MMM GROUP

Prepared for: Grand Niagara.

REPORT
VIBRATION IMPACT STUDY

GRAND NIAGARA SECONDARY PLAN

14-15039-001-N02 | April 2016

WSP | MMM GROUP

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April 25, 2016
1415039-001-N02

Mr. Frank Baldesarra, P.Eng.
Managing Co-owner of Grand Niagara
5285 Solar Drive
Mississauga, Ontario L4W 5B8

Dear Mr. Baldesarra:

Subject: **Vibration Impact Study**
Grand Niagara Secondary Plan

MMM Group, a WSP Global company, is very pleased to submit the enclosed Vibration Impact Study in support of the Grand Niagara Secondary Plan.

The report examines the vibration impact of trains passing on the Canadian Pacific Rail right-of-way bisecting the subject lands. Our study concludes that the issue of ground-borne vibration from train pass-bys **does not pose any constraint** to the re-development of the subject lands.

We thank you for the opportunity to undertake this study. Should you have any comments or questions or require clarification, please contact us at your earliest convenience.

Yours truly,

MMM GROUP LIMITED

Bill Hoogeveen, P.Eng.
Senior Project Manager
Noise and Vibration Section
Transportation Planning

Felipe Vernaza, P.Eng.
Project Engineer
Noise and Vibration Section
Transportation Planning

1.0 INTRODUCTION

MMM Group, a WSP Global company, was retained by Grand Niagara to undertake a Vibration Impact Study in support of the Grand Niagara Secondary Plan. The purpose of this study is to ensure that ground-borne vibration resulting from passing freight trains on the Canadian Pacific Railway right-of-way complies with applicable ISO (International Organization for Standardization) vibration criteria. This report assesses the impacts of the vertical vibration displacement originating from the tracks that bisect the subject site from southwest to northwest. The objective of this study is to determine if the residential uses which are proposed to be located along the railway tracks will be impacted by ground-borne vibration generated by passing CPR freight trains.

2.0 RAILWAY VIBRATION GUIDELINES

The ground-borne vibration criteria used in this study are based on the CPR guidelines. The CPR guidelines are based on criteria set by the International Organization for Standardization (ISO).

The measured vibration velocity or equivalent acceleration should not exceed the vibration velocity limit of **0.10 mm/sec (root mean square)** for trains on the rail line, from 4 Hz to 200 Hz over the one-third octave band frequency, at a reasonably short integration time of one second or less.

The suggested railway vibration limit applies directly to the measured outdoor and indoor ground-borne vibration levels. If the measured vibration levels exceed these limits, then vibration control measures must be investigated and considered to ensure that vibration velocity limits are not exceeded at living areas on and above the first floor of the dwelling.

3.0 VIBRATION MEASUREMENT METHODOLOGY

Vibration measurements were undertaken at two locations as shown in **Figure 1**. The resulting measurement locations' distance to the railway right-of-way is approximately 30 metres. These measurement locations are referred to as Locations 1 and 2.

Vibration instrumentation used in this assessment includes the following:

1. Two types of ICP accelerometers;
    a. Type 353B33 by PCB Piezotronics, suitable for lower amplitude vibration tests from 1 to 4000 Hz;
    b. Type 393A03 by PCB Piezotronics suitable for lower amplitude vibration tests from 1 to 2000 Hz;
2. Four-Channel Handheld Dynamic Signal Analyzer, Model CoCo-80 by Crystal Instruments; and,
3. Engineering Data Management (EDM) System by Crystal Instruments.

The Handheld Dynamic Signal Analyzer was set to read the "maximum" (rms) vibration levels in every one-third octave band for the range 3.15 Hz to 315 Hz in one second intervals.

The accelerometers were rigidly mounted on a large steel stake vertically placed in the ground at Locations 1 and 2. This accelerometer mounting procedure is used to measure the vertical axis vibration component. Both accelerometers were connected to the CoCo-80 Handheld Dynamic Signal Analyzer.

The vertical acceleration of a CPR freight train was recorded on November 26, 2015 at both locations. The vibration measurements were recorded on the CoCo-80 Handheld Dynamic Signal Analyzer and were later downloaded to a desktop computer using the EDM system. The vibration measurement data was then compiled and analyzed to determine the vibration levels associated with the CPR freight train pass-bys on the nearby railway track.

Not to Scale

MMM GROUP

Legend

● **Vibration Measurement Locations**

FIGURE 1
CPR Freight Train Pass-by
Vibration Measurement Locations
Grand Niagara Secondary Plan

4.0 VIBRATION MEASUREMENT RESULTS

Based on our research and observations by employees at the Grand Niagara Golf Course, a short freight train passes along this section of railway approximately only 1-3 times per week. However, no train pass-bys were observed during some weeks. We understand this secondary track only services a ceramic materials factory. The train from which vibration levels were measured was comprised of 12 rail cars.

The results are shown as amplitude of acceleration versus frequency. The acceleration levels are presented in terms of decibels (dB) relative to 1 g (9.807 m/s^2) (rms). For example, -20 dBg is equal to 0.1g, -40 dBg is equal to 0.01g, etc. These acceleration values can be converted to vibration displacement or vibration velocity if a sinusoidal or near sinusoidal waveform is assumed.

Figure 2 and **Table 1** in the **Appendix** contain the measured vibration levels taken at Locations 1 and 2. Measured vibration levels are compared to the CPR Vibration Guidelines criteria outlined in Section 2 of this report.

