

Region of Waterloo
Stage 1 Light Rail Transit Project

Performance Output Specifications
Article 4
System Environmental Design Criteria

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ARTICLE 4 SYSTEM ENVIRONMENTAL DESIGN CRITERIA

4.1 Introduction

- (a) This Article addresses the System environment in which all elements of the LRT shall function.
- (b) The System shall be capable of being operated, stored, and maintained as specified without impairment within the parameters of the environmental conditions, specified herein, occurring either individually or in natural combinations. System operations and maintenance shall not cause environmental consequences in excess of the levels specified herein.

4.2 Cited References

- (a) Occupational Health and Safety Act, Ontario Regulation 278/05 as amended (last amendment O.Reg. 479/10) – Designated Substance – Asbestos on Construction Projects and in Buildings Repair Operations
- (b) Occupational Health and Safety Act, Ontario Regulation 490/09 as amended (last amendment O.Reg. 148/12) – Designated Substances
- (c) Environmental Protection Act, R.S.O. 1990, c. E.19
- (d) R.R.O. 1990 Regulation 347 as amended (last amendment O.Reg. 283/12) - General Waste Management
- (e) Ontario Regulation 153/04 as amended (last amendment O.Reg. 269/11) – Record of Site Condition
- (f) R.R.O. 1990 Regulation 903 as amended (last amendment O.Reg 468/10) – Wells
- (g) Ontario Regulation 419/05 as amended Air Pollution — Local Air Quality
- (h) Ontario Regulation 255/11 as amended Applications for Environmental Compliance Approvals
- (i) Region of Waterloo Sewer Use By-law (1990) By-law 1-90, Amended by By-law 92-050
- (j) Region of Waterloo Request for Waste Disposal Approval – Standard Operating Procedure – as amended (latest revision February 27, 2013)

4.3 Environmental Assessment Act Compliance

- (a) This project is subject to compliance with the Ontario Environmental Assessment Act, O.Reg. 231/08 as it relates to Transit Projects and the Canadian Environmental Assessment Act.
- (b) The Environmental Project Report (EPR) Revision 5 dated March 8, 2012 is the latest version of the document and Project Co. shall be responsible for compliance with document as a whole and as it relates to this article, the environmental mitigation measures indicated therein.
- (c) Any deviations from the mitigation measures or preferred alternatives identified in the EPR shall be subject to review by the Region and the Ministry of the Environment Environmental Assessment and Approvals Branch to determine if this constitutes a material change that could require an addendum or additional public consultation. Project Co. shall maintain a log of all changes that may relate to the EPR and confirmation of compliance/non-compliance of each change including mitigating measures proposed.

- (d) Any material deviations requested by Project Co. that require any Environmental Assessment reviews or public consultation shall be completed at the cost of Project Co. and shall not result in a project schedule delay.

4.4 Temperature and Humidity

- (a) The System shall be designed to operate in all natural combinations of an ambient temperature range of minus 30 degrees Celsius (-30°C) to plus 44 degrees Celsius (44°C), and relative humidity conditions from 0 to 100%, including periods of condensation.

4.5 Electromagnetic Compatibility

- (a) The System shall be electromagnetically compatible with its environment. The System shall not produce electromagnetic emissions, whether conducted, radiated, or induced, that in any way interfere with the normal operation of electromagnetic devices or any equipment items used in or around the Project.
- (b) Conversely, all System electrical and electronic equipment shall function satisfactorily in the presence of electromagnetic emissions, whether generated by other components within the System or by devices within the surrounding environment. The surrounding environment may include: communications systems, radio base stations, radar systems, computer equipment and accessories, magnetometers, electric motors, controls, power tools, welders, x-ray equipment, power substations and equipment, and automotive vehicles.
- (c) Prior to the issuance of the Final Completion Certificate, should the System, when installed and operating, create electromagnetic emissions that adversely affect other equipment or be adversely affected by the surrounding electromagnetic environment, the Project Co. shall investigate the problem and successfully complete remedial measures that remove the adverse effect(s). The Project Co. shall continue monitoring emissions during the operations and maintenance period to ensure adverse effects do not recur.
- (d) The Project Co. shall develop an Electromagnetic Compatibility Control Plan in compliance with American Public Transit Association document APTA SS-E-010-98, “Electromagnetic Compatibility Standard” The Project Co. shall submit this plan in accordance with the Contract Deliverables Requirements List (CDRL).
- (e) All System transmitting and receiving equipment and Automatic Train Control (ATC) shall meet the licensing requirements of Industry Canada, or other applicable parts (e.g., the field intensity for unlicensed equipment containing oscillators or other continuous wave sources, given in RSS-210). Requirements of licensing through Industry Canada for a radio spectrum band license should be procured as required to operate the ATC

4.6 Noise

- (a) Definitions
 - (i) Daytime Equivalent Sound Level Leq, 16h is the daytime equivalent sound level.
 - (ii) Night time Equivalent Sound Level Leq, 8h is the night time equivalent sound level.
 - (iii) Point of Reception is any point on residential property, 15 meters or more from the nearest track’s centerline where sound originating from the line is received.
 - (iv) Passby Sound Level is the a weighted equivalent sound level over the time interval of the vehicle takes to pass by.

- (b) Regulatory Requirements and Guidelines
- (i) The Ministry of Environment and the Toronto Transit Commission MOEE/TTC Draft Protocol for Noise and Vibration Assessment for the Proposed Scarborough Rapid Transit Extension, May 11, 1993
 - (ii) MOEE/TTC Protocol for Noise and Vibration Assessment for the Proposed Waterfront West Light Rail Transit Line, November 11, 1993.
 - (iii) 1981 APTA (American Public Transit Association) “Guidelines for Design of Rapid Transit Facilities” (June 1981)
 - (iv) 1995 FTA (Federal Transit Administration) “Transit Noise and Vibration Assessment” (April 1995 and May 2006).
 - (v) Ministry of Transportation of Ontario Protocol for dealing with noise concerns during the preparation, review and evaluation of Provincial Highways Environmental Assessments
 - (vi) MOE Model Municipal Noise Control By-Law
 - (vii) Ontario Environmental Protection Act, R.S.O. 1990, c. E.19
 - (viii) Environmental Guide for Noise, Ministry of Transportation of Ontario, October 2006
 - (ix) Noise and Vibration Impact Assessment – Region of Waterloo, J.E. Coulter Associates January 9, 2012
 - (x) Region of Waterloo Implementation Guideline for Noise policies – Part B - Existing Development Impacted by Proposed Regional Road Undertakings
 - (xi) Ontario Regulation 419/05: Air Pollution – Local Air Quality
 - (xii) Noise Bylaws:
 - A. City of Waterloo Noise Bylaw 2010-073
 - B. City of Kitchener General Noise Bylaw Chapter 450
 - C. City of Cambridge “Prohibiting and Regulating Noise” Bylaw 32-04
 - (xiii) Ministry of Environment Guidelines:
 - A. NPC-101 -Technical Definitions
 - B. NPC-102 -Instrumentation
 - C. NPC-103 -Procedures
 - D. NPC-104 -Sound Level Adjustments
 - E. NPC-206 -Sound Levels due to Road Traffic
 - F. NPC-232 -Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)
 - G. NPC-233 -Information to be Submitted for Approval of Stationary Sources of Sound
 - H. ORNAMENT, Ontario Road Noise Analysis Method for Environment and Transportation

