Yonge Street Subway Extension Project
Train Storage and Maintenance Facility
Environmental Noise and Vibration Assessment

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by McCormick Rankin (MRC), a member of MMM Group, to assess the potential for environment noise and vibration impacts from construction and operation of the proposed Train Storage and Maintenance Facility (TSMF), which is part of the proposed Yonge Street Subway Extension project.

1.1 Project Background

In 2009-2010, the TTC undertook a review of the subway rail yard needs for the Yonge Subway to the year 2030. It was determined that the car fleet would grow from 62 trains to a total of 88 trains. The implication for the Yonge Subway Extension is the need for a train storage facility in the area of Richmond Hill Centre.

1.1.1 Planning Requirements and Design Considerations

Primary maintenance for the Yonge Subway Extension will continue to be at the Wilson Yard located south of Downsview Station. However, overnight train storage will be provided in the area of Richmond Hill Centre Station and within an underground train storage facility where light-duty maintenance and cleaning of the subway vehicles will occur.

Several alternatives were developed for the storage facility, including options which extended under Yonge Street north of the Langstaff Station, under the Commuter Parking Lot within the hydro corridor, and extending easterly within the hydro corridor north of Highway 7. Several alternatives were also developed which extended the subway line north of Richmond Hill Centre Station.

Based on a high-level screening, a preferred alternative has been selected. The study area, including the preferred alternative footprint is shown in **Figure 1**. Detailed drawings showing the preferred alternative are included in **Appendix A**.

1.1.2 Facility Operations

The following operational requirements were compiled following several meetings with TTC Subway Operations:

- The facility will be below grade/enclosed and will be used for overnight storage and light maintenance interior cleaning and repairs, as well as off-peak storage (i.e. trains are not expected to deadhead to any other yards on YUS during off-peaks);
- Maintenance crew will access/egress the underground facility from the Richmond Hill Centre Station Platform or from EEB #8 provided at the north end of the train storage facility;
- Trains entering revenue service will be delivered by maintenance crew to the south end of the Richmond Hill Centre Station platform to be picked up by the operator, and
- The facility will be staffed overnight to perform preventative maintenance diagnostic checks (self-diagnostics) and to provide a permanent presence (overnight security) in the facility.

An assessment of the traction power and electrical requirements for the train storage facility has identified the need for an Electrical Service Building including a high voltage room, communication room, emergency power room, HVAC mechanical room and a switchgear-switchboard room.

An assessment of the ventilation requirements for the Yonge Subway extension including the train storage facility has identified the need for an emergency ventilation fan, a fan room and a ventilation shaft to be located at the north end of the train storage facility.

1.2 Key Features within the Study Area

The proposed subway line and TSMF within the study area will be underground, with two buildings aboveground (EEB8 / Maintenance Operator Facility and the Electrical Service Building). The TSMF will extend approximately 20 m underground, just to the west of the existing CN / GO Richmond Hill rail line. Key features within the study area are shown in **Figure 1**.

2.0 Noise and Vibration Assessment Criteria

The noise and vibration criteria used in this assessment are based on protocols developed by the Ministry of the Environment (MOE) and Toronto Transit Commission (TTC) for previous transit system expansions (MOE/TTC 1993, MOE 1995). Additional criteria for ground-borne noise impacts were developed based on criteria from the U.S. Federal Transit Authority (FTA). Details on the guidelines are provided below.

2.1 Noise from Subway Surface Operations

No surface subway operations are anticipated in the study area. Therefore, surface transportation noise has not been considered.

2.2 Noise from "Stationary" Operations

The TSMF and associated ventilation shafts / HVAC are considered to be "Ancillary Facilities" under the MOE / TTC guidelines. The TSMF will have an HVAC system for station comfort ventilation, and an emergency fire ventilation system to supply air to the stations and tunnel system.

TTC Design Manual DM-0403-00 (TTC 1994) sets out requirements for ancillary equipment in public areas. Noise from "Ancillary Equipment" (excluding emergency ventilation fans) should not exceed 60 dBA at 1 m distance in all public areas.

In addition, MOE Publication NPC-300 (MOE 2013) noise guidelines apply for these facilities. These guidelines state that the 1-hour average sound level from the equipment (L_{eq} (1-hr) values measured in dBA), must meet the following limits at all off-site noise sensitive points of reception:

Table 1: Noise Limits for Ancillary Operations (HVAC, Tunnel Ventilation)

Time Period	Guideline Limit
Daytime (0700-1900h)	50 dBA L_{eq} (1-hr), or existing ambient, whichever is higher
Evening (1900-2300h)	47 dBA L_{eq} (1-hr), or existing ambient, whichever is higher
Night-time (2300-0700h)	45 dBA L_{eq} (1-hr), or existing ambient, whichever is higher

Notes: - Limits for Class 1 Urban area are shown

Noise sensitive points of reception include but are not limited to:

- Permanent and seasonal residences;
- Hotels, motels, campgrounds;
- Noise sensitive institutional uses such as hospitals, daycares, nursing homes, and schools; and
- Places of worship.

The MOE guidelines require that impacts be assessed for the "predictable worst-case operating scenario". The four tunnel ventilation fans are the dominant noise sources, and will be used in one of three modes:

a) Regular Operations

During regular operations of the Train Storage Facility (TSF) system, the fans operate on half (½) speed on a continuous basis during warm days.

b) Emergency Operation

In emergency operation, all fans will operate at full speed. As an emergency, this situation is excluded from the MOE's noise guidelines.

c) Track Maintenance

During overnight track maintenance, the fans will be operated at three-quarter (¾) speed. The fans could run for extended periods of time between 0200 – 0600h.

d) Testing

Full speed testing of the fans occurs on a weekly basis. The fans are operated in both directions (supply and discharge) at full speed for up to 60 seconds for each direction (2 minute total test times).

From the above, the "predictable worst-case scenario" is the track maintenance operations, which occurs for extended periods of time, during the over-night period. Despite the 2-minute long higher sound level during full speed testing, average hourly sound levels will be higher for maintenance operations.

The noise guidelines also provide for procedures and adjustments for addressing noise of an especially annoying character, such as tonal noise, beats, impulsive noise and quasi-steady impulsive noise

(MOE 1977 a,b). Based on the generic sound data provided for the tunnel ventilation fans, sound from the ventilation fans will likely be tonal in nature. In accordance with Publication NPC-104 guidelines, a + 5 dB penalty has been applied in predicting noise impacts from these sources (MOE 1978).

2.3 Vibration from Subway Operations

2.3.1 Residential

Ground-borne vibration from subway operations is addressed under the MOE/ TTC Protocols. Criteria are provided for maximum vibration levels outside of the premises of the receptor (outside of the foundation). Similar to noise, the point of assessment is any outdoor point on the property more than 15 m from the track centreline.

Vibration is measured in terms of root-mean-squared (rms) vibration velocity in units of mm/s. Only vertical axis vibration is included in the assessment. For subway systems, this is the dominant direction of vibration excitation.

The guideline limit for vibration is 0.10 mm/s rms. When vibration levels are predicted to exceed this threshold, then mitigation measures need to be investigated and implemented if they are technically, economically, and administratively feasible.

In terms of human perception, a 0.10 mm/s vibration velocity level is just perceptible for most people.

2.3.2 Vibration-Sensitive Industrial / Commercial Uses

Meeting the vibration perceptibility criteria of 0.10 mm/s discussed above is generally more than adequate for most commercial and industrial uses, which are usually less vibration-sensitive than residential uses (ISO, 1985). However, in situations where vibration-sensitive equipment is in use, such as magnetic resonance imaging (MRI) machines or scanning electron microscopes, stricter limits are required.

