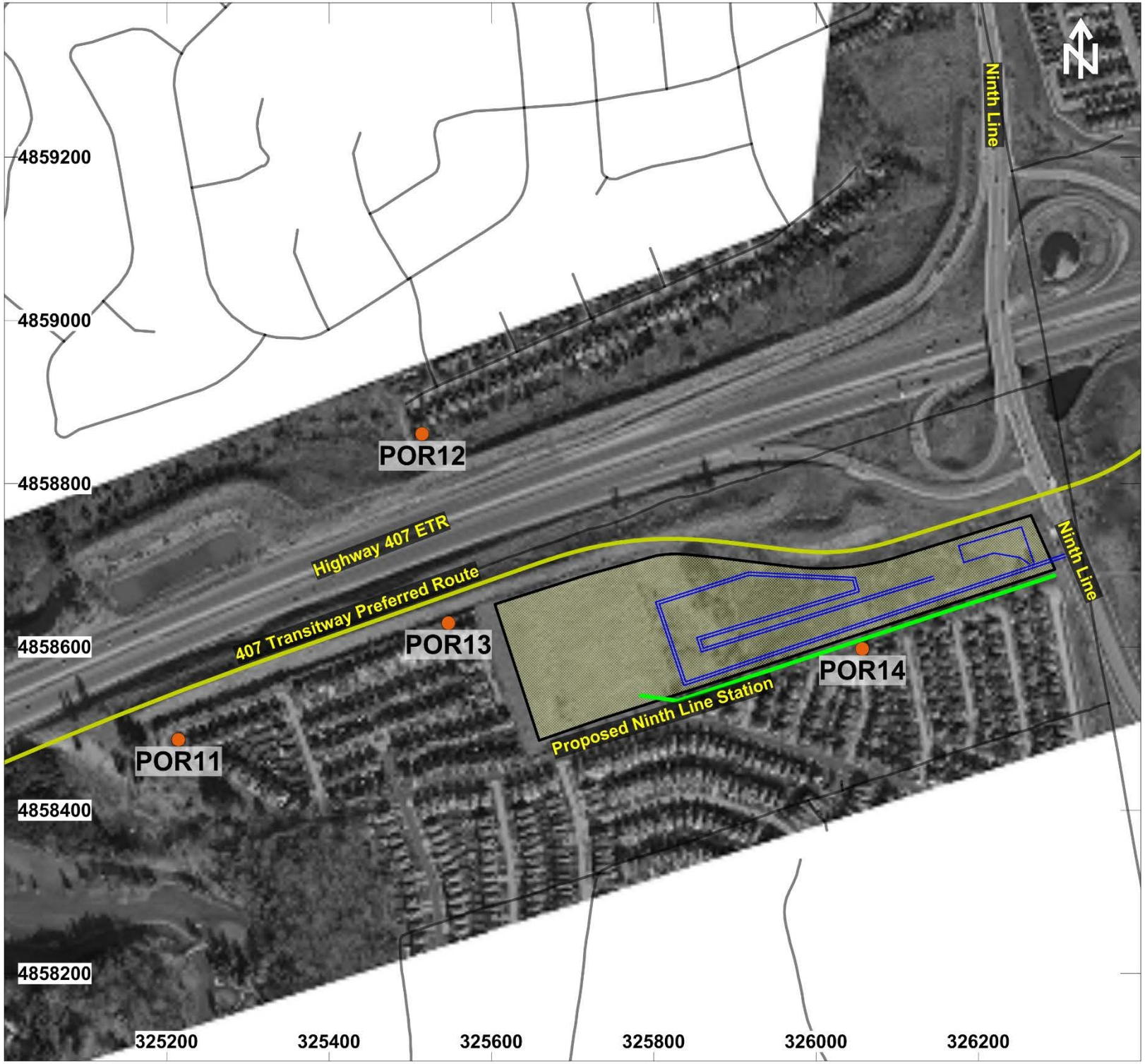
ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations: Markham Rd.**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 7 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Station Traffic (modelled routes)
- Approximate Station Footprint
- Proposed Berm

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
| | | | |
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**Markham Rd. to Ninth Line**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 8 |
| Date: Dec. 2015 | Project No.: 350982 | |


**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

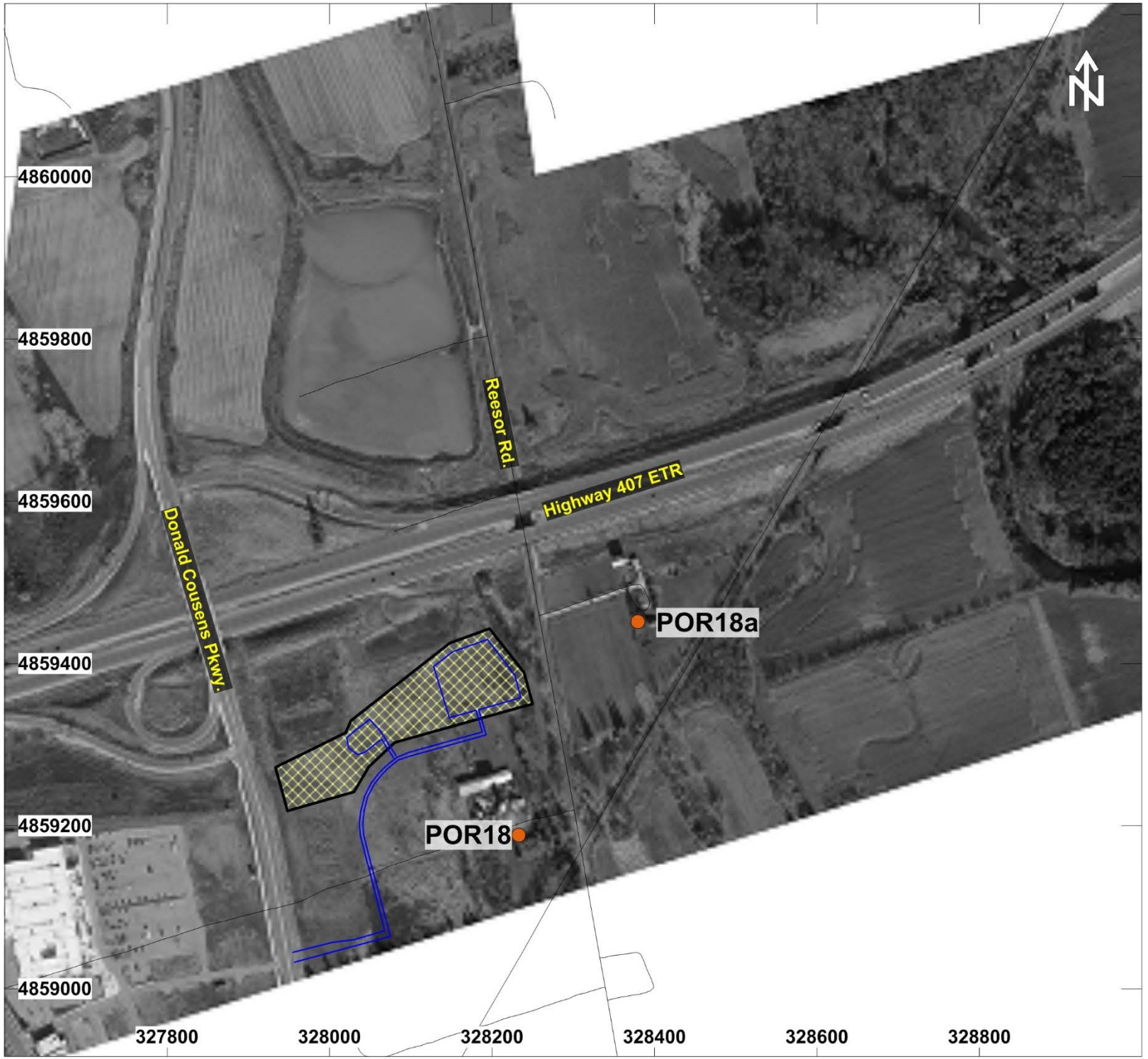
ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**Ninth Line to Donald Cousens Pkwy.**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 9 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Station Traffic (modelled routes)
- Approximate Station Footprint