- I. NPC-205 -Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban)
- (c) Noise Prediction
 - (i) Road traffic sound levels have been predicted using the technique developed by the U.S. Federal Highway Administration (FHWA) enhanced by the Ministry of Transportation and the Ministry of the Environment.
 - (ii) The MOE ORNAMENT model is used for prediction of road and traffic noise and includes empirical data for several vehicle classifications; automobile, medium trucks (including city buses) and heavy trucks.
 - (iii) The STAMSON program Version 5.04 (2000) was used for calculating all roads, bus, and LRT traffic sound levels based on analysis of multiple road sections/segments to further enhance its three-dimensional capabilities. STAMSON is the computerized version of the MOE's current noise prediction model, ORNAMENT.
- (d) Noise Measurement
 - (i) Mobile Source
 - A. All noise level measurements are to be taken with a train on which there are three test/observation personnel and necessary equipment. All auxiliary systems, including air conditioning, compressors, and pumps, shall be operating. Exterior noise levels shall be measured using at least a Type II instrument, as defined in NPC 102, "Instrumentation".
 - B. Exterior noise level measurements shall be made in each station and on open section of elevated trackway. Exterior noise measurements shall be made to determine the noise print profiles at certain distances from the vehicle surface. An ultimate length train shall be operated with all auxiliaries in operation, including the air conditioning, compressors, fans, and any compressed air compressors. For the steel wheel/rail system, the tests shall be performed on recently ground, smooth rail at the test locations. At least three runs shall be made for each case and data taken for at least the following cases:
 - 1. Train operated at maximum cruising speed;
 - 2. Train accelerating from zero speed at its maximum acceleration to the maximum cruise speed; and
 - 3. Train decelerating to zero speed at the maximum service deceleration from the maximum cruise speed.
 - C. Other runs may be made for slower speeds and/or train operating conditions, as applicable for certain sections of the line. The Project Co shall then perform a Noise Analysis over the entire system to determine compliance with the noise level limits, or any site-specific exterior noise limits to be decided before commissioning the equipment for regular operations. Where special noise mitigation is provided and for places where noise limits are analyzed to be exceeded, the Project Co shall make site-specific noise measurements.

- (ii) Stationary Source
 - A. Noise measurement requirements for stationary sources are specified by the NPC series set out by the Ministry of Environment. Noise measurement should follow requirements as specified in NPC-103. In addition since stationary source will likely require Environmental Compliance Approval and noise assessments and subsequent reporting as prescribed by NPC – 233 will be required before commencement of construction of the facility.
- (e) Operation
 - (i) Mobile Source
 - A. Criteria
 - 1. The Ministry of Environment in conjunction with the TTC prepared a set of noise limits for an LRT system which has been used as a guideline for other similar projects. Noise impact shall be predicted and assessed during design of the line using these sound level criteria:
 - I. Daytime Equivalent Sound Level Criteria: The limit at a point of reception for the predicted daytime equivalent sound levels for rail transit operating alone (excluding contributions from the ambient) is 55 dBA or the ambient Leq, 16h, whichever is higher.
 - II. Nighttime Equivalent Sound Level Criteria: The limit at a point of reception for the predicted nighttime equivalent sound levels for rail transit operating alone (excluding contributions from the ambient) is 50 dBA or the ambient Leq, 8h, whichever is higher.
 - III. Passby Sound Level Criteria: The limit at a point of reception for the predicted passby for a single train operating alone and excluding contributions from other sources is 80 dBA. This limit is based on vehicles operating on tangent track. It does not apply within 100m of special track work and excludes wheel rail squeal.
 - 2. Where buses are part of the road traffic there are no additional criteria requirements beyond those presented in the Ministry of Transportation of Ontario Protocol for dealing with noise concerns during the preparation, review and evaluation of Provincial Highways Environmental Assessments. Buses should be considered as medium trucks in the traffic noise prediction models.
 - 3. The protocol applies to existing and proposed residential development having municipal approval on the date of this protocol. The protocol also applies to proposed nursing homes, group homes, hospitals and other such institutional land uses where people reside. This protocol does not apply to commercial and industrial land uses. This protocol does not apply closer than 15m to the centerline of the nearest track. Any such cases shall be assessed on a case by case basis.

B. Mitigation

1. Mitigating measures will be incorporated in the design of the Line when predictions show that any of the above limits are exceeded by more than 5 dB. All mitigating measures shall ensure that the predicted sound levels are as close to or lower than the respective limits as is technologically, economically and administratively feasible.
2. As per “Region of Waterloo Implementation Guideline for Noise policies – Part B”, types of noise control measures other than barriers should be considered first, subject to considerations of economics, attenuation achieved and affected resident wishes. Should a barrier alternative be necessary recommendation for installation will be based on projected noise levels exceeding 65 dBA or exceeding 60 dBA and having a difference between existing and projected noise of 5 dBA or more.
3. The Noise and Vibration Impact Assessment Report produced by J. E. Coulter should be consulted for mitigation recommendations, specifically those found in Section 4.2.4 and 4.3.4. Recommendations should be reviewed and incorporated in the mitigation efforts if appropriate.

C. Additional Requirements

1. In addition the Project Co will meet two alternative noise level criteria provided by the American Public Transit Association (APTA) and the Federal Transit Administration FTA. The Project Co will meet air-borne and ground-borne noise criteria generated by system operations outlined in APTA’s “1981 Guidelines for Design of Rapid Transit Facilities,” Noise and Vibration Section as shown in Exhibit 4.6-1.