For these types of installations, the vibration criteria (VC) curves are widely accepted as a basis for evaluating potential impacts at facilities where vibration-free performance is critical (Gordon 1999).

The limits are provided in terms of rms vibration velocity, in 1/3rd-octave frequency bands. For a site to comply with a particular equipment category, the measured one-third octave band velocity spectrum must lie below the appropriate criterion curve shown in **Figure 2**. Maximum allowed vibration levels and the types of suitable uses are discussed in **Table 2** below.

Table 2: Vibration Criteria for Vibration Sensitive Uses

Criterion Curve (See Figure 1)	Maximum Allowable Vibration Level Above 8 Hz (mm/s., rms)	Description of Use
Workshop (ISO 2613)	0.800	Distinctly perceptible vibration. Appropriate for general industrial uses.
Office (ISO 2613)	0.400	Perceptible vibration. Appropriate for offices and non-sensitive areas.
Residence, Day (ISO 2613)	0.200	Barely perceptible vibration. Appropriate to sleep areas in most instances. Probably adequate for computer equipment, probe test equipment and low-power (to 20X) microscopes.
Operating Theatre/ Limit of Human Perception (ISO 2613)	0.100	**Adopted for Residential Uses (overall vibration) in this Assessment (MOE/TTC)** Vibration is imperceptible. Suitable for sensitive sleep areas. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A	0.051	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	0.025	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	0.013	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	0.006	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	0.003	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.

Notes: - Adopted from Gordon, 1999.
- Levels are measured in 1/3rd-octave bands between 8 Hz and 100 Hz.
- Maximum allowable vibration levels below 8 Hz increase at 2v per doubling of frequency (where v is the allowed rms velocity), unless the equipment incorporates pneumatic isolation. For example, the limit at 4 Hz for VC-A equipment is (2 x 50 at 8 Hz) = 100 mm/s rms,

2.4 Ground-Borne Noise from TSF Operations

Ground-borne noise is created by ground-borne vibration transmitting into a building structure and causing the surface of interior walls and structural member to vibrate, resulting in potentially audible noise. According to the MOE/ TTC protocol, it is unlikely that audible ground-borne noise will result from vibration levels that meet the 0.10 mm/s rms residential vibration criterion. Vibration levels of 0.20 mm/s rms should generate indoor sound levels less than 35 dBA, which is reasonable for sleeping and unlikely to disturb residences (FTA 2006).

2.5 Construction Noise

2.5.1 Provincial Policy

The MOE stipulates limits on noise emissions from individual items of equipment, rather than for overall construction noise. In the presence of persistent noise complaints, sound emission standards for the various types of construction equipment used on the project should be checked to ensure that they meet the specified limits contained in MOE Publication NPC-115 – "Construction Equipment", as follows (MOE, 1977a):

Table 3: NPC-115 Maximum Noise Emission Levels for Typical Construction Equipment

Type of Unit	Maximum Sound Level [1] (dBA)	Distance (m)	Power Rating (kW)
Excavation Equipment [2]	83	15	< 75
	85	15	> 75
Pneumatic Equipment [3]	85	7	-
Portable Compressors	76	7	-

Notes: [1] Maximum permissible sound levels presented here are for equipment manufactured after Jan. 1, 1981.
[2] Excavation equipment includes bulldozers, backhoes, front end loaders, graders, excavators, steam rollers and other equipment capable of being used for similar applications.
[3] Pneumatic equipment includes pavement breakers.

2.5.2 Town of Richmond Hill Noise Bylaw

Chapter 1055 of the Town or Richmond Hill Municipal Code includes provisions for addressing construction noise (Richmond Hill 2008). Section 1055.2.14, Table 3-1 addresses prohibitions by time and place. Table 3-1 indicates that "operation of any equipment in connection with construction" is prohibited "7:00 p.m. one day to 7:00 a.m. next day" and "all day Sundays and statutory holidays."

2.6 Construction Vibration

The Town of Richmond Hill does not have a by-law addressing construction vibration. Although not directly applicable within Richmond Hill, City of Toronto By-law 514-2008 provides limits on maximum allowable vibration levels for construction and demolition activities (Toronto, 2008). City of Toronto vibration limits have conservatively been applied to this study. The vibration limits are shown in the following table:

Table 4: City of Toronto Vibration By-law – Construction Vibration Limits

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

The by-law identifies requirements for:

a) Preliminary studies of vibration impacts;
b) The identification of a "vibration zone of influence", where such a zone will extend beyond the property line / legal boundary of the construction site;
c) The existence within the zone of influence of any buildings that have been designated under the Ontario Heritage Act;
d) Pre-construction consultation with property owners within the zone of influence;
e) Pre-construction measurements of ambient background vibration levels, and site inspections; and,
f) Development of a monitoring plan and continuous measurements of construction vibration during activities which may affect off-site receptors.

The vibration Zone of Influence is identified in the by-law as the area beyond the property line of the construction site where vibration levels may exceed 5 mm/s.

It should be noted that vibration meeting the limits in **Table 4** would be perceptible during the construction activity.

3.0 Assessment Procedures

3.1 Operational Noise Modelling

3.1.1 Surface Operations

No surface subway operations are anticipated in the study area. Therefore, surface transportation noise has not been considered.

3.1.2 "Stationary" Operations

Operational noise impacts from the TSMF and associated ventilation equipment were modelled using Cadna/A, a computerized version of the internationally recognized ISO 9613 environmental noise propagation algorithms. Noise modelling based on ISO 9613 is the preferred approach of the MOE. The modelling method accounts for:

- Distance attenuation;
- Source characteristics and directivity;
- Screening effects of buildings, noise barriers, and topography;
- Atmospheric absorption;
- Ground attenuation; and
- Worst-case meteorological conditions (downwind, under a light temperature inversion).

The ISO 9613 noise model therefore provides a reasonable worst-case assessment of potential noise impacts, in that actual noise impacts at any given point of reception would generally be less than those predicted.

As described in ISO 9613-2, ground factor values that represent the effect of ground absorption on sound levels range between 0 and 1. Based on the specific site conditions, the ground factor values used in the modelling were a ground factor value of 0 for acoustically hard surfaces, such as asphalt and concrete, with absorptive areas (grass, trees, etc.) drawn in as local areas of ground absorption equal to 1. A default temperate of 10 ºC and 70 % relative humidity, typical of average Ontario conditions, were also used.

Sound Emission Data

Base sound emission data and silencer performance for the emergency fire ventilation fans were the same as those used in the 2010 EPR study, for ¾ speed operation, typical of night-time maintenance usage.

Table 5: Generic Sound Power Level for Station Fans (3/4 Speed Operation)

Sound Power Level (dB) in Each 1/1 Octave Band (Hz)								Overall Sound Power	
63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dBA	dBZ
109	107	123	109	108	105	100	98	116.4	123.6

Note: From sub-Appendix D of 2010 Noise Report (2010 EPR Appendix H)

Table 6: Generic Silencer Insertion Losses

Dynamic Silencer Insertion Loss (dB) in Each 1/1 Octave Band (Hz)							
63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
7	19	9	46	54	43	27	18

Note: From sub-Appendix D of 2010 Noise Report (2010 EPR Appendix H)

HVAC noise sources were not modelled using predicted sound level data; instead, maximum allowable sound level emissions were calculated based on the TTC maximum allowable sound level of 60 dBA at 1m in public areas (refer to **Section 2.2**).

3.2 Operational Vibration Modelling

Vibration from subway operations were modelled using a numerical implementation of the U.S. Federal Transit Authority (FTA) environmental vibration model (FTA 2006). The model accounts for a number of factors including:

- Vehicle type and speed;
- Track type and condition;
- Presence of special track work such as double-ended pocket tracks or crossovers;
- Track bed vibration mitigation treatments such as floating slabs, ballast mats, or resilient fasteners / ties; and
- Distance from the track and the nature of the propagation path.

