December 14, 2017

Vincent Dénommé
Brigil
98 Rue Lois
Gatineau, QB J8Y 3R7

Dear Mr. Dénommé:

Re: Addendum Letter, Noise
8466 Jeanne-d'Arc Boulevard "Petrie's Landing", Ottawa
GWE File No.: 17-139

1. INTRODUCTION

This addendum letter describes how have addressed the engineering comments received in the City of Ottawa, in their memo dated November 3rd, 2017 pertaining to the "Petrie's Landing" development, as outlined in our *Roadway Traffic Noise Assessment – Petrie's Landing Block 6, 7, and 8*, dated September 22, 2017. Following the report and based on the City of Ottawa comment, GWE performed a test calculation to assess the noise impacts due to the proposed Confederation East Light Rail Transit (LRT) to be located south of the development in the median of Highway 174. Additionally, the vibration impact on the development was also assessed.

2. TRAFFIC NOISE IMPACTS DUE TO LRT

A test calculation using STAMSON was performed to update Receptor 2 (shown in Figure 2 of the September 22nd Traffic Noise Assessment) which includes the combined effects of roadway and LRT noise. Receptor 2 is the worst-case receptor with regards to the effects of the proposed LRT. The theoretical noise predictions of the LRT were based on the following parameters:

- LRT modelled as a 4-car SRT
- LRT day/night volume split taken to be 318/ 63 at a speed of 80 km/hr based on the Environmental Project Report (Confederation Line East Extension – Blair Station to Trim Road) by PARSONS
- Full exposure angles taken for the LRT (-90 to 90 degrees)

Results of the calculation are indicated in Table 1 below. Receptor 2 represents noise levels without the effects of the LRT, while Receptor 2A includes the effects of the LRT.

TABLE 1: EXTERIOR NOISE LEVELS FOR RECEPTOR 2

Receptor Number	Receptor Description	Noise Level (dBA)	
		Daytime Period (07:00-23:00)	Nighttime Period (23:00-07:00)
2	POW – Block 6 – South Façade (Initial – excludes LRT)	74.5	66.9
2A	POW – Block 6 – South Façade (Updated – Includes LRT)	74.5	67.0

As shown above, the change in noise levels due to the LRT is insignificant. Therefore, the results, conclusions, and recommendations of the original study are still valid, and no changes are required.

3. GROUND VIBRATION AND GROUND-BORNE NOISE

Transit systems and heavy vehicles on roadways can produce perceptible levels of ground vibrations, especially when they are in close proximity to residential neighbourhoods or vibration sensitive buildings. Similar to sound waves in air, vibrations in solids are generated at a source, propagated through the medium, and intercepted by a receiver. In the case of ground vibrations, the medium can be uniform, or more often, a complex layering of soils and rock strata. Also, similar to sound waves in air, ground vibrations produce perceptible motions and regenerated noise known as 'ground-borne noise' when the vibrations encounter a hollow structure such as a building. Ground-borne noise and vibrations are generated when there is excitation of the ground, from a train for instance. Repetitive motion of the wheels on the track or rubber tires passing over an uneven surface causes vibrations to propagate through the soil. When they encounter a building, vibrations pass along the structure of the building beginning at the foundation and propagating to all floors. Air inside the building excited by the vibrating walls and floors represents regenerated airborne noise. Characteristics of the soil and the building are imparted to the noise, thereby creating a unique noise signature.

Human response to ground vibrations is dependent on the magnitude of the vibrations, which is measured by the root mean square (RMS) of the movement of a particle on a surface. Typical units of ground vibration measures are millimeters per second (mm/s), or inch per second (in/s). Since vibrations can vary over a wide range, it is also convenient to represent them in decibel units, or dBV. In North America, it is common practice to use the reference value of one micro-inch per second (μin/s) to represent vibration levels for this purpose. The threshold level of human perception to vibrations is about 0.10 mm/s RMS or about 72 dBV. Although somewhat variable, the threshold of annoyance for continuous vibrations is 0.5 mm/s RMS or 85 dBV, five times higher than the perception threshold, whereas the threshold for cosmetic structural damage is (10 mm/s RMS or 112 dBV) at least one hundred times higher than the perception threshold level.