Exhibit 4.6 - 1

Exterior Noise Level Parameters

Condition	Maximum Noise Level	Measurement Location
a. Ultimate system length train entering and leaving the station - elevated	74 dBA	Inside the station, 1.5 m from the station doors and 1.5 m above the station floor
b. Ultimate system length train stopped in station	67 dBA	Inside the station, 1.5 m from the station doors and 1.5 m above the station floor
c. Ultimate system length train traveling along the entire trackway at normal maximum speed and under normal accelerating and decelerating conditions	75 dBA	15 m from the track centerline, and 1.5 m above the surface of the track
d. Ultimate system length train negotiating curved track	75 dBA	15 m from the track centerline, and 1.5 m above the surface of the track. (Noise will still be noticeable even when sound criteria are met.)

2. The APTA criteria are based on maximum single passby noise level in dBA from train operations and the maximum levels are specified for different categories of community in the transit corridor (Exhibit 4.6 - 2).
3. The FTA criteria are based on the existing and proposed land uses within the project area (Exhibit 4.6 - 3) and on comparing the combined future noise levels from traffic and train operations with the existing ambient noise levels (Exhibit 4.6 - 4).
4. According to the APTA criteria, the maximum single passby level shall not exceed 70 dBA in low density residential areas and 75 dBA in average residential areas.

**Exhibit 4.6 - 2(A)
APTA Guidelines for Maximum Airborne Passby Noise from Train Operations (dBA)
Residences and Commercial Buildings**

Community Area Category	Single Family Dwellings	Multifamily Dwellings	Commercial Buildings
I Low Density Residential	70	75	80
II Average Residential	75	75	80
III High Density Residential	75	80	85
IV Commercial	80	80	85
V Industrial/Highway	80	85	85

**Exhibit 4.6 - 2(B)
APTA Guidelines for Maximum Airborne Passby Noise from Train Operations (dBA)
Specific Types of Buildings**

Building or Occupancy Type	Maximum Passby Noise Level
Amphitheaters	65
“Quiet” outdoor recreation area	70
Concert halls, Radio and TV studios	70
Churches, Theaters, Schools, Hospitals, Museums, Libraries	75

Note: The APTA criteria are generally applicable at the nearside of the nearest dwelling or occupied building under consideration or at 15 meters (50 feet) from track centerline, whichever is closer.

5. According to the FTA criteria, total noise from combined road traffic and train operations in residential areas shall not exceed the existing ambient traffic noise by 1 dBA or more (Exhibit 4.6 - 4) if existing L_{dn} is between 65 and 75 dBA. No exceedance is allowed if existing L_{dn} is equal to or greater than 75.

Exhibit 4.6 - 3

FTA Criteria -- Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor $L_{eq}(h)^*$	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheatres and concert pavilions, as well as National Historic Landmarks with significant outdoor use.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor $L_{eq}(h)^*$	Institutional land uses with primary daytime and evening use. This category includes schools, libraries, and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material.

* L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.

Exhibit 4.6 - 4

FTA NOISE IMPACT CRITERIA --- EFFECT ON CUMULATIVE NOISE EXPOSURE
 L_{dn} or L_{eq} in dBA (rounded to nearest whole decibel)

EXISTING NOISE EXPOSURE	ALLOWABLE PROJECT NOISE EXPOSURE	ALLOWABLE COMBINED TOTAL NOISE EXPOSURE	ALLOWABLE NOISE EXPOSURE INCREASE
45	51	52	7
50	53	55	5
55	55	58	3
60	57	62	2
65	60	66	1
70	64	71	1

EXISTING NOISE EXPOSURE	ALLOWABLE PROJECT NOISE EXPOSURE	ALLOWABLE COMBINED TOTAL NOISE EXPOSURE	ALLOWABLE NOISE EXPOSURE INCREASE
75	65	75	0

6. The Project Co shall give special attention to those areas that are noise-sensitive, as designated by the lowest noise limits of Exhibits 4.6-1, 4.6-2(A), 4.6-2(B), 4.6-4, and 4.6-5 of this Article. The Project Co shall provide any noise mitigation measures, with appropriate attention to urban design factors.
7. The exterior noise level generated by the system, with all contributing noise sources in operation, shall not exceed the levels specified in Exhibit 4.6-1, measured in still air in the environment along the System. Measurements shall be made as defined below. Should the required noise levels not be met, the Project Co shall design and install additional noise mitigation measures at the source, on the trackway along the alignment, such that the noise levels are not exceeded.
8. Noise emanating only from maintenance and support equipment and any MRV or similar vehicle shall meet all exterior noise level requirements, and the use and functions of these vehicles shall have appropriate noise muffling devices, particularly considering their normal use for maintenance during night time periods.

E. New Railway Grade Crossings

1. New railway grade crossings constructed as a result of the project will require audible warning signals at a quarter mile approach to the crossing until the train has reached that intersection as required by the Railways Safety Act RSC 1985. Procedures involving the Municipality, Minister of Transport and the Railway company may exempt the requirement and whether this exemption is likely should be considered in any noise assessment.
2. Ministry of Environment document LU-131, “Noise Assessment Criteria in Land Use Planning: Requirements, Procedures and Implementation October 1997”, provides guidance to deal with audible train warnings (train whistle) in noise assessment of the interior and exterior living area of effected sensitive receptors and should be consulted in the noise evaluations.

(ii) Stationary Sources

- A. Predicted noise impacts from “ancillary facilities” shall be assessed during the design of the line in accordance with the stationary source guidelines of the MOE included in their publication NPC-205. The predictions used shall be compatible with and at least as accurate as CSA Standard Z107.55.
- B. Stationary noise sources should meet the limits set out in Ministry of Environment guidelines NPC-205 and NPC 232. Potential sources of noise

including substations, platforms and maintenance facilities (including yards) should be identified with the use of the appropriate screening tools available from the Ministry of Environment. Sources considered for further assessment should be evaluated in accordance with guides NPC102, 103 and 233. Noise is considered a contaminant which may pose an adverse effect and as such must comply with Ont. Regulation 419 and requires an Environmental Compliance Approval from the Ministry of Environment.