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

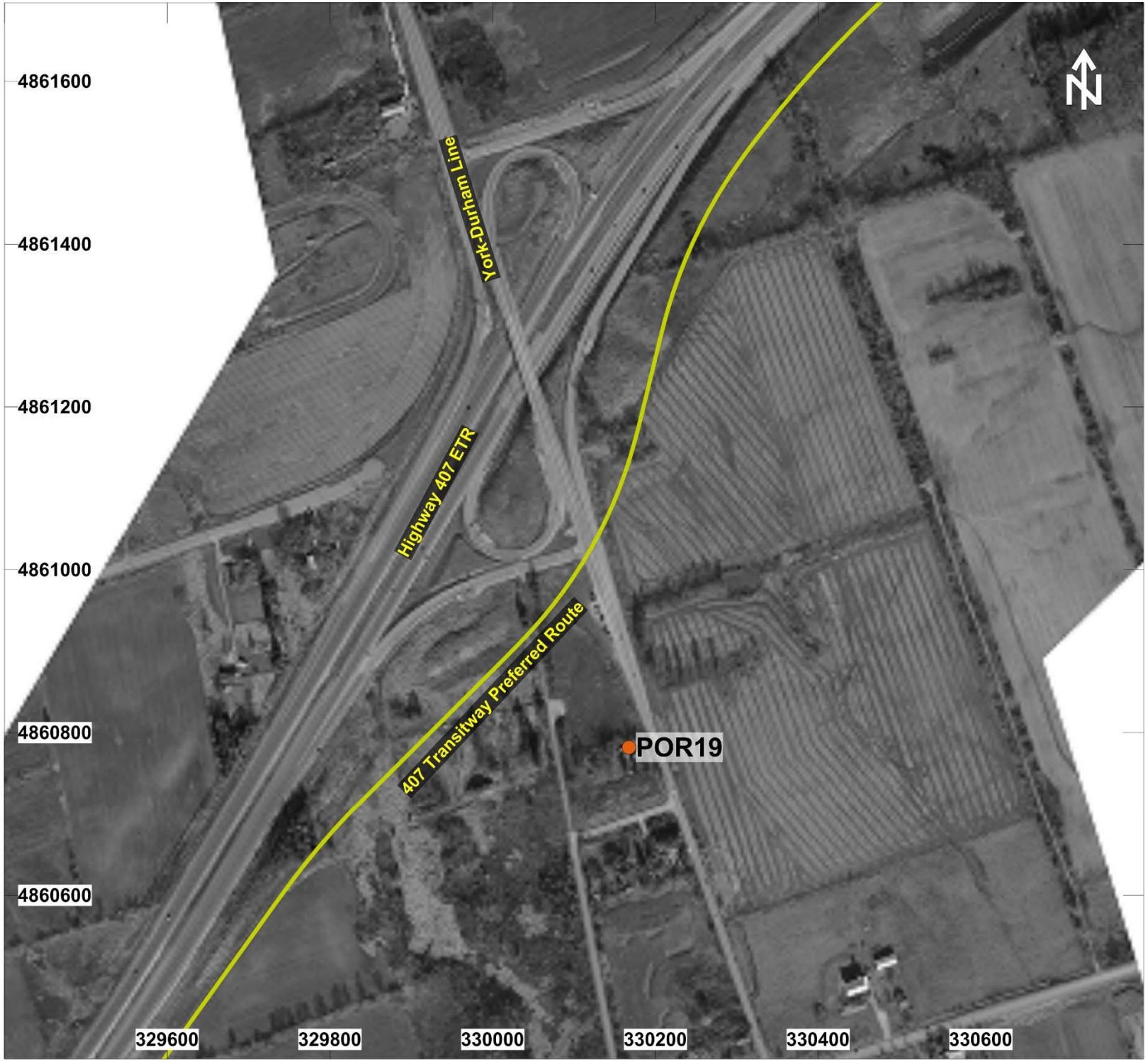
ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**Donald Cousens Pkwy.**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 10 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**York-Durham Line**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 11 |
| Date: Dec. 2015 | Project No.: 350982 | |


**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

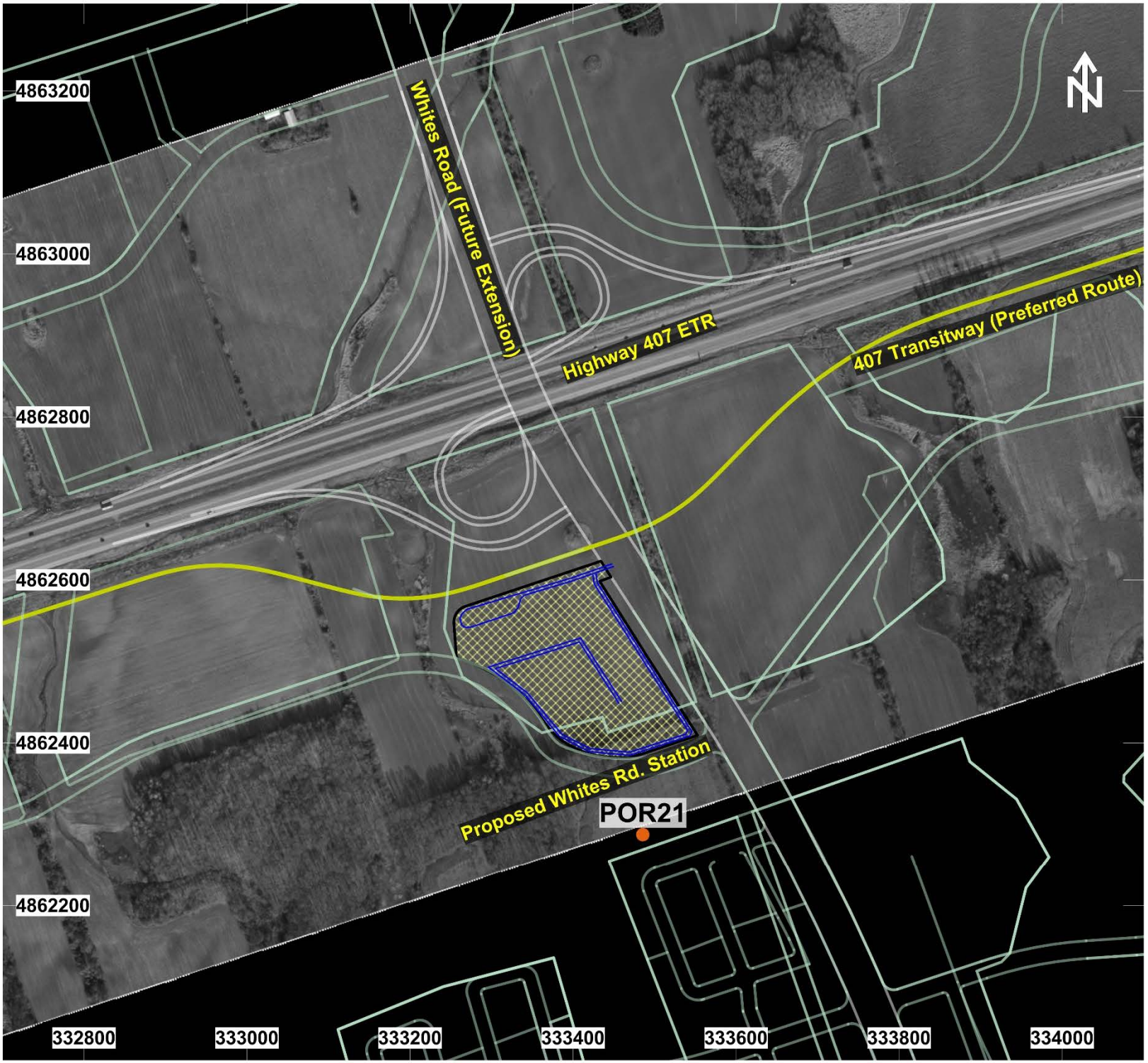
ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**York-Durham Line-Whites Rd.**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 12 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Station Traffic (modelled routes)
- Approximate Station Footprint
- Seaton Community Lands