3.1 Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land use next to transit corridors. Similar standards have been developed by a partnership between the MOECC and the Toronto Transit Commission[1]. These standards indicate that the appropriate criteria for residential buildings are 0.1 mm/s RMS for vibrations. For main line railways, a document titled *Guidelines for New Development in Proximity to Railway Operations*[2], indicates that vibration conditions should not exceed 0.14 mm/s RMS averaged over a one second time period at the first floor and above of the proposed building. As the main vibration source is due to a main line LRT corridor, the 0.1 mm/s RMS (72 dBV) vibration criteria and 35 dBA ground borne noise criteria is used.

3.2 Theoretical Ground Vibration Prediction Procedure

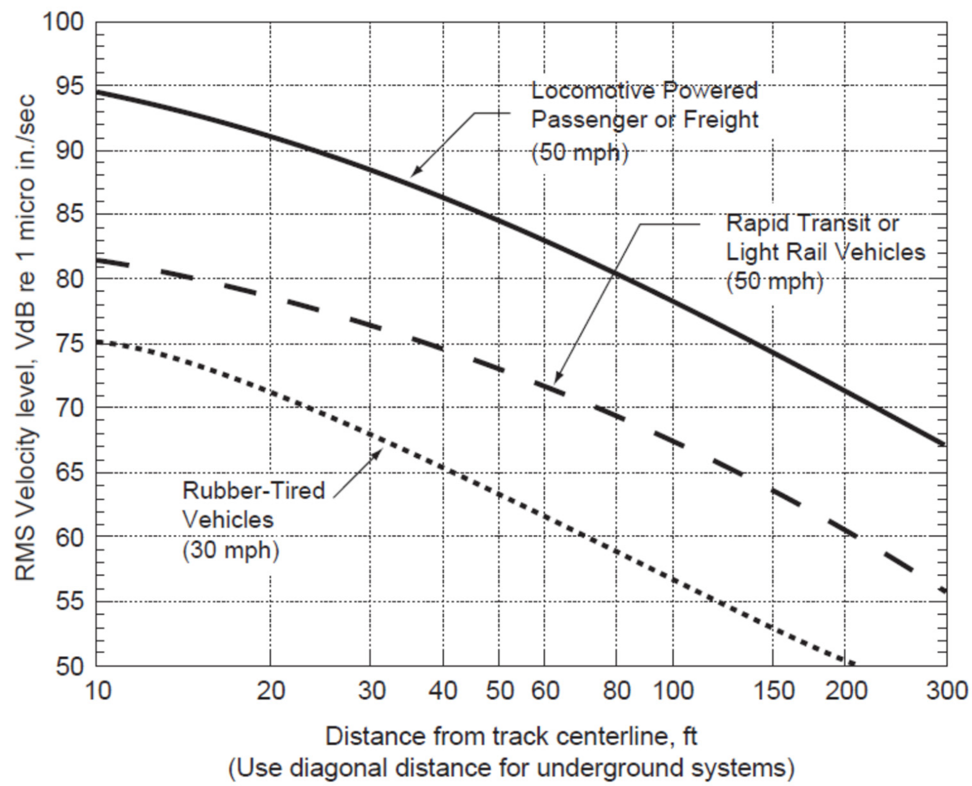
Potential vibration impacts of the proposed Confederation LRT rail line were predicted using the FTA's Transit Noise and Vibration Impact Assessment[3] protocol. The FTA general vibration assessment is based

[1] MOEE/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop, June 16, 1993

[2] Dialog and J.E. Coulter Associates Limited, prepared for The Federation of Canadian Municipalities and The Railway Associated of Canada, May 2013

[3] C. E. Hanson; D. A. Towers; and L. D. Meister, Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006.

on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure below, are based on ground vibration measurements at various transit systems throughout North America. Vibration levels at points of reception are adjusted by various factors to incorporate known characteristics of the system being analyzed; such as operating speed of vehicles, conditions of the track, construction of the track and geology; as well as the structural type of the impacted building structures. Based on the setback distance to the closest building (Block 6), vibration levels were deduced from a curve for light rail trains at 50 miles per hour (mph).