(f) Construction Phase

- (i) Noise impacts from the construction of the line are to be examined. For the purposes of impact assessment and identifying the need for mitigation, the Ministry of the Environment guidelines for construction presented in the MOE Model Municipal Noise Control By-Law, Guidelines for class EA's of road undertakings and local municipal noise By-Laws are to be referred to. Local noise bylaws include City of Waterloo Noise Bylaw 2010-073, City of Kitchener General Noise Bylaw Chapter 450 and City of Cambridge "Prohibiting and Regulating Noise" Bylaw 32-04.
- (ii) Sound levels generated by construction equipment are assessed against the Ontario Ministry of the Environment Publication NPC-115 "Construction Equipment" and Publication NPC-118, "Motorized Conveyances". These publications do not set overall combined sound level limits due to construction sites but set limits for noise generated by the individual pieces of equipment used on construction sites. MOE approval will be based on whether or not the equipment used on site meets their requirements.
- (iii) With respect to truck noise, the governing criteria are contained in the Federal Government safety test standards for manufacturing of new trucks included in their publication titled "SECTION 1106-Noise Emission Tests for Motor Vehicles, and the relevant Consolidated Regulations of Canada, 1978 amended by SOP-179-115, September 1, 1979: Section 1106". Typical trucks maximum sound emission level is 83 dBA for a vehicle gross weight of over 4500 kg.
- (iv) In cases where work must commence at night or in other cases where contraventions of the bylaws are likely and no other resolution of the noise exceedance is possible, an exemption must be obtained from the municipality prior to initiating the activity.
- (v) Effect of Pure Tones: The noise limits specified above shall be reduced by 3 dBA if significant pure tones in the range of 300 Hz to 4,000 Hz are present in the noise spectrum. Pure tones shall be considered significant if any 1/3 octave band sound pressure is 5 dB or higher than the average of the two adjacent 1/3 octave bands. This requirement shall apply under all conditions including acceleration and braking.

4.7 Ground-Borne Vibration

(a) Definitions

- (i) Point of Vibration Assessment is the location 5M to 10M away from the building foundation in a direction parallel to the tracks or adjusted as required to accommodate site conditions.
- (ii) Vibration is measured as the average Root Mean Square (RMS) vibration velocity (mm/sec).

- (iii) Vibration Velocity Level (VdB) is 10 times the common logarithm of the ratio of the square of the amplitude of the vibration velocity to the square of the amplitude of the reference velocity.
- (iv) Sensitive Land Use means a residential dwelling or place where people ordinarily sleep or a commercial/industrial operation that is exceptionally sensitive to noise or vibration.
- (b) Regulations and Guidelines
 - (i) MOEE/GO Transit Draft Protocol for Noise and Vibration Assessment – January 1995 (Draft #9)
 - (ii) 1981 APTA (American Public Transit Association) “Guidelines for Design of Rapid Transit Facilities” (June 1981)
 - (iii) 1995 FTA (Federal Transit Administration) criteria contained in “Transit Noise and Vibration Assessment” (April 1995 and May 2006)
 - (iv) Construction Activity Vibration Specifications ...prepared for the Region of Waterloo, March 2002
 - (v) NPC-119 –Blasting, Ontario Ministry of Environment
- (c) Measurement and Prediction
 - (i) The Project Co shall provide an initial report estimating the ground borne vibration produced by the Light Rail Vehicle operating at maximum speeds (km/h) on level and tangent track and anticipated speeds over special track work.
 - (ii) Ground borne vibration produced by a Light Rail Vehicle operating at maximum speeds on ties and ballast, and concrete tangent track shall be measured at locations to be specified.
 - (iii) Ground borne vibration produced by a Light Rail Vehicle operating at anticipated speeds over rigid construction, special track work shall be measured at locations to be specified.
 - (iv) Screening procedures and generalized assessment methods described in the Federal Transit Administration “Transit Noise and Vibration Impact Assessment” manual should be followed to predict vibration levels at sensitive receptors. Locations such as requiring greater accuracy will need on site field measurements with specified vehicular operation and track conditions application to the anticipated situation.
- (d) Operation
 - (i) Mobile Source
 - A. Vibration velocities at points of assessment shall be predicted during design of the line. If the predicted RMS vertical vibration velocity from the Line exceeds 0.1 mm/sec, mitigation methods shall be applied during the detailed design to meet this criterion to the extent technologically, economically, and administratively feasible.
 - B. The Project Co shall provide for control of ground-borne vibration from the operation and maintenance of the system and from ancillary facilities such as yard operations, electrical substations, and service buildings. Vehicle interactions with the track and the track running structures and surfaces shall be such that the

transmission of vibration through the track structure to the surrounding buildings and terrain during the passage of trains is minimized.

- C. Ground-borne vibration criteria from train operations are also governed by APTA and FTA criteria, and are presented in Exhibits 4.7 - 1 and 4.7 - 2.
- D. The Project Co shall maintain and operate the system to achieve compliance with the above vibration levels at all times. In particular, the Project Co shall maintain the system against degradation which would adversely affect vibration levels, such as the condition of special track work, corrugated or worn track, and flattened wheels.
- E. Additionally, the structural integrity of adjacent buildings shall be considered during construction, operations, and major maintenance activities.

Exhibit 4.7 - 1(A)

APTA Criteria for Maximum Groundborne Vibration Velocity Level (dB re 10⁻⁶ in/sec) from Train Operations

Residences and Buildings with Sleeping Areas

Community Area Category	Single-family Dwellings	Multi-family Dwellings	Hotel/Motel Buildings
I Low Density Residential	70	70	70
II Average Residential	70	70	75
III High Density Residential	70	75	75
IV Commercial	70	75	75
V Industrial/Highway	75	75	75

Exhibit 4.7 - 1(B)

APTA Criteria for Maximum Groundborne Vibration Velocity Level (dB re 10⁻⁶ in/sec) from Train Operations

Special Function Buildings

Type of Building or Room	Maximum Passby Vibration Velocity Level (dB re 10⁻⁶ in/sec)
Concert Halls and TV Studios	65
Auditoriums and Music Rooms	70
Churches and Theaters	70-75
Hospital Sleeping Rooms	70-75
Court Rooms	75

Type of Building or Room	Maximum Passby Vibration Velocity Level (dB re 10 ⁻⁶ in/sec)
Schools and Libraries	75
University Buildings	75-80
Offices	75-80
Commercial and Industrial Buildings	75-85
Vibration Sensitive Industrial or Research Laboratory	60-70

Exhibit 4.7 - 2

**FTA Groundborne Vibration Impact Criteria
(Vibration Levels Expressed in VdB re 1 microinch/sec)**

Land Use Category	Vib.Vel. Impact Levels for Frequent ¹ Events	Vib.Vel. Impact Levels for Infrequent ² Events
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB ³	65 VdB ³
Category 2: Residences and buildings where people normally sleep	72 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use	75 VdB	83 VdB

1. “Frequent Events” is defined as more than 70 vibrations per day. Most rapid transit projects fall into this category.
2. “Infrequent Events” is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.
3. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes.
 - (ii) Stationary Source
 - A. Vibration considerations are confined to those sources that are produced by the operation of the line vehicles and excludes vibration due to stationary sources such as fans, furnaces, generators and chillers.