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations: Whites Road**

City of Pickering

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 13 |
| Date: Dec. 2015 | Project No.: 350982 | |


**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations:**
**24 Sideline**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 14 |
| Date: Dec. 2015 | Project No.: 350982 | |


**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Seaton Community Lands

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
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| | | | |

**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

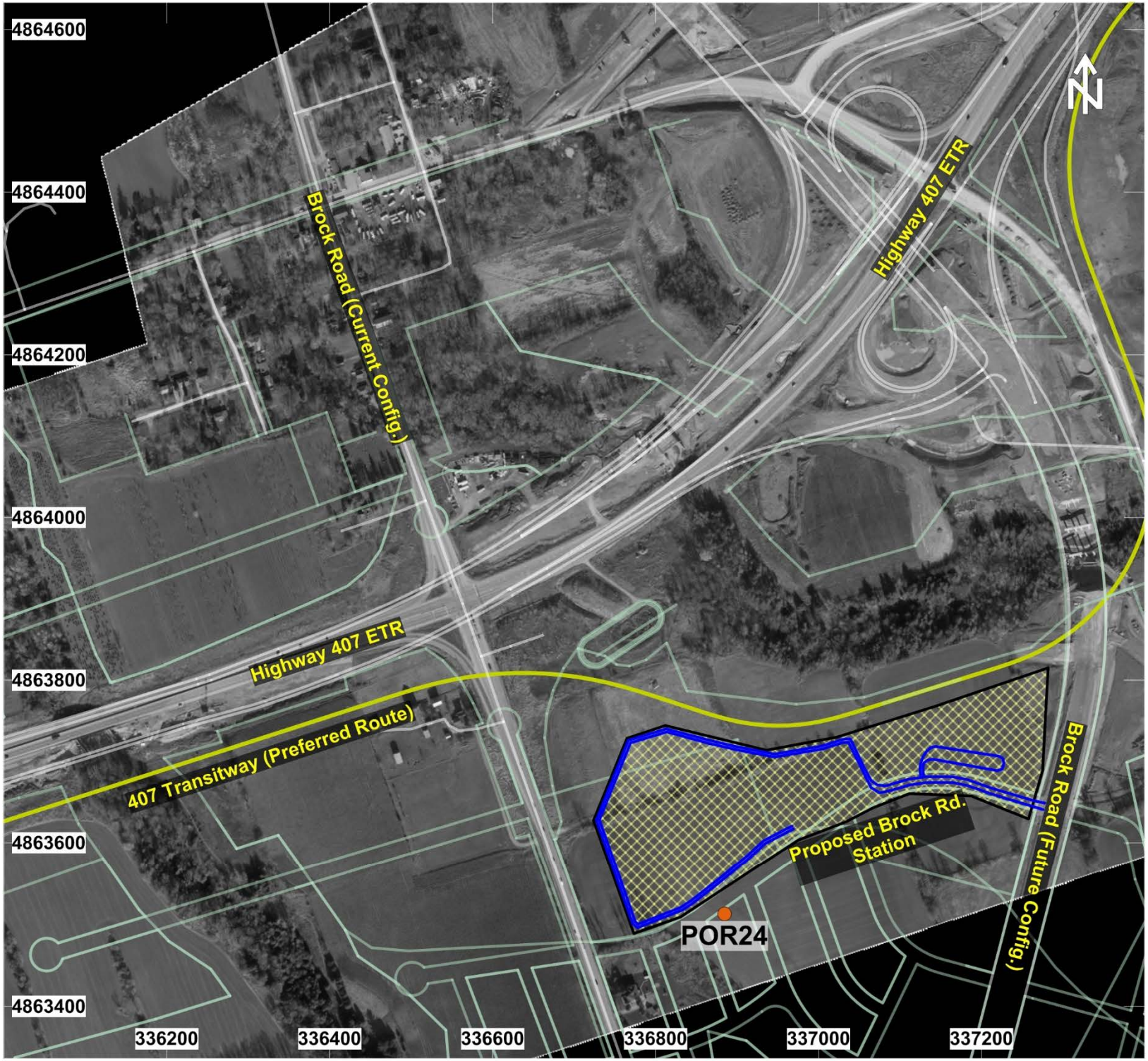
ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations: Rossland Road**

City of Pickering

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 15 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Station Traffic (modelled routes)
- Approximate Station Footprint
- Seaton Community Lands

**NOTES:**

**SCALE:**

0 m 100 m 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

ARCADIS

Ontario Ministry of Transportation (MTO)

**Receptor Locations: Brock Road**

City of Pickering

| Drawn By: | Approved By: | Figure No.: |
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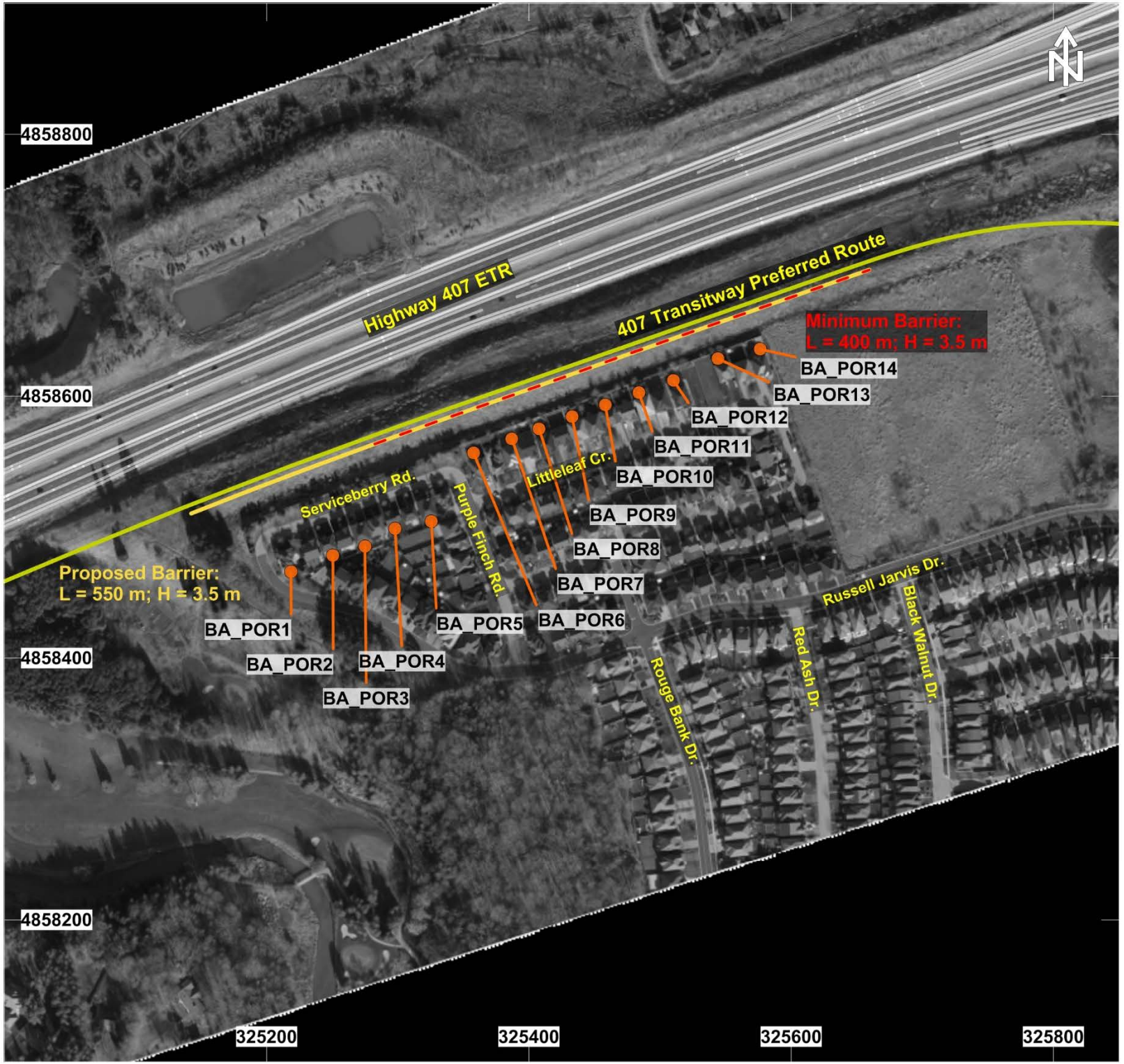
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Proposed Barrier
- Min. Barrier