The vibration impact assessment assumes the track will be constructed using current TTC track bed and “double tie” designs, which reduce ground-borne noise and vibration. In accordance with the

MOE/TTC guidelines, the assessment also assumes the vehicles are in good operating condition, with minimal wheel flats, operating on well-maintained rail, with minimal rail corrugation.

Operational vibration impacts were estimated assuming no coupling losses related to transmission from ground to building. In practice, vibration levels inside a residence are lower than those measured outside the building at grade due to attenuation from the foundation. However, MOE/TTC guidelines require vibration criteria to be met outside the residence, at grade. Coupling losses for a standard wood-framed house have the potential to lead to vibration impacts approximately 2 times lower than those outside of the structure.

3.3 Construction Noise Modelling

Similar to operational noise impacts from the site ventilation equipment, noise impacts from construction activity were modelled using a software implementation of the internationally recognized ISO 9613 environmental noise propagation algorithms. The potential impacts from the generic types of equipment anticipated to be in use were predicted.

3.4 Construction Vibration Modelling

Vibration impacts from surface construction equipment were predicted based on levels for generic types of construction equipment measured at various distances from the source, published in the literature (Wiss 1981, FTA 2006). This was used to identify a “zone of influence” per City of Toronto Noise Bylaw requirements.

4.0 Noise and Vibration Predictions

4.1 Operational Noise

4.1.1 Surface Operations

No surface subway operations are anticipated in the study area. Therefore, surface transportation noise has not been considered.

4.1.2 “Stationary” Operations

Stationary noise sources have been assessed cumulatively. Cumulative noise impacts include ventilation noise and noise from HVAC in the mechanical rooms of the electrical and access buildings.

The number, size and location of required HVAC equipment at the MSF is unknown at this time. However, the HVAC is expected to be vented to a public area. As part of the detailed design, the equipment should be selected such that the noise level of the equipment at 1 m from the vent does not exceed 60 dBA.

The locations of the closest noise sensitive receptors and predicted off-site noise levels are shown in **Figure 3**. Compliance at worst case receptors are highlighted in **Table 7**.

Table 7: "Stationary" Noise Impacts – Predicted Sound Levels

Receptor	Predicted Sound Level	Applicable Guideline Limit	Meets Guideline
Residential House to the West	45	45	Yes
Residential House to the Southwest	39	45	Yes
Residential House to the East	37	45	Yes
Residential House to the Southeast	32	45	Yes

As shown in the above table, excesses over the guideline limits are not expected in any noise sensitive areas. Therefore, mitigation investigation is not required.

4.2 Operational Vibration

Ground-borne vibration will be generated by underground operations of the subway travelling through the TSMF. In assessing the potential for impacts, conservative worst-case speeds of 60 km/h have been assumed. Actual speeds are anticipated to be much lower. The distances required to meet the criteria are provided in **Table 8** below.

Table 8: Distance From Track Centreline to Meet Vibration Criteria

Criteria (from Table 3)	Vibration Limit (mm/s rms)	Distance From Track Centreline to Meet Guideline Limit (m)
		Normal Track
Residential	0.10	12

Throughout the study area, the track is planned to be approximately 20 m underground. As shown in **Table 8**, with the conservative assumption of trains travelling of 60 kph through the TSMF, the guideline limit is not expected to be exceeded at any of the sensitive receptors. Therefore, mitigation investigation is not required.

4.3 Construction Noise

Cut-and-cover and open construction will be required for the construction of the TSMF. Construction activity may include:

- Installation of secant or soldier piling, to hold up the sides of excavations;
- Removal of overburden, excavation of foundations and excavation for vent shafts and stairway shafts;
- Front end loaders and trucks for removal of material from the site;
- Concrete trucks and pumps for foundation and building construction; and
- Backfilling, finishing, repaving, and landscaping.

Construction noise levels will vary over time as the activities at the site change. Worst-case sound levels from construction activity, at the closest noise-sensitive receptors, will range from:

- 75 dBA to 104 dBA, for removal of original surface material (including a +10 dB annoyance penalty applied to the hoe ram / mounted impact hammer).
- 73 dBA to 96 dBA, for pile driving.
- 74 dBA to 85 dBA, for general excavation and removal of material.

These worst-case impacts are expected to occur immediately to the west of the cut-and-cover construction.

Noise sensitive areas to the east, across the CN / GO Richmond Hill rail line can expect worst-case sound levels at least 17 dB lower than those outlined above.

In order to minimize the potential for construction noise complaints, a Construction Code of Practice, as outlined in **Section 5.3**, should be followed.

4.4 Construction Vibration

The City of Toronto vibration by-law defines the construction vibration zone of influence as the area where vibration from construction activity is likely to exceed 5 mm/s ppv. **Table 9** provides the typical setback distances associated with the 5 mm/s threshold, for various types of construction activity.

Table 9: Construction Activity Zone of Influence By Activity

Construction Activity	Source Vibration Level at 7.5 m (25 ft) (mm/s, ppv)	Zone of Influence Offset Distance (m)
Pile Driver (impact)	38.6	30
Pile Driver (sonic)	18.6	18
Vibratory Roller	5.3	8
Hoe Ram	2.3	4
Large bulldozer	2.3	4
Caisson drilling / Secant Piling	2.3	4
Loaded trucks	1.9	4
Jackhammer	0.9	2
Small bulldozer	0.1	0
2.4 m dia tunneling machine in soil	1.0	3

Notes: - Zone of influence is the distance required to meet 5 mm/s ppv vibration level from typical construction activity.

Figure 4 shows the areas of influence for impact pile driving (30 m) and general construction activity (8 m).

- Vibration from pile driving and other general construction activities at the Station could affect buildings on Coburg Crescent.

Under the terms of the City Vibration By-law, pre-construction consultation, vibration monitoring, and site inspections would likely be required, and monitoring will be required during construction. Although not required within the Town of Richmond Hill, construction vibration monitoring is recommended.

5.0 Conclusions

5.1 Operational Noise

5.1.1 Surface Operations

No surface subway operations are anticipated in the study area. Therefore, surface transportation noise has not been considered.

5.1.2 "Stationary" Operations

Based on the generic sound power emission data and silencer insertion loss data used in this assessment (Section 3.1.2), the emergency fire ventilation fans are expected to meet the applicable MOE NPC-300 guideline limits at all noise sensitive locations.

Based on the TTC requirement for all ancillary equipment to meet 60 dBA at 1 m in all public spaces, no adverse impacts are expected from the HVAC equipment to be located at the surface electrical service building.

Should noise emissions or operations vary significantly from those outlined above, noise impacts should be reassessed to assure compliance with all relevant legislative requirements.

5.2 Operational Vibration

Vibration levels due to operations are expected to be below the MOE/TTC guideline limit of 0.10 mm/s rms at all locations. Therefore, no adverse vibration impacts from normal operations are anticipated.

5.3 Construction Noise

Construction noise impacts are temporary in nature, and generally unavoidable. Although for some periods and types of work construction noise will be noticeable, with adequate controls impacts can be minimized. This section of the report provides an evaluation of noise impacts from construction, and recommends a Code of Practice to minimize impacts.

To minimize the potential for construction noise impacts, it is recommended that provisions be written into the contract documentation for the contractor, as outlined below:

- Construction should be limited to the time periods allowed by the locally applicable by-laws (no operations between 1900h-0700h, on Sundays, or on Statutory Holidays, except in the case

of emergencies). If construction activities are required outside of these hours, the Contractor must seek permits / exemptions directly from the Town of Richmond Hill in advance.