- (e) Construction Phase
 - (i) The Regional Municipality of Waterloo document “Construction Activity Vibration Specifications” should be consulted before construction activities which have the potential to cause adverse affects from vibration are commenced. A listing of common non-blasting activities is included in addition to blasting activities. The specification details requirements of pre-condition surveys, vibration limit criteria, monitoring methods and resolution of complaints.
 - (ii) The Project Co shall identify all potential issues resulting from excessive vibration caused by construction activities and shall endeavour to reduce or eliminate the effect on the nearby sensitive receptors. The Project Co shall have a complaint recording system in place to log complaints received from nearby receptors. With appropriate judgment the Project Co will alleviate valid complaints by providing an effective economical technical or administrative solution.

4.8 Air Quality

- (a) The design, construction, operation, and maintenance of the System and all of its subsystems and items of equipment shall conform to applicable Provincial, municipal, and local laws, ordinances, rules, and regulations for air quality, gaseous and particulate emissions.
- (b) Definitions
 - (i) Point of Impingement is any point on the ground or on a receptor, such as nearby buildings, located outside the company’s property boundaries at which the highest concentration of a contaminant caused by the aggregate emission of that contaminant from a facility is expected to occur.
- (c) Regulations and Guidelines
 - (i) Ontario Environmental Protection Act, R.S.O. 1990, c. E.19
 - (ii) Ontario Regulation 419/05
 - (iii) Environmental Activity and Sector Registry (EASR)
- (d) Measurement and Prediction
 - (i) Determination of emission rates will utilize well recognized sources of information such as the USEPA’s AP42- Compilation of Air Pollutant Emission Factors. Emission rates that are developed should abide by the concept of worst case scenario as required for approvals from the Ministry of Environment. AERMOD will be used to perform the dispersion modeling for all contaminants since it represents the future compliance requirement for assessment after the year 2020.
- (e) Operation
 - (i) The Project Co should determine the air quality impacts for sources required for the operation of the line. An emission inventory should be generated following MOE guideline A-10 “Procedure for Preparing an Emission Summary and Dispersion Modeling Report”, (March 2009). Heating equipment and standby generators that are eligible for inclusion to the Environmental Activity and Sector Registry should be so registered.

- (ii) For other contaminant sources, air dispersion modeling should be conducted to assess impacts along the property line and at sensitive receptors using MOE Guideline A-11 “Air Dispersion Modeling Guideline for Ontario (March 2009).
 - (iii) The current and future air contaminants will be compared to Ont. Reg 419/05 standards “Summary of Ont. Reg 419/05 Standards and Point of Impingement Guidelines and Ambient Air Quality Criteria (AAQC) (February 2008). Should any existing or future concentrations of air contaminant emissions not be in compliance with Ont. Reg 419/05 standards, alternative mitigative measures will need to be evaluated.
- (f) Construction Phase
- (i) The Project Co must assess the air quality impacts that the construction activities will have on nearby receptors. Sensitive receptors should be identified at each construction site. Particulate and combustion gases are anticipated to be the prime contaminants generated from the construction activities. Dust suppression should include frequent site watering, minimization of vehicle dust generation and covering of standing material piles. Should the site be on contaminated soil or have a dust loading that is visually excessive, ambient monitoring should be performed to ensure provincial standards are met.
 - (ii) Motorized equipment using fossil fuels should be maintained in good working order and operated in a manner that has the least emissions without compromising its functionality. Equipment using low sulphur fuels should be favored over higher sulphur fuels.
 - (iii) The Project Co shall set up a system to record complaints of air quality from nearby receptors. Efforts should be made to resolve valid complaints by the most economical means using technical or administrative means.

4.9 Water Quality

- (a) Storm water run-off from the LRT and all related facilities shall be directly routed to the Municipal storm drainage system. System design and operations shall be such that the quantities of pollutants, dropped or deposited by vehicles, that may be washed into the storm drainage system shall be minimized. Stormwater runoff must comply with the Region of Waterloo Storm Sewer Use By-Law and be approved as appropriate through the GRCA approval/pre-consultation process.
- (b) The car wash drainage system provided by the Project Co. shall retain any accidental spills. Car wash run-off shall be filtered and re-used to the extent of 80 percent or more. If necessary, the Project Co. shall pre-treat all discharge to meet the requirements of the local sewer use bylaw and The Ministry of the Environment, and other applicable Federal, Provincial, municipal, and local laws, ordinances, rules, and regulations governing water pollution. Sanitary sewer discharges must comply with the Region of Waterloo Sanitary Sewer Use By-Law.

4.10 Wind

- (a) The System shall be capable of normal operations in sustained winds of up to 90 km/h (55 mph).
- (b) The System structural integrity, with trains up to the maximum-length train stopped on any section in both tracks, shall withstand wind speeds of up to 161 km/h (100 mph) per AASHTO, increased for height above nine meters (9 m) in accordance with “Height Variation” in ASCE 7, with no damage to the vehicle, track, or appurtenant equipment.

4.11 Precipitation

(a) Design Precipitation Conditions

(i) The System shall be designed to operate in severe rain, sleet, ice, and snow conditions prevalent in the Region of Waterloo. As a minimum, the System shall operate normally under the following conditions:

- A. Snowfall, less than or equal to 76.2 mm/hour (3"/hour) with accumulation of up to 508 mm (20") in a period of twenty-four (24) hours.
- B. Freezing rain, sleet or ice glaze: less than or equal to 12.7 mm/hour (0.5"/hour) with an accumulation of up to 25.4 mm (1.0")/hour in a period of two (2) hours.
- C. Values of rainfall intensity (I) shall be determined by:

$$I = A / (T_c + B)^c$$

Where A, B, C are defined as follows:

- 1. The existing City of Kitchener IDF curves, for return periods ranging from two (2) years to one-hundred (100) years and with a duration less than six (6) hours:

Exhibit 4.11-1 City of Kitchener Design Storm Parameters <6hrs

Return Period	A	B	C
25 mm	509	6	0.7989
2 Year	743	6	0.7989
5 Year	1593	11	0.8789
10 Year	2221	12	0.9080
25 Year	3158	15	0.9355
50 Year	3886	16	0.9495
100 Year	4688	17	0.9624

- 2. For design storms with a duration of six (6) hours or more:

Exhibit 4.11-2 City of Kitchener Design Storm Parameters ≥6hrs

Return Period	A	B	C
2 Year	521.30	3.75	0.7400
5 Year	1371.00	12.90	0.8400

10 Year	1471.90	11.44	0.8225
25 Year	1499.10	9.63	0.7963
50 Year	1498.10	8.38	0.7775
100 Year	1479.10	7.20	0.7613

(ii) The System structural integrity, with trains up to the maximum-length train stopped on any section on both tracks, shall be capable of withstanding snow and wind loads with no damage to the vehicles, track, or appurtenant equipment. The rain, snow, and ice loading conditions specified herein shall be included in the design of the track and trackway structures and in the operating and maintenance plans.