**NOTES:**

**SCALE:**

0 m 50 m 100 m 150 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
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**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

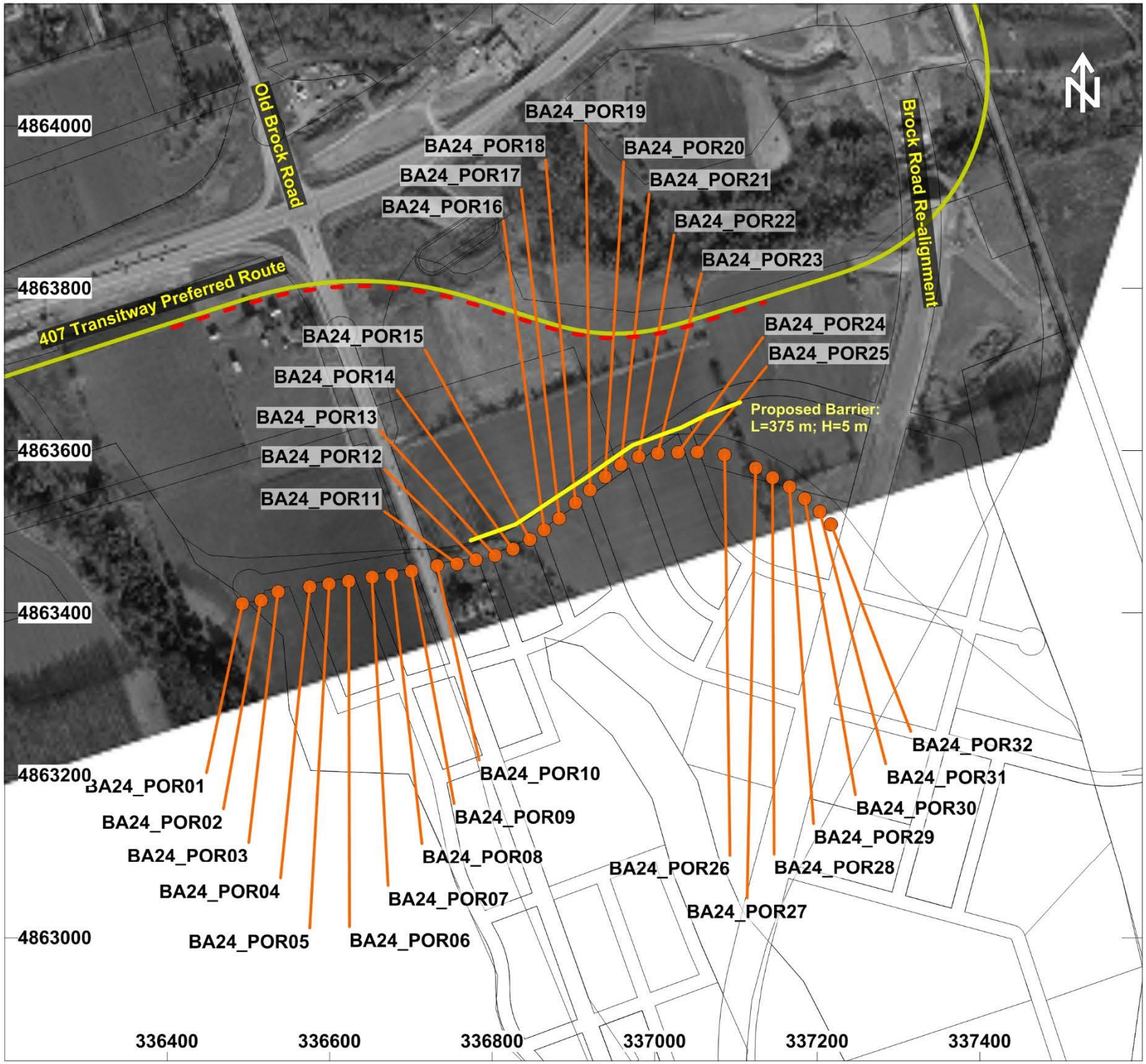
ARCADIS

Ontario Ministry of Transportation (MTO)

**Barrier Analysis:**
**Receptor and Barrier Locations**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 17 |
| Date: Dec. 2015 | Project No.: 350982 | |




**LEGEND:**

- Point of Reception
- 407 Transitway Preferred Route
- Proposed Barrier
- ROW Barrier (not feasible)

**NOTES:**

**SCALE:**

0 m — 100 m — 300 m

**REVISIONS:**

| No. | Date | By | Revision |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**REFERENCE:**

Coordinate System: MTM (Zone 10); WGS84

ARCADIS

Ontario Ministry of Transportation (MTO)

**POR24 Barrier Analysis: Barrier and Receptor Locations**

City of Markham

| Drawn By: | Approved By: | Figure No.: |
|---|---|---|
| NZS | FDB | 18 |
| Date: Dec. 2015 | Project No.: 350982 | |