FTA GENERALIZED CURVES OF VIBRATION LEVELS VERSUS DISTANCE (ADOPTED FROM FIGURE 10-1, FTA TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT)

3.3 Ground Vibrations Results

Based on an offset distance of 44 metres between the Confederation LRT line and Block 6, the estimated vibration levels at the nearest point of reception are expected to be 0.02mm/s RMS based on the United States Federal Transit Authority (US FTA) protocol. Details of the calculations are provided in Appendix A. Since predicted vibration levels are below the criterion of 0.1 mm/s RMS, no mitigation will be required.

According to the United States Federal Transit Authority's vibration assessment protocol, ground-borne noise can be estimated by subtracting 35 dB from the velocity vibration level in dBV. Since calculated vibration levels were found to be 58 dBV, ground-borne noise levels of 23 dBA are expected fall below the FTA criterion of 35 dBA.

4. CONCLUSION

Results of the calculations indicated that transportation noise levels due to the proposed LRT have not changed significantly, compared to the previous results presented in our noise assessment report. With regards to vibration levels at the nearest point of reception (Block 6), they are expected to be 0.020 mm/s RMS based on the US FTA. This is below the criterion of 0.1 mm/s RMS. Additionally, the ground-borne noise levels were found to be 23 dBA which is below the FTA criterion of 35 dBA. Therefore, no mitigation is required. Therefore, the results, conclusions, and recommendations of the original report are still valid.

This concludes our addendum letter. Please contact us should you have any questions.

Yours truly,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. R. FOSTER
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Dec 14, 2017
PROVINCE OF ONTARIO

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GWE17-139– Addendum Letter

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Principal

APPENDIX A

FTA VIBRATION CALCULATIONS

Possible Vibration Impacts on Block 6 of Petrie's Landing
Perdicted using FTA General Assesment

Train Speed 80 km/h 50 mph

	Distance from C/L	
	(m)	(ft)
LRT	44.0	144.4

		Vibration	
From FTA Manual Fig 10-1			
	Vibration Levels at distance from track	64	dBV re 1 micro in/sec
Adjustment Factors FTA Table 10-1			
	Speed reference 50 mph	0	Speed Limit of 80 km/h (50 mph)
	Vehicle Parameters	0	Assume Soft primary suspension, Wheels run true
	Track Condition	0	None
	Track Treatments	0	None
	Type of Transit Structure	0	None
	Efficient vibration Propagation	0	Propagation through rock
	Vibration Levels at Fdn	64	0.040
	Coupling to Building Foundation	-10	3-4 Storey Masonry
	Floor to Floor Attenuation	-2.0	Ground Floor Ocupied
	Amplification of Floor and Walls	6	
	Total Vibration Level	58	dBV or 0.020 mm/s
	Noise Level in dBA	23	dBA