(b) Precipitation Operations

- (i) The System shall sustain normal operation in conditions of rain, snow, and ice specified in this Article. Rain, ice, and snow conditions shall not hinder the normal precision stopping of trains at the stations. The track and track equipment shall minimize the accumulation of water, snow, and ice, particularly on running rails, power rails, and switches. Snow melting equipment shall be provided for strategic locations, to keep the System operational during snow and ice conditions; areas with trackage with grades of four percent (4%) or greater, and all switches, shall be included in this requirement.
- (ii) Ice and snow accumulation on emergency and maintenance walkways shall be minimized such that safe walking conditions are maintained at all times. Manual clearance means, shall not be used during train operations, or when propulsion power is on. Removal of ice and snow from the walkway, tracks, or structures shall not interfere with or impede at-grade traffic. The design of these walkways shall be subject to review by the Region.
- (iii) Anti-icing or de-icing chemicals shall not be used to keep track and track equipment free of ice and snow. The means to accomplish these requirements shall be included in the appropriate operations and maintenance procedures, as specified in the Project Agreement.
- (iv) The power distribution system, particularly the vehicle power collection and distribution equipment, shall prevent the occurrence of electrical faults, interruption of power, and loss of power and grounding contact under the precipitation conditions specified in this Article.
- (v) The design for precipitation protection of the vehicle, track, switch, and wayside equipment shall not present accumulation of water, ice, and snow on, around, or within equipment and equipment compartments such that operation is inhibited or equipment is endangered.

4.12 Lightning Protection

(a) All Project Co. provided equipment and facilities shall be protected against lightning incidences encountered in the area. Lightning protection shall comply with the requirements of UL 96A, "Lightning Protection. The Project Co. shall coordinate lightning protection with the grounding

system(s). The Project Co.'s lightning protection system design shall be subject to review by the Region.

4.13 Sand, Dust and Other Obstacles

- (a) The Project Co. shall design the System to operate in the presence of, and with accumulations of, wind-blown sand, dust, vegetation, and litter.

4.14 Contaminated Materials / Hazardous Waste

- (a) Contaminated materials and hazardous waste may be encountered during the design and construction of the Project. The presence of contaminated materials and hazardous waste may present a health and safety risk to Project Co. personnel, Region personnel, and the public, and may cause costly delays if not identified and mitigated prior to Project construction. The Project Co. shall conduct pre-construction environmental assessments and investigations, in accordance with the requirements of this Article and applicable regulations, to identify potential contaminated materials and hazardous wastes which may impact project design and construction.

- (b) Regulations and Procedures

- (i) All work covered under this Article shall be performed in accordance with the Project Co.'s Health and Safety Plan and shall be in accordance with all applicable regulations. Any discrepancies shall be resolved in favor of the more stringent provision. Applicable statutes, rules, regulations, and procedures include:

- A. Occupational Health and Safety Act, Ontario Regulation 278/05 as amended (last amendment O.Reg. 479/10) – Designated Substance – Asbestos on Construction Projects and in Buildings Repair Operations
 - B. Occupational Health and Safety Act, Ontario Regulation 490/09 as amended (last amendment O.Reg. 148/12) – Designated Substances
 - C. R.R.O. 1990 Regulation 347 as amended (last amendment O.Reg. 283/12) - General Waste Management
 - D. Environmental Protection Act, Ontario Regulation 153/04 as amended (last amendment O.Reg. 269/11) – Record of Site Condition
 - E. R.R.O. 1990 Regulation 903 as amended (last amendment O.Reg 468/10) - Wells
 - F. Region of Waterloo Sewer Use By-law (1990) By-law 1-90, Amended by By-law 92-050
 - G. Region of Waterloo Request for Waste Disposal Approval – Standard Operating Procedure – as amended (latest revision February 27, 2013)
 - H. RWSSP 180.01, Management of Excess Materials
 - I. Schedule 17 Part 5 Contamination, Waste Management and Earth/Shale Rock Management.

- (c) Quality Assurance

- (i) The Project Co. shall have a minimum of three (3) years experience in successfully completing projects similar in size and scope to the work under this Article.