# APPENDIX A: GLOSSARY OF TERMS

**Table A-1: Glossary of Terms**

| Term | Definition |
|---|---|
| A-weighting | A frequency-based adjustment applied to measured or modelled sound levels that de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear, and correlates well with subjective reactions to noise. |
| dBA | A-weighted decibels (see *A-weighting* and *Decibel*) |
| Decibel (dB) | When applied to sound pressure levels (SPL), the decibel (dB) is a logarithmic ratio of a given sound pressure level ($p$) in Pascals (Pa) to a reference quantity of 20 µPa ($p_{ref}$, the threshold of hearing). Expressing sound levels in dB rather than Pa allows the full range of audible sound, which spans six orders of magnitude when expressed in Pa, to be expressed within a much smaller range of 0 to 120 dB (the threshold of pain). |
| Energy Equivalent Sound Level ($L_{eq}$) | The value of the constant sound level which would result in the exposure to the same total A-weighted energy as would the specified time-varying sound, if the constant sound persisted over an equal time interval |
| Noise Sensitive Area (NSA) | means the following land uses with an OLA associated with them:<br>• Private homes such as single family residences (owned or rental);<br>• Townhouses (owned or rental);<br>• Multiple unit buildings, such as apartments with OLAs for use by all occupants;<br>• Hospitals, nursing homes for the aged, where there are OLAs for all patients.<br><br>There is no minimum number of land uses that defines a NSA. Therefore, all noise sensitive land uses, regardless of size or location (urban or rural), will be assessed for application of noise control measures.<br><br>Where a new freeway/highway corridor or route is planned, the following land uses would qualify as NSAs in addition to the land uses noted above:<br>• Educational facilities and day care centres, where there are OLAs for students;<br>• Campgrounds that provide overnight accommodation; and<br>• Hotels/motels where there are OLAs (i.e., swimming pool area, etc.) for visitors.<br>Land uses listed below, by themselves do not qualify as NSAs:<br>• Apartment balconies above ground floor;<br>• Churches;<br>• Cemeteries;<br>• Parks and picnic areas which are not inherently part of an NSA;<br>• All commercial; and<br>• All industrial. |

| | |
|---|---|
| Octave band | A frequency band whose upper limit is twice the lower limit, and is identified by a geometric mean frequency, called the centre frequency. |
| Outdoor Living Area (OLA)<br>[*MTO definition*] | means an area at ground level, adjacent to a NSA and accommodating outdoor living activities. This area may be situated on any side of the NSA. The usual distance from the dwelling unit wall is 3 m. The vertical height is 1.2 m above the existing ground surface. Where unknown, the side closest to the highway should be assumed. Paved areas for multiple dwelling residential units may not be defined as an OLA. |
| Peak particle velocity (PPV) | The peak particle velocity (PPV) is defined as the maximum instantaneous positive or negative peak of the vibration signal. |
| Point of Reception (POR) | The point at which a noise level has been calculated. |
| Root-mean-square (RMS) vibration velocity | The root mean square of a signal is the square root of the average of the squared amplitude of the signal and is calculated over a one-second period. |

# APPENDIX B: TOWN OF MARKHAM NOISE BY-LAW

# *TOWN OF MARKHAM*

**Ontario**

# BY-LAW NO. 2003-137

**A BY-LAW TO REGULATE NOISE WITHIN THE TOWN OF MARKHAM**

This By-law is printed under and
by authority of the Council of
the Town of Markham

(Consolidated for convenience only
to May 30, 2005)

Amended by:

By-law 2005-143 – May 24, 2005

Clause 11, Report 36, 2003

# BY-LAW 2003-137

Being a By-law To Regulate Noise and to Repeal By-law 218-89

**WHEREAS** section 128 of the *Municipal Act, 2001*, S.O. 2001, c. 25 authorizes a local municipality to prohibit and regulate matters that, in the opinion of Council, are or could become public nuisances;

**AND WHEREAS** section 129 of the *Municipal Act, 2001*, authorizes municipalities to pass by-laws to prohibit and regulate noise;

**AND WHEREAS** section 391 of the *Municipal Act, 2001* authorizes Council to pass by-laws imposing fees and charges on any class of persons for services or activities provided or done by or on behalf of it;

**AND WHEREAS** excessive sound vibration and inadequately controlled noise may impair public health, safety and welfare and may become a nuisance;

**AND WHEREAS** the people of the Town of Markham expect, and have a right to an environment free from unusual, unnecessary, or excessive sound or vibration or which may degrade the quality and tranquillity of their life or cause nuisance;

**AND WHEREAS** a recognized body of scientific and technological knowledge exists by which sound and vibration may be substantially reduced;

**NOW THEREFORE** the Council of The Corporation of the Town of Markham enacts as follows:

## Definitions

1. In this By-Law,

   **"Applicable Publication"** means any publication referred to in the provisions of this By-Law including a schedule hereto;

   **"Applicant"** includes any person who applies in writing to Council for a permit for an exemption from the provisions and requirements of this By-law;

**"Authorized Emergency Vehicle"** includes any ambulance or hearse, any vehicle of the fire department, or of the local, provincial or federal police, any vehicle operated by or for the Town, the Bell Telephone Company of Canada, Canada Post, armoured cars carrying cash, and public utility company while actively engaged in the construction, maintenance or repair of any highway, or any equipment or facilities thereon, or a snow plough or other maintenance vehicle operated by or for the Ministry of Transportation;

**"Certificate"** means a current certificate of competency in environmental acoustics technology of a specified class issued by an accredited program of an Ontario community college or other approved agency;

**"Clerk"** means the Clerk of The Corporation of the Town of Markham or his or her designate;

**"Construction"** includes erection, alteration, repair, dismantling, demolition, structural maintenance, painting, moving, land clearing, earth moving, grading, excavating, the laying of pipe and conduit whether above or below ground level, street and highway building, concreting, equipment installation and alteration and the structural installation of construction components and materials in any form or for any purpose, and includes any work in connection therewith;

**"Construction Equipment"** means any equipment or device designed and intended for use in construction, or material handling, including but not limited to, air compressors, pile drivers, pneumatic or hydraulic tools, bulldozers, tractors, excavators, trenchers, cranes, derricks, loaders, scrapers, pavers, generators, off-highway haulers or trucks, ditchers, compactors and rollers, pumps, concrete mixers, graders, or other material handling equipment;

**"Construction Site"** means the area or portion of land used for construction or any other area used for any purpose related to the construction or for any related purpose;

**"Conveyance"** includes a vehicle and any other device used to transport a person or persons or goods from place to place but does not include any vehicle or device operated only within any premises;

**"Council"** means the Council of the Town of Markham;

**"Highway"** includes a common and public highway, street, avenue, parkway, driveway, square, place, bridge, viaduct or trestle designed and intended for or used by, the general public for the passage of vehicles;

**"Minister"** means the Minister of the Environment;

**"Ministry"** means the Ministry of the Environment;

**"Motor Vehicle"** means any motorized conveyance and includes any automobile, motorcycle and any other vehicle propelled or driven otherwise than by muscular

power, but does not include the cars of electric or steam railways, or other motor vehicle running only upon rails, or a motorized snow vehicle, traction engine, farm tractor, self-propelled implement of husbandry or road building machine within the meaning of the *Highway Traffic Act*, R.S.O. 1990, c.H.8, as amended;

**"Motorized Conveyance"** means a conveyance propelled or driven otherwise than by muscular, gravitational or wind power;

**"Municipality"** means the land within the geographic limit of the Town of Markham;

**"Noise"** means any unwanted sound;

**"Officer"** means a person commissioned or authorized to fill a public situation or to perform any public duty, appointed for the purpose of enforcing bylaws of the municipality, and includes any municipal law enforcement officer appointed by the Town and any police constable who is a member of the York Regional Police Service;

**"Permit"** means any permit issued by Council for an exemption from the terms and conditions of this By-law, and includes any conditions imposed by Council on the holding of such a permit;

**"Person"** includes a corporation, organization, association and partnership;

**"Point of Reception"** means any point on a premises of a person where sound or vibration originating from other than those premises is received;

**"Publication"** means a specified publication of the Noise Pollution Control Section of the Pollution Control Branch of the Ministry of the Environment named in Schedule 4 to this By-Law;

**"Quiet Zone"** means an area of the municipality so designated by the Town of Markham Zoning By-Laws;

**"Residential Area"** means an area of the municipality designated as residential area in the Town of Markham Zoning By-Laws;

**"Residential Renovations"** means construction that does not require any building permits and renovations that are constructed without the operation of heavy equipment;

**"Source"** or **"Source of Sound or Vibration"** means an activity, matter, thing, or tangible personal property or real property, from which sound or vibration is emitted;

**"Sound"** is an oscillation in pressure, stress, particle displacement or particle velocity, in a medium with internal forces (e.g. elastic, viscous), or the superposition of such propagated oscillations, which may cause an auditory sensation;

**"Stationary Source"** means a source of sound, which does not normally move from place to place and includes the premises of a person as one stationary source unless the dominant source on the premises is construction equipment or a conveyance;

**"Town"** means The Corporation of the Town of Markham.

**Technical Terms**

2. In this By-Law all words and definitions that are of technical nature and are related to sound and vibration shall have the meanings specified for them in Schedule 4 - Publication NPC-101.