- There should be explicit indication that Contractors are 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 done by Contractors.
- All equipment should be properly maintained to limit noise emissions. As such, all construction equipment should be operated with effective muffling devices that are in good working order.
- The Contract documents should contain a provision that any initial noise complaint will trigger verification that the general noise control measures agreed to, are in effect.
- In the presence of persistent noise complaints, all construction equipment should be verified to comply with MOE NPC-115 guidelines, as outlined in **Section 2.5.1**.
- In the presence of persistent complaints and subject to the results of a field investigation, alternative noise control measured may be required, where reasonably available. In selecting appropriate noise control and mitigation measures, consideration should be given to the technical, administrative and economic feasibility of the various alternatives.
- Any blasting works should be designed to meet any applicable overpressure and vibration limits established by the MOE in Publication NPC-119 and by the MTO in OPSS 120.
- Since the sound levels from the construction activity are anticipated to be quite high during some periods, and the site is located adjacent to public space, construction hoarding/temporary fences are recommended where feasible.

5.4 Construction Vibration

Under the terms of the City of Toronto Vibration By-law, pre-construction consultation, vibration monitoring, and site inspections would likely be required, and monitoring would be required during construction. Although not required within the Town of Richmond Hill, construction vibration monitoring is recommended.

Zones of influence for construction activities (the area where vibration levels may exceed 5 mm/s ppv) are shown in the construction vibration sections of this report. Care should be taken where structures are located within the zone of influence.

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Figures

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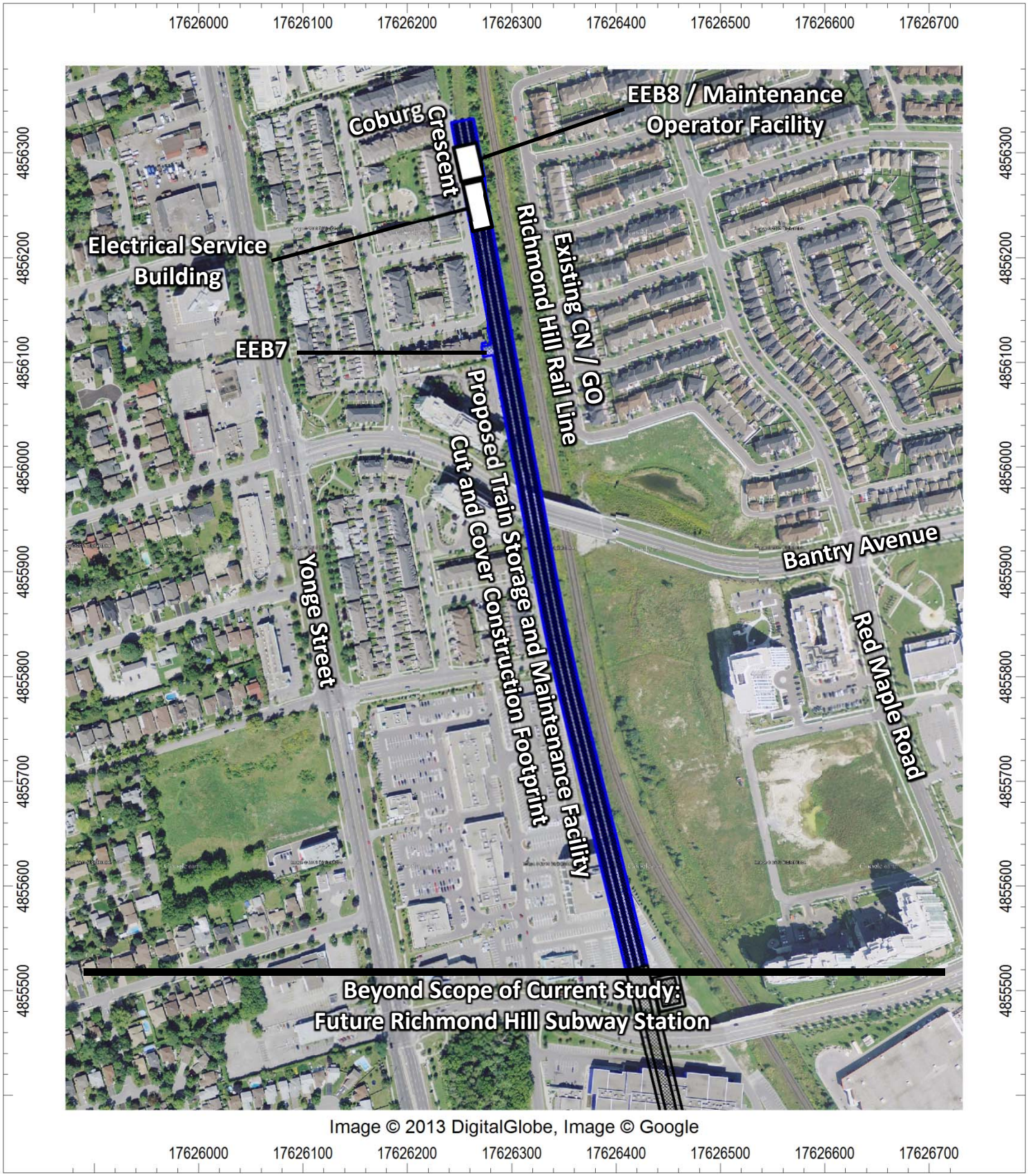

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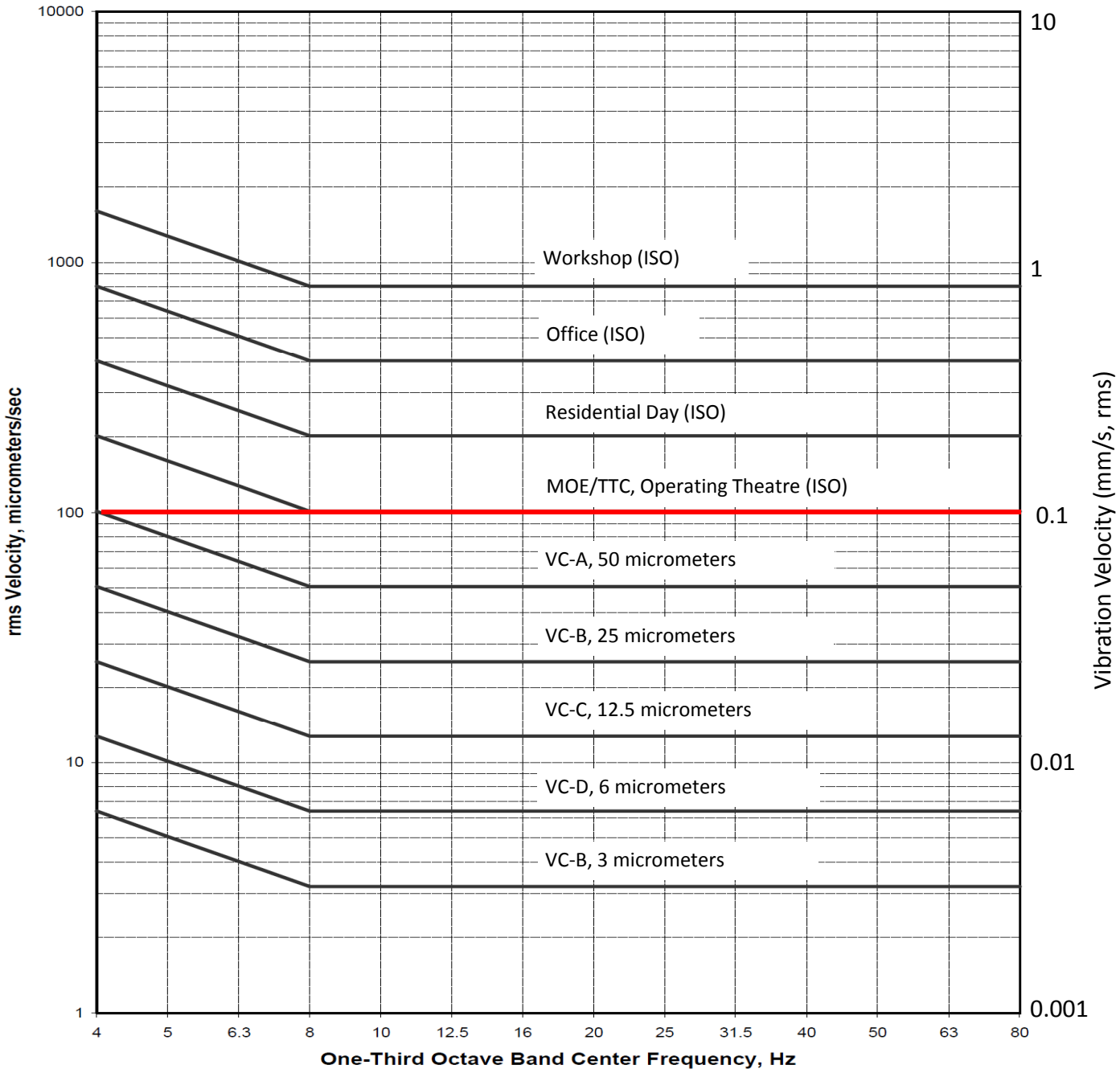
Study Area Showing Key Features and Surrounding Area		Date: 13/05/30	
		File No.: 12-0111	
Yonge Street Subway Extension Project **Train Storage and Maintenance Facility**		Drawn By: KAC	