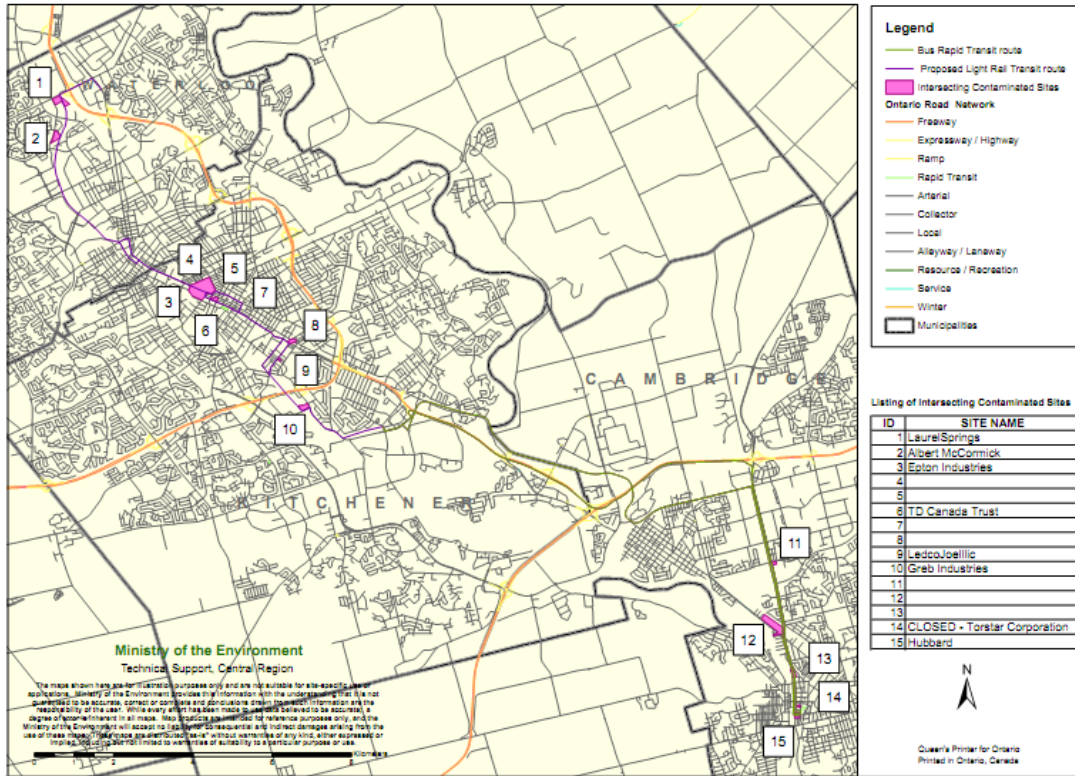
- (ii) All Work covered under this Article shall be conducted only by experienced personnel who are fully trained, qualified, and certified in accordance with The Occupational Health and Safety Act, as applicable, and all other applicable Federal, Provincial, and local statutes, rules, regulations, and procedures.
 - (iii) The Project Co. shall be responsible for securing all necessary and applicable permits, certificates, licenses, and approvals required for the performance of this Work and shall be responsible for the payment of all associated fees and fines.
 - (iv) The Project Co. shall be responsible for all notifications required by Federal, Provincial, and local statutes, rules, regulations, and procedures.
 - (v) The Project Co. shall conduct all environmental work, including sample collection, sample transport, and sample analyses in accordance with Quality Assurance/Quality Control (QA/QC) provisions and as required by the Ministry of the Environment. The analytical laboratory selected by the Project Co. shall be certified as required by the Ministry of the Environment and other applicable bylaws, codes, regulations, etc.
 - (vi) The Project Co. shall comply with all required reporting and recordkeeping requirements in accordance with the provisions of this Project Agreement and all applicable Federal, Provincial, and local statutes, rules, regulations, and procedures.
 - (vii) Any disposal facility utilized by the Project Co. for receipt of materials transported offsite shall be in good standing and hold current, valid permits and licenses as required by The Ministry of the Environment and all other Federal, Provincial, and local statutes, rules, regulations, and procedures.
 - (viii) Throughout the performance of this Project Agreement, the Project Co. shall be responsible for preventing the release or the spread of contaminated materials or hazardous wastes as a result of the Project Co.'s operations.
- (d) Health and Safety Requirements
- (i) Health and safety is the sole responsibility of the Project Co.. The Project Co. shall perform all Work required by the Project Agreement in a safe and environmentally acceptable manner. The Project Co. shall provide for the safety of all Project Co. personnel, Region personnel and their representatives, and the public for the duration of the Project Agreement.
 - (ii) The Project Co. shall provide for the Work of this Article, a site-specific Health and Safety Plan (HASp). The HASp shall be approved by a Certified Industrial Hygienist (CIH) and implemented by the Project Co.'s Safety Manager experienced with the health and safety requirements of OH&S Act and other applicable Federal, Provincial, and municipal, rules, regulations and procedures. All personnel working in contaminated or hazardous areas shall be adequately trained in accordance with the HASp and thoroughly briefed on anticipated hazards, safety equipment to be employed, safety practices to be followed, and emergency procedures and communications.
 - (iii) The HASp shall be distributed to all on-site personnel. On-site personnel shall be required to read the HASp, sign a compliance agreement, and abide by all provisions. The HASp shall be displayed and made available at the Site at all times.

- (iv) All Work covered under this Article shall conform to the requirements of OH&S Act and other applicable Federal, Provincial, and Municipal rules, regulations and procedures, which include but not limited to:
 - (v) Federal
 - A. Canadian Standards Association (CSA)
 - 1. Canada CSA S350-M1980(R2003), Code of Practice for Safety in Demolition of Structures.
 - C. National Building Code 2010 (NBC)
 - 1. NBC 2005, Division B, Part 8 Safety Measures at Construction and Demolition Sites.
 - D. National Fire Code 2010 (NFC)
 - 1. NFC 2005, Division B, Part 2 Emergency Planning, subsection 2.8.2 Fire Safety Plan.
 - E. Fire Commissioner of Canada (FCC)
 - 1. FC-301 Standard for Construction Operations, June 1982.
 - 2. FC-302 Standard for Welding and Cutting, June 1982.
 - (vi) Provincial
 - A. Occupational Health and Safety Act Revised Statutes of Ontario 1990, Chapter O.1 as amended, and Regulations for Construction Projects, O. Reg. 213/91 as amended.
 - B. Workplace Safety and Insurance Act, 1997.
 - C. Ontario Building Code Act, 1992, as amended.
 - C. Municipal statutes and authorities.
- (e) Submittals
 - (i) Prior to the initiation of any work covered by or related to this Article in accordance with Table 3.5 of Schedule 17, the Project Co. shall submit the following to the Region for approval:
 - A. The site-specific HASP and all modifications to the HASP.
 - B. Copies of all necessary and applicable permits, certificates, and approvals required for the performance of this Work.
 - C. All sampling and analysis plans required by this Article. The Project Co. shall not implement any report recommendations until so directed by the Region.
 - D. All environmental assessment and investigation reports, including supporting data, required by this Article. The Project Co. shall not implement any report recommendations until so directed by the Region.

- E. The proposed Hazardous Waste Management Plan for the management of contaminated materials and hazardous waste during construction as defined in Schedule 17.
 - F. If deemed necessary, a contaminated water handling and treatment plan as defined in Section 5.3.F. of Schedule 17, consisting of working drawings and descriptions of proposed sampling, storage, treatment, and discharge systems and facilities shall be submitted and include but not be limited to: equipment, methods, standby equipment, power supply, sampling and analysis requirements, required permits, contaminated water handling and discharge procedures, and discharge locations to be utilized. A schedule of installation and details of the systems operations shall also be submitted. The Project Co. shall resubmit, as appropriate, if the system is modified during installation or operation.
 - G. The Project Co. shall submit to the Region information and recommendations regarding the proposed facility(ies) for the transportation and disposal of each type of contaminated material or hazardous waste requiring disposal. The submittal shall also contain copies of all permits and licenses required by this Article and a complete listing of any notices of violations, citations, or administrative complaints issued by any Federal, Provincial, or Municipal agency for the facilities described.
- (ii) Thirty (30) calendar days after the completion of any work item covered by or related to this Article and the Work, or as otherwise described herein, the Project Co. shall submit the following to the Region for approval:
- A. Worker training logs and worker compliance agreements, air monitoring reports, safety inspection logs, and emergency and accident reports.
 - B. Detailed records of sampling and analysis conducted under this Article, including sample locations maps and chain-of-custody forms, within forty-eight (48) hours of receipt of analytical data.
 - C. Copies of all discharge and disposal records within three (3) calendar days of the completion of the discharge or disposal event.
 - D. All manifests, gate receipts, bills-of-lading, and records of final waste disposition from the accepting disposal facility(ies), and all other documentation relating to the off-site transportation and disposal of waste.
 - E. The final Project closeout report including, at a minimum, sufficient detail and supporting documentation to describe all contaminated material and hazardous waste Work performed under this Project Agreement.
- (iii) No work will proceed to the next phase until required submittals have been received and approved by the Region.
- (iv) The Project Co. shall make all necessary modifications to the submittals, as requested by the Region, and perform all activities in accordance with such modifications.
- (v) Any review, acceptance, or approval of the Project Co.'s submittals shall be construed merely to mean that the Region is unaware of any reasons at the time to object thereto. Approval by the Region shall not impose any liability upon the Region, nor shall any such approval relieve the Project Co. of any responsibilities under the Project Agreement.