**Prohibitions**

3. No person shall emit or cause to permit the emission of sound resulting from:

(1) an act listed in Schedule 1 - General Prohibitions, and which sound is clearly audible at a point of reception;

(2) any act listed in Schedule 2 - Prohibitions by Time and Place, if clearly audible at a point of reception;

(3) a stationary source such that the level of resultant sound at a point of reception located in a residential area, or quiet zone exceeds the applicable sound level limit prescribed in Schedule 4, Publication NPC-205.

**Limitations on Sound Levels**

4. No person shall emit or cause or permit the emission of sound resulting from:

(1) any piece of construction equipment of a type referred to in Schedule 4, Publication NPC-115 at a work site, any part of which is located within 600 m of a residential area, unless;

a) the equipment was put into use prior to January 1, 1979; or

b) the equipment bears a label affixed by the manufacturer or distributor, which states:

(i) the year of manufacture; and

(ii) that the equipment complies with the residential sound emission standards set out in Schedule 4 - Publication NPC-115, as applicable to that type of equipment and date of manufacture; or

c) the owner, operator, manufacturer or distributor provides proof that the item of equipment complies with the residential sound emission standard set out in Schedule 4 - Publication NPC-115, as applicable to that type of equipment and date of manufacture.

(2) any piece of construction equipment of a type referred to in Schedule 4 - Publication NPC-115, at a work site, any part of which is located in a Quiet Zone, unless,

(a) the piece of construction equipment bears a label affixed by the manufacturer or distributor, which states:

(i) the year of manufacture; and

(ii) that the equipment complies with the Quiet Zone sound emission standard set out in Schedule 4 - Publication NPC-115, as applicable to that type of equipment and date of manufacture; or,

(3) from any air conditioning device of a type referred to in Schedule 4 - Publication NPC-216 unless the device:

(a) was put into use prior to January 1, 1979; or

(b) bears a label affixed by the manufacturer or distributor, which states:

(i) the year of manufacture; and

(ii) that the device complies with the sound emission standard set out in Schedule 4 - Publication NPC-216 as applicable to that type of device and date of manufacture; or

c) the owner, operator, manufacturer or distributor provides proof that the device complies with the sound emission standard set out in Schedule 4 - Publication NPC-216, as applicable to that type of device and date of manufacture;

(4) any motorized conveyance of a type referred to in Schedule 4 - Publication NPC-118, unless the motorized conveyance complies with the sound emission standard set out in Schedule 4 - Publication NPC-118, as applicable to that type of motorized conveyance and date of manufacture.

**Pre-emption**

5. Where subsections 3(2) or (3) applies to a source of sound, the less restrictive provision shall prevail.

**Permits and Exemptions**

6. Notwithstanding any other provision of this By-law, the provisions and requirements of this By-law shall not apply to any person who emits or causes or permits the emission of sound or vibration:

   (1) in connection with any activities listed in Schedule 3; or

   (2) to impulsive sound or blasting; or

   (3) for which a permit has been issued under the authority of this By-law.

7. Exemptions to this by-law may be granted by making a written request to the Manager, By-law Enforcement and Licencing outlining the particulars of and the reason(s) for the exemption and shall be accompanied by the required exemption request fee.
(Amended by By-law No. 2005-143)

8. The Manager, By-law Enforcement and Licencing is authorized to grant exemptions to the Noise By-law upon review of the request for the Prohibitions listed below, with all other requests to be forwarded to Council, along with a report by the Manager, for Council approval of the exemption.

   (a) Manager Exemptions

| Schedule | Clause | Prohibition | Maximum Exemption |
|---|---|---|---|
| 2 | 1 | The detonation of fireworks | Till midnight |
| 2 | 4 | "The operation of any electronic device or group of connected electronic devices..." | Till midnight |
| 2 | 11 | Yelling, shouting, hooting, whistling or singing | None |
| 2 | 16 | Pouring of cement in connection with construction | Till 11:00 p.m. |

(Amended by By-law No. 2005-143)

9. In deciding to grant an exemption, Council or the Manager, By-law Enforcement and Licencing may include any terms or conditions with the exemption and any breach of the terms and conditions shall immediately render the exemption null and void.
(Amended by By-law No. 2005-143)

10. A report shall be taken to Council, which report shall attach the completed application and a recommendation as to terms and conditions, if any.

11. In deciding whether to grant the exemption, Council shall consider the application, the report of any By-law Enforcement Officer or professional staff and any written submission then received by Council and shall give the applicant and any person interested in the application an opportunity to be heard and may consider such other matters as it sees fit.

12. Where an application is not approved or approved upon terms and conditions or approval to a lesser extent than the exemption applied for, Council shall set out in writing the reasons therefore and shall serve a copy of the decision upon the applicant.

13. The decision of Council to issue a permit, to refuse to issue a permit or to set terms and conditions for holding a permit is final.

14. A breach by the applicant of any of the terms or conditions imposed by Council in granting an exemption shall immediately render the exemption null and void.

**Exemption of Traditional, Festival or Religious Activities**

15. Notwithstanding any other provision of this By-law, this Bylaw does not apply to the any sound or vibration made or caused to be made by any of the traditional, festive, religious and other activities listed herein:

    (1) any Markham Fair activity authorized by Council;
    (2) any Markham Heritage Days activity authorized by Council;
    (3) any Thornhill Village Festival activity authorized by Council;
    (4) any Unionville Village Festival activity authorized by Council;
    (5) any Victoria Day activity authorized by Council; or
    (6) any Canada Day activity authorized by Council.

16. For greater certainty, the exemptions contained in section 12 of this By-law only apply to the organizers and performers associated with the activities listed therein and do not apply to those persons who attend the activities.

**Severability**

17. If a court of competent jurisdiction declares any section or part of this By-law invalid or unenforceable, it is the intention of Council that the remainder of the By-law shall continue to be in force.

**Enforcement and Administration**

18. The Clerk shall administer and enforce this By-Law.

19. Council may appoint such officers as are necessary for the purpose of enforcing this By-law.

20. Such officers as are necessary for the purpose of enforcing this By-law who do not possess a Certificate shall only enforce the portions of this By-law where sound level measurements are not required.

**Penalties**

21. Any person who contravenes any provision of this By-law is guilty of an offence and upon conviction, is liable to the penalty specified by the *Provincial Offences Act*, R.S.O. 1990, c. P.33, as amended.

**Interpretation**

22. Any use of a singular term includes its plural, any use of a masculine term includes the feminine term and any use of the present tense includes the past tense, where applicable, in this By-law.

**Enactment**

23. This By-Law comes into force and effect on the date of its passing and enactment.

24. By-law 218-89, a By-law to Control Noise, is hereby repealed.

**Title**

24. This By-law shall be referred to as the "Noise Control By-Law".

READ A FIRST, SECOND, AND THIRD TIME AND PASSED THIS
27TH DAY OF MAY, 2003.