Notes:

- Residential criterion adopted for this assessment is MOE / TTC Protocol value of 0.100 mm/s rms for overall vibration (all frequencies combined). Assuming impacts mainly occur in a narrow frequency range above 8 Hz (as is typical), then the overall limit would be equivalent to the 1/3rd-octave band frequency limit shown in the chart.
- General office space and industrial workshop spaces can tolerate greater vibration levels than residential spaces (ISO 2631).
- Specific vibration-sensitive industrial or commercial uses may require stricter limits, depending in the nature of the operation. The Vibration Criteria (VC) curves shown provide generic criteria for a number of vibration sensitive uses (see text).

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Generic Vibration Criterion (VC) Curves for Vibration-Sensitive Equipment		Date: 13/05/30	
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Yonge Street Subway Extension Project Train Storage and Maintenance Facility		Drawn By: KAC	

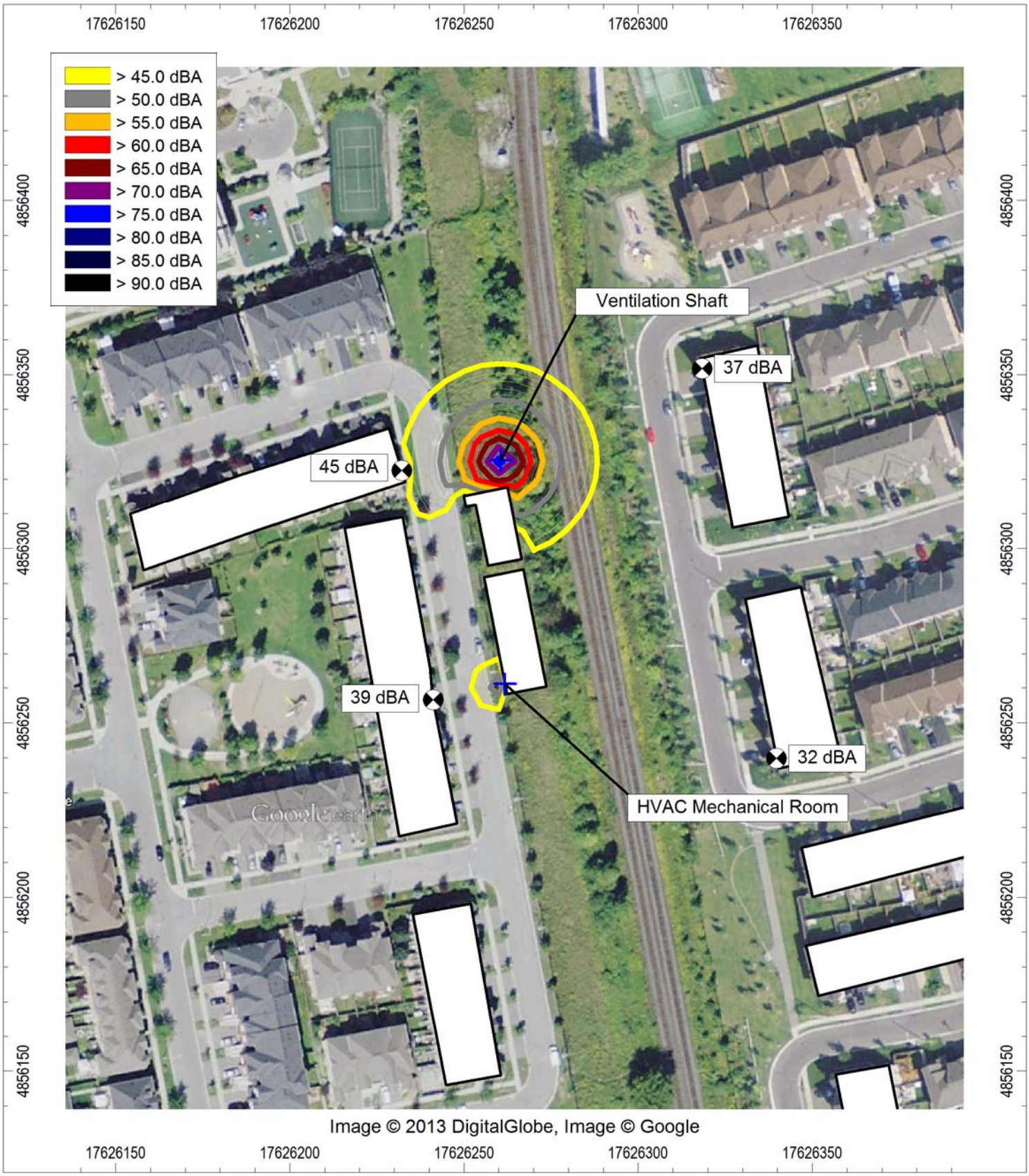

Figure No. **3**	True North	Scale: 1: 1,500	novus ENVIRONMENTAL 150 Research Lane, Suite 105 Guelph, ON, Canada, N1G 4T2 t. 226.706.8080 f.226.706.8081 www.novusenv.com
Predicted "Stationary Source" Off-site Noise Levels Assumes HVAC meets TTC Requirement of 60 dBA at 1m		Date: 13/05/30	
		File No.: 12-0111	
Yonge Street Subway Extension Project **Train Storage and Maintenance Facility**		Drawn By: KAC	