- (f) Pre-Construction Environmental Assessments and Investigations
- (i) Project Co. shall conduct pre-construction environmental assessments and investigations to identify potential sources of designated substances, contaminated materials and hazardous wastes which may impact the Projects design and construction.
- (ii) Phase I Environmental Site Assessment
- A. A Screening Level Phase I Environmental Site Assessments (ESA) of the Project area has been conducted by the Region to identify potential sources of designated substances, contaminated materials and hazardous wastes which may require:
1. Characterization and cleanup or mitigation prior to Project construction.
 2. Development of special testing, handling, and disposal requirements during construction.
 3. Implementation of special health and safety procedures during construction.
- B. The Phase I ESA includes:
1. Environmental database search,
 2. Historical land use evaluation,
 3. Site reconnaissance, and
 4. Report of Phase I ESAs results.
- (iii) Phase II Environmental Site Assessment
- A. The Region has conducted a limited Phase II ESA of potential sources of contaminated materials and hazardous wastes identified during the Phase I ESA to confirm the presence and characterize the nature of the hazardous wastes which may require:
1. Characterization and cleanup or mitigation prior to Project construction.
 2. Development of special testing, handling, and disposal requirements during construction.
 3. Implementation of special health and safety procedures during construction.
- B. The Region shall provide Project Co with supplemental information on the limited Phase II ESA via addendum.
- C. Based on Appendix E of the Environmental Project Report, the locations of the known contaminated sites are shown in Exhibit 4-14.1 below.

Exhibit 4-14.1- Location of Contaminated Sites Relative to the Waterloo LRT



(g) Construction Waste Management Program

- (i) Based on information developed during the Phase I ESA and Phase II ESA, the Project Co. shall develop a Waste Management Program for implementation during construction; to ensure materials are properly characterized; to determine whether they are contaminated material or hazardous waste that must be properly handled, transported, and disposed in accordance with all environmental regulations, and to protect the health and safety of Project Co. personnel, Region personnel, and the public.
- (ii) The Waste Management Program shall include the following activities and be conducted in accordance with industry standards and all applicable statutes, rules, regulations, and procedures and all existing permits required for the Work under this Project Agreement:
 - A. Preparation and implementation of a Soil Confirmation Sampling Plan for confirmed contaminated areas and potentially contaminated areas and likely uncontaminated areas, including figures and QA/QC protocols for approval by Region. Sampling and analysis shall be conducted during excavation activities and on potentially contaminated groundwater encountered during dewatering operations in addition to any other potentially contaminated media.
 - B. Preparation and implementation of a Waste Management Plan, as necessary and as directed by the Region. This plan shall detail all phases of the management of all types of contaminated materials and hazardous waste (e.g., excavated soils,

sediment, and groundwater and surface water generated during dewatering), including, but not limited to, excavation, phasing, staging, sampling and analysis, handling, erosion and dust controls, storage, transportation, and disposal.

- C. Design, install, maintain, and operate a dewatering system that will minimize the migration of any existing groundwater contaminant plumes and minimize the volume of water generated.
- D. Design, install, maintain, and operate a temporary water storage and treatment system, as necessary and as directed by the Region, to reduce identified contaminant concentrations to acceptable levels provided in applicable discharge permits.
- E. Preparation and implementation of a site-specific HASP in accordance with the requirements of this Article.
- F. If, during the course of construction, the Project Co. becomes aware of any contaminated material or hazardous waste or has cause to suspect the presence of such materials not previously identified and made part of the Work under this Article, the Project Co. shall immediately notify the Region. The Project Co. shall immediately stop work in and secure the area against injury to persons or damage to property pending further instructions from the Region.

(h) **Hazardous Material Management Plan**

- (i) The Project Co. shall develop and implement during construction a Hazardous Material Management Program (HMMP), in accordance with the requirements of this Article, to identify the presence of designated substances and hazardous materials. The purpose of this management plan is to ensure the identification, proper handling and disposal of these materials and adherence to required health and safety protocols.
- (ii) Designated substances are found in many building/construction materials. As part of the requirements of the HMMP, prior to the demolition activities involving any structure, an intrusive designated substance survey shall be conducted to identify any designated substances and hazardous materials present. This assessment shall be completed following the procedures detailed in O.Reg. 278/05 and O.Reg. 490/09. This information allows Project Co involved in the demolition of these structures to take appropriate steps to control their exposure to these substances.
- (iii) There are eleven substances that have been “designated” in Ontario by the Occupational Health & Safety Act, which include acrylonitrile, arsenic, asbestos, benzene, coke oven emissions, ethylene oxide, isocyanates, lead, mercury, silica and vinyl chloride.
- (iv) Additional Hazardous Materials include Polychlorinated Biphenyls (PCBs) Ozone Depleting Substances, Urea formaldehyde foam insulation, Fuel, oil and/or waste oil storage, Chemical Storage, Radioactive materials, and Mould.
- (v) A report shall be generated identifying any designated substances and hazardous materials present in the area of work, and include recommendations regarding the management or abatement of these materials during the completed scope of work. The report will include the location and condition of the materials identified, and include the supporting analytical results, where applicable, and an estimate of the quantity present.

- (vi) During construction or demolition activities, should any potential asbestos containing materials or designated substances, or hazardous materials not identified in the above stated survey report be encountered during any part of the said work, all work in the area of this material should cease until the material is assessed by a competent person. If the material is confirmed to contain asbestos or any other type of designated substance or hazardous material, the appropriate procedures shall be followed in accordance with the Regulations.
- (i) Project Closeout Report
 - (i) The Project Co. shall prepare a final Project closeout report at the completion of the Project Agreement. This report shall, at a minimum, include sufficient detail and supporting documentation to describe all contaminated material and hazardous waste Work performed under this Project Agreement.