SHEILA BIRRELL, TOWN CLERK

DON COUSENS, MAYOR

## Schedule 1

## General Prohibitions

1. Racing of any motorized conveyance other than in a racing event regulated by law.

2. The operation of a motor vehicle in such a way that the tires squeal.

3. The operation of any combustion engine without an effective exhaust-muffling device in good working order and in constant operation.

4. The operation of a vehicle or a vehicle with a trailer resulting in banging, clanking, squealing or other like sounds due to improperly secured load or equipment;

5. The operation of an engine or motor in, or on, any motor vehicle or item of attached auxiliary equipment for a continuous period exceeding five minutes, while such vehicle is stationary in a Residential Area or, unless,

   (1) The vehicle is in an enclosed structure constructed so as to effectively prevent excessive noise emission; or,

   (2) The original equipment manufacturer specifically recommends a longer idling period for normal and efficient operation of the motor vehicle in which case such recommended period shall not be exceeded;

   (3) Operation of such engine or motor is essential to a basic function of the vehicle or equipment, including but not limited to, operation of ready mixed concrete trucks, lift platforms or refuse compactors and heat exchange systems; or,

   (4) Weather conditions justify the use of heating or refrigerating systems powered by the motor or engine for the safety and welfare of the operator, passengers or animals, or preservation of perishable cargo; or,

   (5) Prevailing low temperatures make longer idling periods necessary, immediately after starting the motor or engine; or,

   (6) The idling is for the purpose of cleaning and flushing the radiator and associated circulation system for seasonal change or antifreeze, cleaning of the fuel system, carburetor or the like, when such work is performed other than for profit.

6. The operation of a motor vehicle horn or other warning device except where required or authorized by law in accordance with good safety practices.

7. The operation of any item of construction equipment without effective muffling devices in good working order and in constant operation.

## Schedule 2

## PROHIBITIONS BY TIME AND PLACE

| | | Prohibited Period of Time | |
|---|---|---|---|
| | | Quiet Zone | Residential Area |
| 1. | The detonation of fireworks or explosive devices not used in construction. | At all times | At all times |
| 2. | The discharge of firearms. | At all times | At all times |
| 3. | The operation of a combustion engine which,<br>(i) is, or<br>(ii) is used in, or<br>(iii) is intended for use in<br>a toy or a model or replica devise, which model or replica has no function other than amusement and which is not a conveyance. | At all times | At all times |
| 4. | The operation of any electronic device or group of connected electronic devices incorporating one or more loudspeakers or other electro-mechanical transducers, and intended for the production, reproduction or amplification of sound. | At all times | C |
| 5. | The operation of any auditory signaling device, including but not limited to the ringing bells or gongs and the blowing of horns or sirens or whistles, or the production, reproduction or amplification of any similar sounds by electronic means except where required or authorized by law or in accordance with good safety practices. | At all times | D & E |
| 6. | The operation of any powered rail car including but not limited to refrigeration cars, locomotives or self-propelled passenger cars, while stationary on property not owned or controlled by a railway governed by the Canada Railway Act. | At all times | B |
| 7. | The operation of any motorized conveyance other than on a highway or other place intended for its operation.* | At all times | At all times |

***Note:** For the purpose of this Schedule, " motorized conveyance" includes, but is not limited to;

a) Snowmobile;
b) Moped;
c) Go-cart;
d) Track bike;
e) Trail bike

| | | | |
|---|---|---|---|
| 8. | The venting, release or pressure relief of air, steam or other gaseous material, product or compound from any autoclave, boiler pressure vessel, pipe, valve, machine, device or system. | At all times | A |
| 9. | Persistent barking, calling or whining or other similar persistent noise making by any domestic pet or any other animal kept or used for any purpose other than agriculture. | At all times | At all times |
| 10. | The operation of a commercial car wash with air drying equipment. | At all times | D & E |
| 11. | Yelling, shouting, hooting, whistling or singing. | At all times | A |
| 12. | The operation of a power assisted hang glider or parafoil. | At all times | D & E |
| 13. | The operation of any item of snow making equipment. | At all times | E |
| 14. | All selling or advertising by shouting or outcry or amplified sound. | At all times | D & E |
| 15. | Loading, unloading, delivering, packing, unpacking, or otherwise handling any containers, products, materials, or refuse, whatsoever, unless necessary for the maintenance of essential services or the moving of private household effects. | D & E | D & E |
| 16. | The operation of any equipment in connection with construction. | D & E | D & E |
| 17. | The operation or use of any tool for domestic purposes other than snow removal. | C | B |
| 18. | The operation of solid waste bulk lift or refuse compacting equipment. | C | B |
| 19. | The operation of a commercial car wash of a type other than mentioned in item 10. | C | A |
| 20. | The use of wind chimes | E | E |

**Prohibited Periods of Time**

A. 23 00 one day to 07 00 next day (09 00 Sundays)
B. 19 00 one day to 07 00 next day (09 00 Sundays)
C. 17 00 one day to 07 00 next day (09 00 Sundays)
D. All day Sundays and Statutory Holidays
E. 19 00 one day to 07 00 next day.

## Schedule 3

1. Operation of authorized emergency vehicles.

2. Operation of bells utilized as traffic control devices including the following:

   (1) Bells and other devices at traffic signal locations;

   (2) Bells at railway crossings.

3. Operation of Town machines and equipment including the following:

   (1) Crosswalk painting machines;

   (2) Catch basin cleaners;

   (3) Tree and shrub pruning and mulching equipment;

   (4) Town owned or contracted street cleaners and flushers;

   (5) Operation of construction equipment and machinery, including snow removal equipment, by or on behalf of the Town carrying on or engaged in the performance of public works for emergency and safety purposes.

## Schedule 4

### Index of Publications

| | |
|---|---|
| Publication NPC 101 | Technical Definitions |
| Publication NPC 102 | Instrumentation |
| Publication NPC 103 | Procedures |
| Publication NPC 104 | Sound Level Adjustments |
| Publication NPC 115 | Construction Equipment |
| Publication NPC 117 | Domestic Outdoor Power Tools |
| Publication NPC 118 | Motorized Conveyances |
| Publication NPC 119 | Blasting |
| Publication NPC 205 | Stationary Source |
| Publication NPC 206 | Road Traffic |
| Publication NPC 216 | Residential Air Conditioners |

# APPENDIX C: CITY OF PICKERING NOISE BY-LAW

# THE CORPORATION OF THE CITY OF PICKERING

## BY-LAW NO.6834/08

A by-law to prohibit and regulate noise

**WHEREAS** section 129 of the *Municipal Act, 2001* provides that a local municipality may prohibit and regulate noise.

**NOW THEREFORE BE IT RESOLVED THAT** the Council of The Corporation of the City of Pickering enacts as follows:

## PART I - INTERPRETATION

### Definitions

1. In this by-law,

"City" means The Corporation of the City of Pickering or the geographical area of the City, as the context requires;

"City Clerk" means the Clerk of the City or a designate;

"construction" includes erection, alteration, repair, dismantling, demolition, structural maintenance, land clearing, earth moving, grading, excavating, the laying of pipe and conduit whether above or below ground level, street and highway building, application of concrete, equipment installation and alteration and the structural installation of construction components and materials in any form or for any purpose;

"construction equipment" means any equipment, tool or device designed or capable of use in construction or material handling, including pile drivers, bulldozers, tractors, excavators, trenchers, cranes, derricks, loaders, scrapers, pavers, generators, off highway haulers or trucks, ditchers, compactors and rollers, pumps, concrete mixers and graders;

"highway" has the same meaning as in subsection 1(1) of the *Highway Traffic Act* and includes unopened and unassumed road allowances;

"motor vehicle" has the same meaning as in subsection 1(1) of the *Highway Traffic Act* and includes a motorized snow vehicle;

"parks area" means any land owned or operated by the City or the Toronto Region Conservation Authority for park or recreational purposes;

"person" includes a corporation and the heirs, executors, administrators or other legal representatives of a person to whom the context can apply according to law;

"point of reception" means any geographic location at which noise can be heard other than the premises from which the noise originates;

"special event" includes a demonstration, parade, sports event, festival, carnival and other similar events; and

"statutory holiday" means any day designated as a holiday in the *Retail Business Holidays Act.*

**References**

2. In this by-law, reference to any Act or by-law is reference to that Act or by-law as it is amended or re-enacted from time to time.