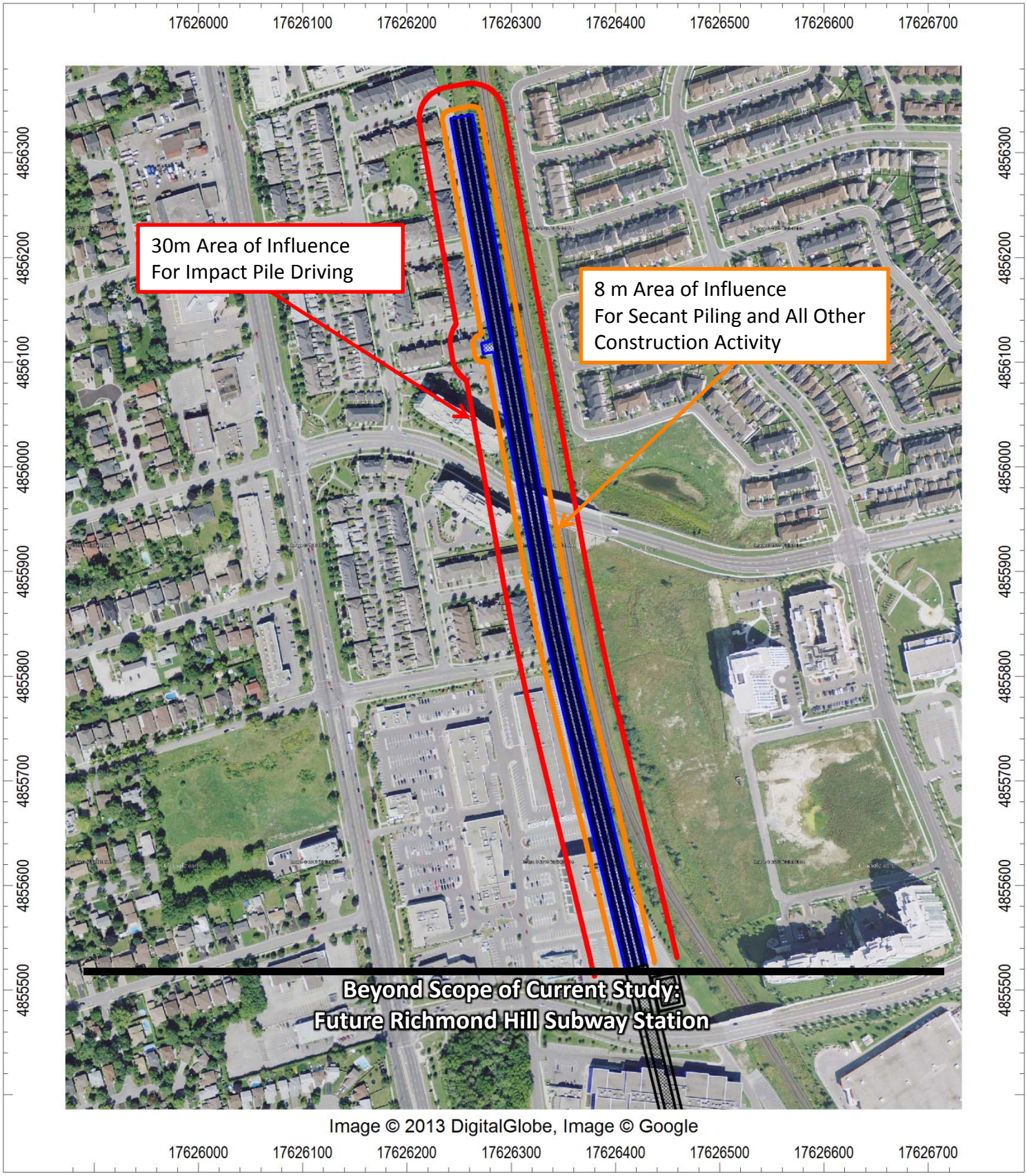

Figure No. **4**	True North	Scale: 1: 5,000	novus ENVIRONMENTAL 150 Research Lane, Suite 105 Guelph, ON, Canada, N1G 4T2 t. 226.706.8080 f.226.706.8081 www.novusenv.com
Construction Vibration Zone of Influence		Date: 13/05/30	
		File No.: 12-0111	
Yonge Street Subway Extension Project **Train Storage and Maintenance Facility**		Drawn By: KAC	

Appendix A

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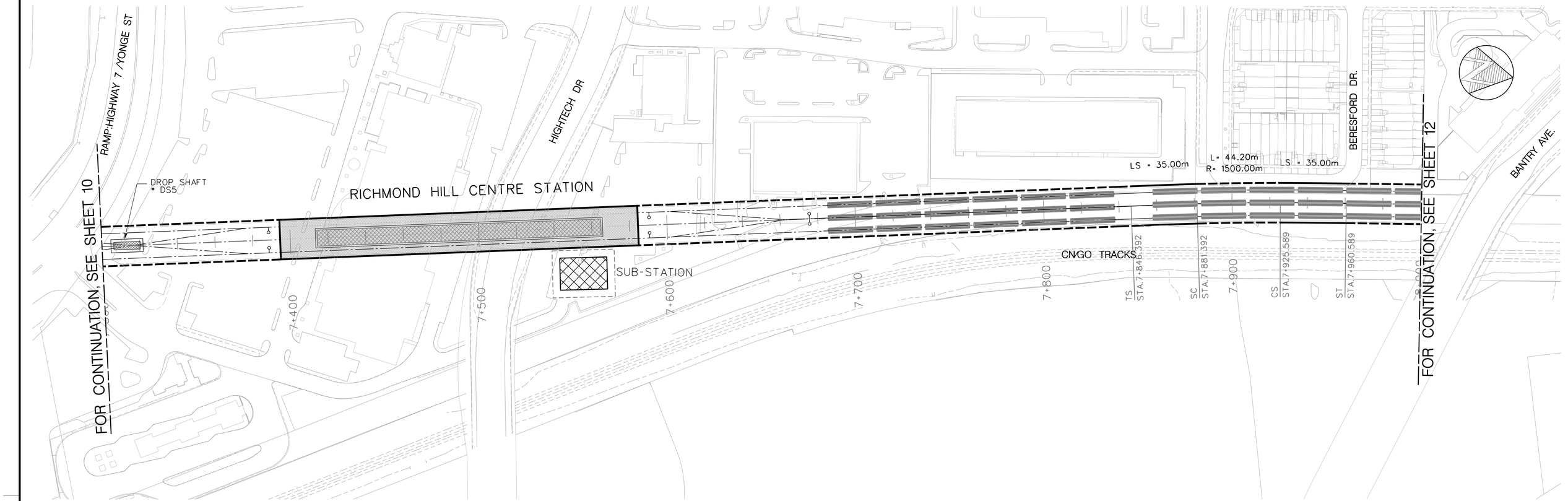
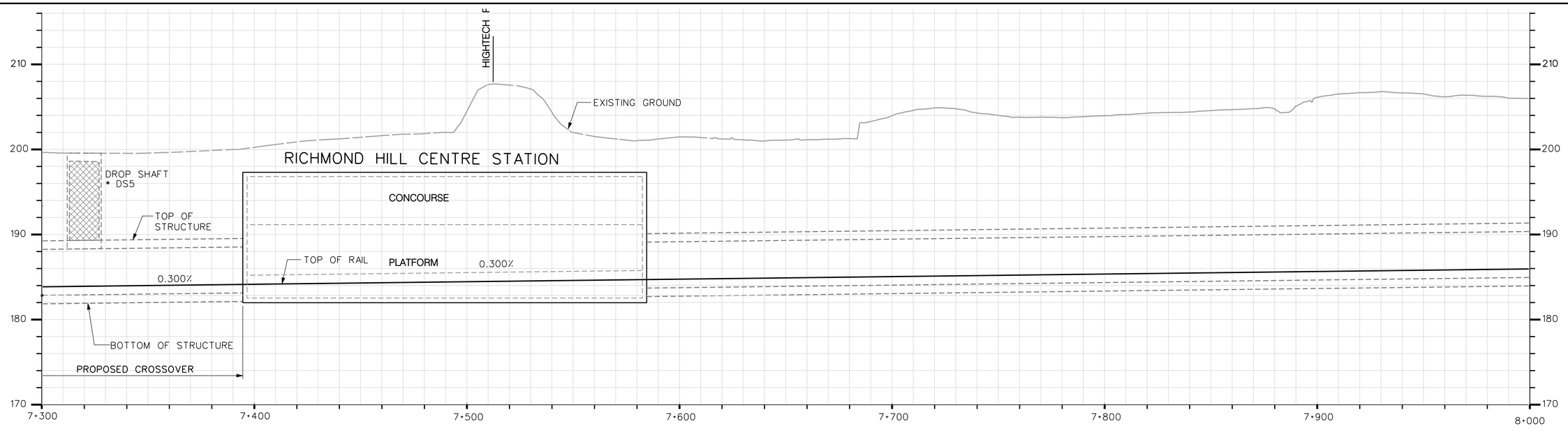




BLDG. REF. No.
FILE
SHEET No.
DRAWING No.