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise

Factors Affecting Vibration Source				
Source Factor	**Adjustment to Propagation Curve**			**Comment**
		Reference Speed		
Speed	Vehicle Speed	50 mph	30 mph	Vibration level is approximately proportional to 20*log(speed/speed$_{ref}$). Sometimes the variation with speed has been observed to be as low as 10 to 15 log(speed/speed$_{ref}$).
	60 mph	+1.6 dB	+6.0 dB	
	50 mph	0.0 dB	+4.4 dB	
	40 mph	-1.9 dB	+2.5 dB	
	30 mph	-4.4 dB	0.0 dB	
	20 mph	-8.0 dB	-3.5 dB	
Vehicle Parameters (not additive, apply greatest value only)				
Vehicle with stiff primary suspension	+8 dB			Transit vehicles with stiff primary suspensions have been shown to create high vibration levels. Include this adjustment when the primary suspension has a vertical resonance frequency greater than 15 Hz.
Resilient Wheels	0 dB			Resilient wheels do not generally affect ground-borne vibration except at frequencies greater than about 80 Hz.
Worn Wheels or Wheels with Flats	+10 dB			Wheel flats or wheels that are unevenly worn can cause high vibration levels. This can be prevented with wheel truing and slip-slide detectors to prevent the wheels from sliding on the track.
Track Conditions (not additive, apply greatest value only)				
Worn or Corrugated Track	+10 dB			If both the wheels and the track are worn, only one adjustment should be used. Corrugated track is a common problem. Mill scale on new rail can cause higher vibration levels until the rail has been in use for some time.
Special Trackwork	+10 dB			Wheel impacts at special trackwork will significantly increase vibration levels. The increase will be less at greater distances from the track.
Jointed Track or Uneven Road Surfaces	+5 dB			Jointed track can cause higher vibration levels than welded track. Rough roads or expansion joints are sources of increased vibration for rubber-tire transit.
Track Treatments (not additive, apply greatest value only)				
Floating Slab Trackbed	-15 dB			The reduction achieved with a floating slab trackbed is strongly dependent on the frequency characteristics of the vibration.
Ballast Mats	-10 dB			Actual reduction is strongly dependent on frequency of vibration.
High-Resilience Fasteners	-5 dB			Slab track with track fasteners that are very compliant in the vertical direction can reduce vibration at frequencies greater than 40 Hz.

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise (Continued)

Factors Affecting Vibration Path				
Path Factor	**Adjustment to Propagation Curve**			**Comment**
Resiliently Supported Ties	-10 dB			Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.
Track Configuration (not additive, apply greatest value only)				
Type of Transit Structure	Relative to at-grade tie & ballast: Elevated structure -10 dB Open cut 0 dB			The general rule is the heavier the structure, the lower the vibration levels. Putting the track in cut may reduce the vibration levels slightly. Rock-based subways generate higher-frequency vibration.
	Relative to bored subway tunnel in soil: Station -5 dB Cut and cover -3 dB Rock-based - 15 dB			
Ground-borne Propagation Effects				
Geologic conditions that promote efficient vibration propagation	Efficient propagation in soil +10 dB			Refer to the text for guidance on identifying areas where efficient propagation is possible.
	Propagation in rock layer	**Dist.** 50 ft 100 ft 150 ft 200 ft	**Adjust.** +2 dB +4 dB +6 dB +9 dB	The positive adjustment accounts for the lower attenuation of vibration in rock compared to soil. It is generally more difficult to excite vibrations in rock than in soil at the source.
Coupling to building foundation	Wood Frame Houses -5 dB 1-2 Story Masonry -7 dB 3-4 Story Masonry -10 dB Large Masonry on Piles -10 dB Large Masonry on Spread Footings -13 dB Foundation in Rock 0 dB			The general rule is the heavier the building construction, the greater the coupling loss.
Factors Affecting Vibration Receiver				
Receiver Factor	**Adjustment to Propagation Curve**			**Comment**
Floor-to-floor attenuation	1 to 5 floors above grade: -2 dB/floor 5 to 10 floors above grade: -1 dB/floor			This factor accounts for dispersion and attenuation of the vibration energy as it propagates through a building.
Amplification due to resonances of floors, walls, and ceilings	+6 dB			The actual amplification will vary greatly depending on the type of construction. The amplification is lower near the wall/floor and wall/ceiling intersections.
Conversion to Ground-borne Noise				
Noise Level in dBA	Peak frequency of ground vibration: Low frequency (<30 Hz): -50 dB Typical (peak 30 to 60 Hz): -35 dB High frequency (>60 Hz): -20 dB			Use these adjustments to estimate the A-weighted sound level given the average vibration velocity level of the room surfaces. See text for guidelines for selecting low, typical or high frequency characteristics. Use the high-frequency adjustment for subway tunnels in rock or if the dominant frequencies of the vibration spectrum are known to be 60 Hz or greater.