3. Unless otherwise specified, references in this by-law to sections and Schedules are to sections and Schedules in this by-law.

**Word Usage**

4. This by-law shall be read with all changes in gender or number as the context may require.

5. A grammatical variation of a word or expression defined has a corresponding meaning.

**Schedules**

6. The following Schedules are attached to and form part of this by-law:

Schedule 1 – PROHIBITED ACTIVITIES
Schedule 2 – ACTIVITIES PROHIBITED BY TIME
Schedule 3 – EXEMPTED ACTIVITIES

**Severability**

7. Each section of this by-law is an independent section, and the holding of any section or part of any section of this by-law to be void or ineffective for any reason shall not be deemed to affect the validity of any other section or parts of sections of this by-law.

## PART II – REGULATIONS

### General Prohibitions

8. No person shall cause or permit the emission of any noise resulting from any of the activities listed in Schedule 1 if the noise is audible at a point of reception.

### Restrictions by Time and Place

9. No person shall cause or permit the emission of any noise resulting from any of the activities listed in Schedule 2 during the prohibited period of time listed opposite such activities if the noise is audible at a point of reception.

### General Exemptions

10. This by-law shall not apply to a person who causes or permits the emission of noise in connection with any of the activities listed in Schedule 3.

### Exemption Requests

11. (1) Any person may request an exemption to permit the operation of construction equipment during the period of time prohibited by Schedule 2. All such requests shall be submitted in writing to the City Clerk and shall,

(a) identify and describe in detail the construction activity that the applicant wishes to have exempted;

(b) set out the time(s) and location(s) for which the exemption is being sought;

(c) state the name, address, telephone numbers and facsimile numbers of the applicant;

(d) set out the reasons why an exemption should be granted; and

(e) be signed by the applicant who shall certifying the accuracy and truth of the contents of the application.

(2) The City Clerk may grant or refuse to grant any exemption request, and may impose any conditions as he or she determines to be appropriate.

(3) Where an exemption is granted, breach of any condition of the exemption shall render the exemption null and void.

## PART III – ENFORCEMENT

### Inspections

12. A municipal law enforcement officer appointed by the City to enforce municipal by-laws may, at any reasonable time, enter upon any property for the purpose of carrying out an inspection to determine whether or not the provisions of this by-law have been complied with.

13. No person shall prevent, hinder or interfere or attempt to prevent, hinder or interfere with an inspection undertaken by an officer.

### Offences and Penalties

14. Every person who contravenes any provision of this by-law is guilty of an offence and upon conviction is liable to a fine pursuant to the provisions of the *Provincial Offences Act*.

15. No person shall make a false or intentionally misleading recital of fact, statement or representation in any exemption request.

## PART IV – GENERAL

### Repeal

16. By-law No. 3821 is repealed.

### Short Title

17. This by-law may be cited as the "Noise Control By-law".

### Effective Date

18. This by-law comes into effect on the date of its passing.

BY-LAW read a first, second and third time and finally passed this 19th day of February, 2008.

David Ryan, Mayor

Debi A. Wilcox, City Clerk

## SCHEDULE 1

## TO BY-LAW NO. 6834/08

## PROHIBITED ACTIVITIES

1. Operation of any electronic device or group of connected electronic devices incorporating one or more speakers and intended for the production, reproduction or amplification of sound (including car stereos) at such a volume that it is audible from the interior of a residence or business whose occupant has made every reasonable attempt to mitigate the reception of the noise.

2. Operation of any electronic device or group of connected electronic devices incorporating one or more speakers and intended for the production, reproduction or amplification of sound (including car stereos) in a park area at a volume that a reasonable person would, in all of the circumstances, consider to be excessive, intrusive or disturbing.

3. Persistent yelling, shouting, hooting, whistling or singing at such a volume that it is audible from the interior of a residence or business whose occupant has made every reasonable attempt to mitigate the reception of the noise.

4. Excessive and unnecessary revving of a motor vehicle engine.

5. Operation of a motor vehicle is such a manner that the tires squeal.

6. Operation of a motor vehicle horn or other warning device except where required or authorized by law or in the interest of good safety practices.

7. Operation of a motor vehicle other than on a highway or other place where its operation is permitted by law.

8. Persistent barking, calling, howling, whining or crying at frequent or lengthy intervals by any domestic pet or any other animal kept or used for any purpose other than agriculture.

9. All selling or advertising by shouting or amplified sound.

## SCHEDULE 2

## TO BY-LAW NO. 6834/08

## ACTIVITIES PROHIBITED BY TIME

| | Type of Activity | Prohibited Periods of Time |
|---|---|---|
| 1 | Operation of any electronic device or group of connected electronic devices incorporating one or more speakers or other electro-mechanical transducers, and intended for the production, reproduction or amplification of sound (including car stereos). | 9:00 PM to 7:00 AM |
| 2 | Persistent yelling, shouting, hooting, whistling or singing. | 9:00 PM to 7:00 AM |
| 3 | Operation of construction equipment. | 7:00 PM to 7:00 AM (all day on Sundays & statutory holidays) |
| 4 | Operation of any powered or non-powered tools for domestic purposes or automotive repair including augers, air compressors, and pneumatic or hydraulic tools. | 9:00 PM to 7:00 AM |
| 5 | Operation of a combustion engine that is used in a toy or model or replica. | 9:00 PM to 7:00 AM |
| 6 | Operation of any equipment or machinery used for yard maintenance that is run by electricity or gasoline, including lawn mowers, leaf blowers, chain saws, hedge trimmers, whipper snippers and pressure washers. | 9:00 PM to 7:00 AM |
| 7 | Operation of snow blowers. | 9:00 PM to 6:00 AM |
| 8 | Operation of solid waste bulk lift or refuse compacting equipment. | 10:00 PM to 6:00 AM |

## SCHEDULE 3

## TO BY-LAW NO. 6834/08

## EXEMPTED ACTIVITIES

1. The use in a reasonable manner of an apparatus or mechanism for the amplification of the human voice or of music in a park area or recreational area provided that the permission of the City has been obtained.

2. Any special event provided that the necessary permissions or approvals have been obtained from the City and the Durham Regional Police Service.

3. Any emergency work undertaken for the immediate health, safety or welfare of the inhabitants of the City or for the preservation, protection or restoration of property.

4. Any emergency work being carried out by the City, The Regional Municipality of Durham, any electric utility company, any natural gas utility company, or any telephone utility company.

5. The ringing of school bells or the sounding of a public address system on a property owned by the Durham District School Board, the Durham Catholic District School Board or a recognized private school.

6. The sounding of bells or chimes on a property operated as a church or a place of worship, or on any property owned or operated by the City.

7. Any sound originating from, or caused by, the operation of farm equipment or machinery for cultivating, seeding, crop maintenance or harvesting purposes on any lands designated as an agricultural area.

8. Any fireworks display authorized by the City in accordance with Fireworks By-law No. 6783/07.

9. Necessary municipal operations carried out in the interest of public necessity and convenience, including but not limited to snow clearing, street cleaning and garbage collection, undertaken by or on behalf of the City.

10. Any snow removal which is essential for the effective operation of a business.

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