REVISIONS	REVISIONS

CONCEPTUAL DESIGN
NOT FOR CONSTRUCTION

Hatch Mott MacDonald
McCORMICK RANKIN CORPORATION
A member of MMM GROUP

DRAWN
CHECKED
CORRECT

SCALE 0 10 20 30 40m HORIZONTAL
0 5 10m VERTICAL

YONGE SUBWAY EXTENSION

TRACKWORK ALIGNMENT

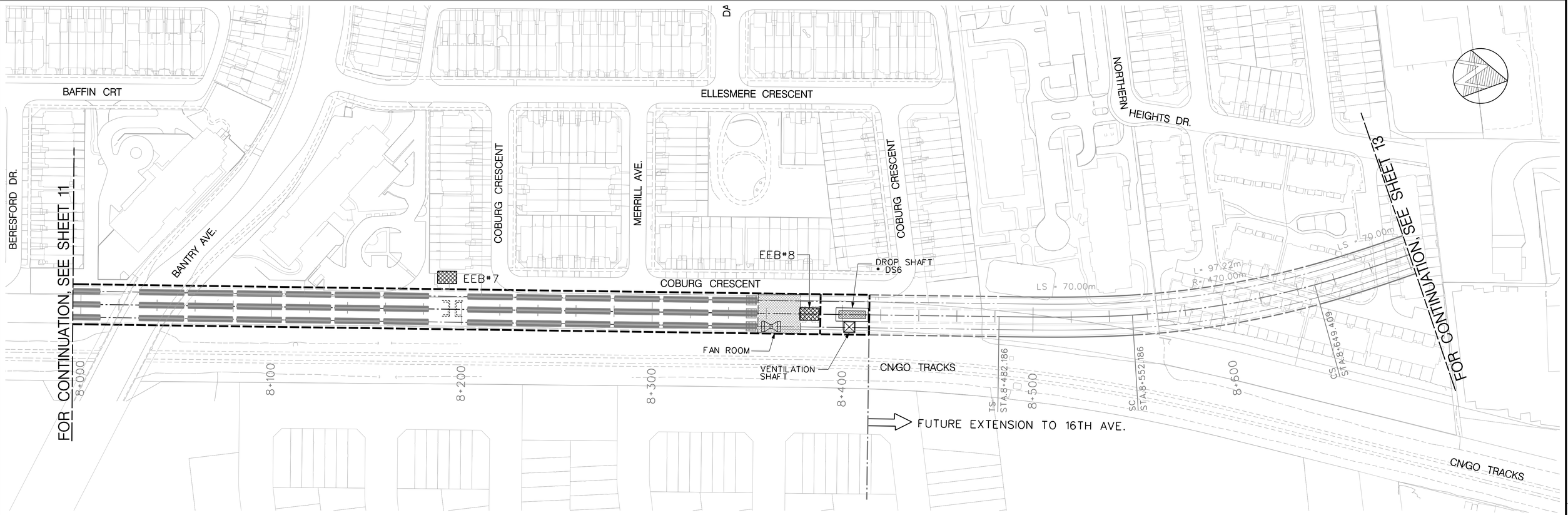
PLAN AND PROFILE
STA. 7+300 TO STA. 8+000

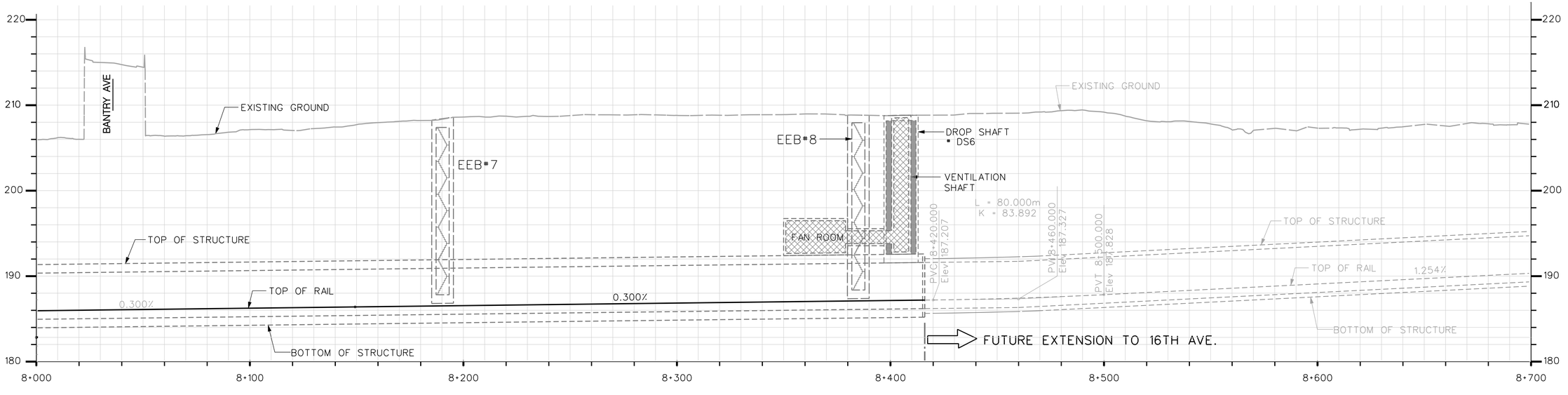
Plot Date: 11-08-22

TORONTO TRANSIT COMMISSION
ENGINEERING DEPARTMENT

Dwg. No. SHEET 11

Sheet No.





BLDG. REF. No. FILE SHEET No. DRAWING No.

REVISIONS	REVISIONS

CONCEPTUAL DESIGN
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McCORMICK RANKIN CORPORATION
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DRAWN
CHECKED
CORRECT
SCALE 0 10 20 30 40m HORIZONTAL
0 5 10m VERTICAL

YONGE SUBWAY EXTENSION

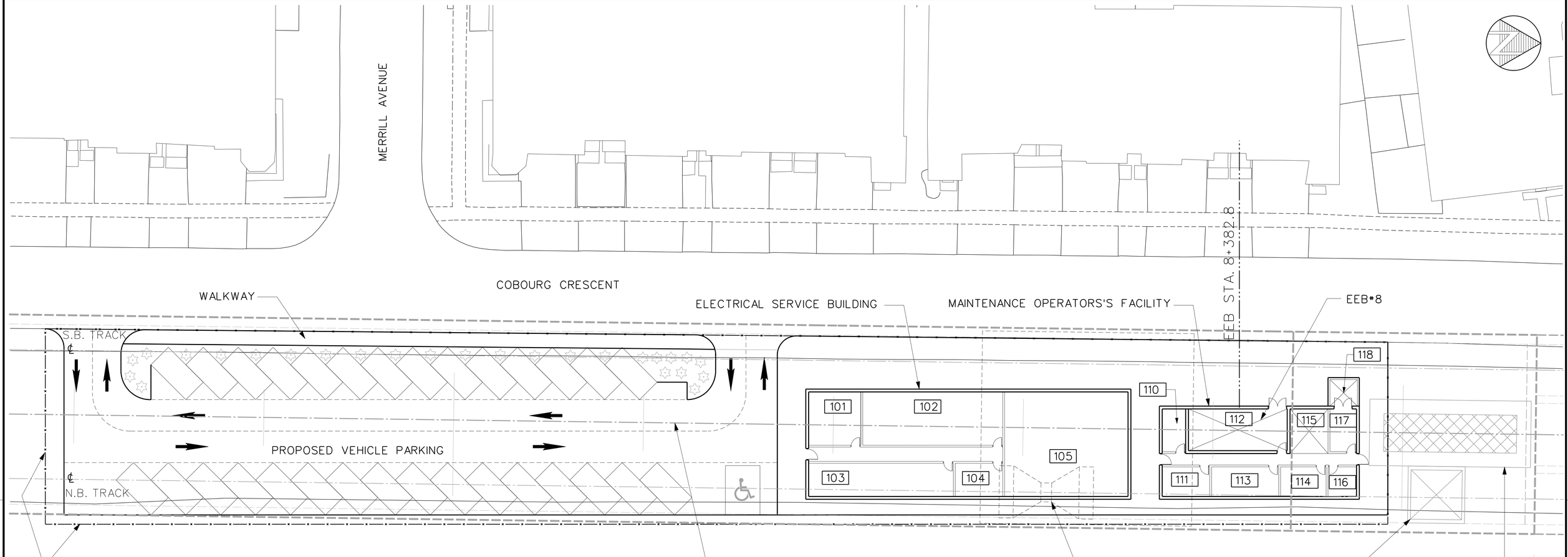
TRACKWORK ALIGNMENT

PLAN AND PROFILE
STA. 8+000 TO STA. 8+700

Plot Date: 11-08-22

TORONTO TRANSIT COMMISSION
ENGINEERING DEPARTMENT

Dwg. No. SHEET 12
Sheet No.



ROOM LEGEND - ELECTRICAL SERVICE BUILDING

RM. No.	ROOM NAME	APPROX. RM. AREA
101	HVAC MECHANICAL ROOM	30
102	HIGH VOLTAGE ROOM	70
103	COMMUNICATION ROOM	50
104	EMERGENCY POWER ROOM	15
105	SWITCHGEAR – SWITCHBOARD ROOM	140

ROOM LEGEND - MAINTENANCE OPERATORS'S FACILITY

RM. No.	ROOM NAME	APPROX. RM. AREA
110	OFFICE	10
111	LUNCH ROOM	15
112	EMERGENCY EXIT STAIR WELL	
113	MEN`S CHANGE ROOM – WASHROOM	20
114	WOMEN`S CHANGE ROOM – WASHROOM	15
115	ELEVATOR	
116	JANITOR CLOSET	5
117	GARBAGE STORAGE	10
118	GARBAGE PICKUP AREA	

BLDG. REF. No.
FILE
SHEET No.
DRAWING No.

REVISIONS	REVISIONS
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SCALE 0 1 2 3 4 5 8m

YONGE SUBWAY EXTENSION

RICHMOND HILL CENTER STATION TO 16TH AVENUE STATION

ELECTRICAL SERVICE BUILDING & MAINTENANCE OPERATORS'S FACILITY – SITE PLAN

Plot Date: 11-08-23

TORONTO TRANSIT COMMISSION
ENGINEERING DEPARTMENT

Dwg. No. SK-043

Sheet No.

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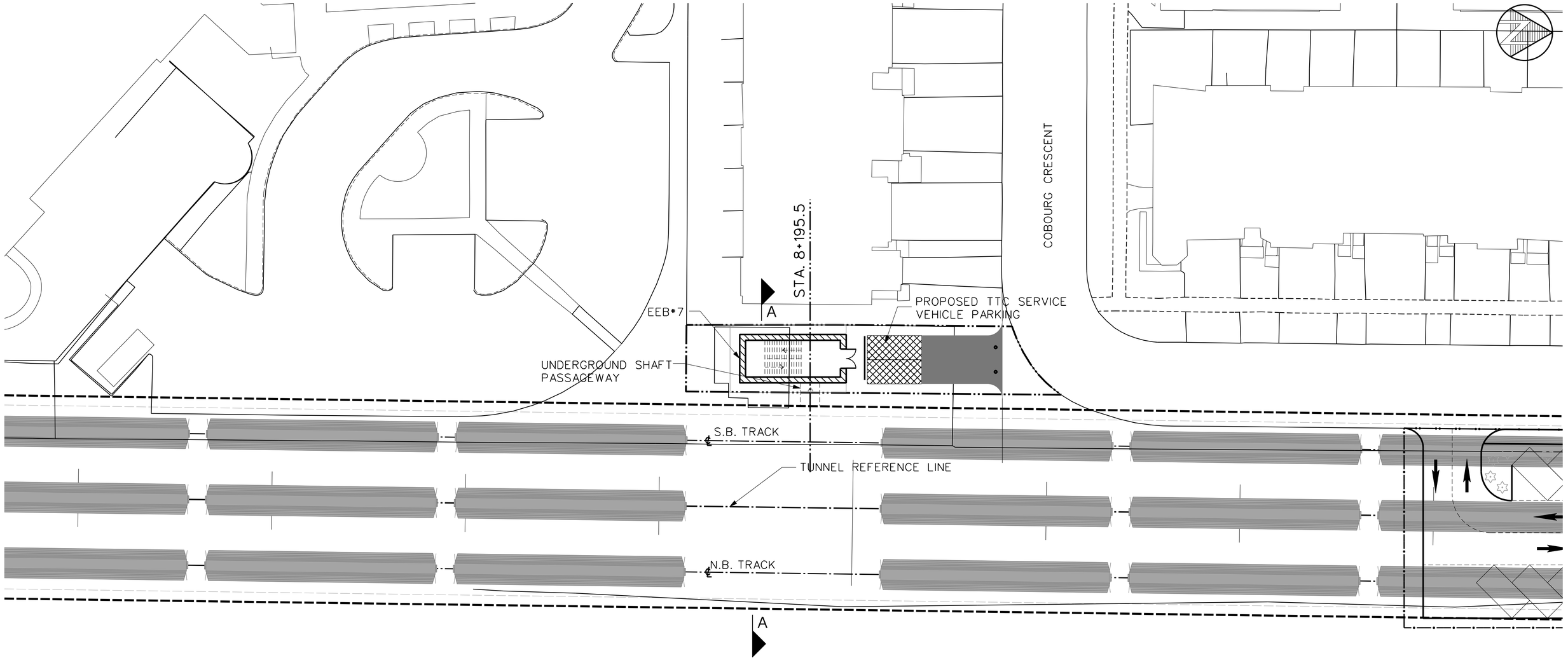

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DRAWING No.

REVISIONS	REVISIONS

CONCEPTUAL DESIGN
NOT FOR CONSTRUCTION

Hatch Mott MacDonald

McCORMICK RANKIN CORPORATION
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SCALE 0 1 2 3 4 5 8m

YONGE SUBWAY EXTENSION

RICHMOND HILL CENTER STATION TO 16TH AVENUE STATION
EMERGENCY EXIT BUILDING NO. 7
SITE PLAN

Plot Date: 11-08-23

TORONTO TRANSIT COMMISSION
ENGINEERING DEPARTMENT

Dwg. No. SK-073

Sheet No.