The results illustrated on the graphs and tables show that the **maximum vibration levels** due to the CPR train pass-bys on the railway lines **exceed the applicable vibration criteria**. This is consistent with the findings of Grand Niagara Resort – Noise/Vibration Study prepared by Aercoustics Engineering Limited in December 7, 2006, at locations approximately 150 to 200 metres away. The vibration exceedances were observed in the 6.3 Hz, 8 Hz, 10 Hz and 12.5 Hz third-octave bands. Given the low frequency of vibration, we note that mitigation may not be practical or effective.

These exceedances are considered marginal and range from only 0.5 to 4 decibels above the ISO criteria. In general, these exceedances manifested themselves as short 1-second exceedances totaling 5 and 11 non-consecutive seconds out of the 90-second observed train pass-by duration for locations 1 and 2, respectively.

Furthermore, based on discussions with CPR and the client, trains operate on the railway one to three times per week. Consequently, vibration levels above the ISO criteria are expected to occur for less than half-a-minute in total during a typical week. Many weeks, this would be less than 10 seconds per week given the infrequent use of this rail spur.

We emphasize that the measured vibration levels are several orders of magnitude lower than vibration levels that could cause damage to any structures in the vicinity of the railway.

Therefore, it is our opinion that the vibration impacts due to train traffic along the CPR railway will be negligible.

Rail unevenness, large gaps between rail segments, roughness and corrugation are very important factors causing vibration during train pass-bys. Train maintenance such as proper wheel alignment and well-

maintained wheels (i.e. no flat spots) are very important as well. These factors can increase vibration levels by up to 20 dB in the most extreme cases. We observed large gaps between rails, and based on a consultation with our Senior Rail Inspector, the rail is badly corrugated, as shown in the **Photograph 1** below. As such, the poor state of the tracks is likely to be exacerbating any vibration caused by the trains (see attached correspondence).

Photograph 1

We also note that based on discussions with the client, it is possible that this rail line be decommissioned in the future.

5.0 FORMAL NOTIFICATION

The dwelling units in this development within 300 metres of the rail right-of-way will require formal notification to the purchasers or occupants by means of a warning clause included in all development agreements, offers to purchase, and agreements of Purchase and Sale or Lease of each dwelling unit. The warning clause shall read as follows:

> *"Warning: Canadian Pacific Railway Company or its assigns or successors in interest has or have a right-of-way within 300 metres from the land the subject hereof. There may be alternations to or expansions of the rail facilities on such right-of-way in the future including the possibility that the railway or its assigns or successors as aforesaid may expand its operations, which expansion may affect the living environment of the residents in the vicinity, notwithstanding the inclusion of any noise and vibration attenuating measures in the design of the development and individual dwelling(s). CPR will not be responsible for any complaints or claims arising from use of such facilities and/or operations on, over or under the aforesaid right-of-way."*

6.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- The measurement results indicate that the maximum vibration levels due to the CPR freight train pass-bys on the railway line exceed the applicable vibration criteria. The poor state of the railway is likely to be exacerbating any vibration caused by the trains. We expect the vibration levels to noticeably drop if the observed corrugation, the roughness and the large gaps between rail segments are addressed by CPR.

- These exceedances manifested themselves as short 1-second exceedances totaling 5 and 11 non-consecutive seconds out of the 90-second observed train pass-by duration. In conjunction with the very infrequent train operations along the track, vibration levels would exceed criteria for less than a minute on a typical week. Moreover, we understand that this secondary track services only a ceramic materials factory on a demand basis and therefore we do not expect train frequency to increase.

- Moreover, the observed vibration levels are several orders of magnitude below vibration levels that could cause damage to any nearby structures to the railway.

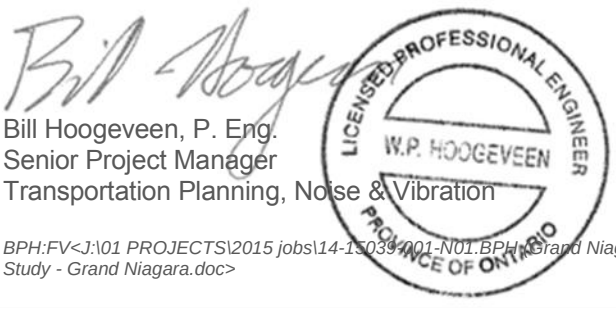
- Thus, it is our opinion that the vibration impacts due to train traffic along the CPR railway are negligible from the CPR right-of-way and therefore no mitigation is recommended.

- Therefore, ground-borne vibration emanating from trains passing along the CPR right-of-way bisecting the subject land do not pose any constraint on the re-development of these lands.

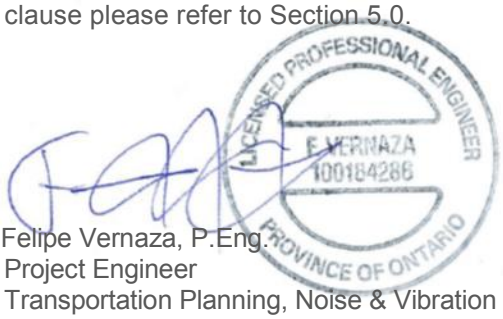
Recommendations

- The dwelling units in this development within 300 metres of the rail right-of-way will require formal notification to the purchasers or occupants by means of a warning clause included in all development agreements, offers to purchase, and agreements of Purchase and Sale or Lease of each dwelling unit. For the exact wording of the warning clause please refer to Section 5.0.

Respectfully submitted,



Bill Hoogeveen, P. Eng.
Senior Project Manager
Transportation Planning, Noise & Vibration



Felipe Vernaza, P.Eng.
Project Engineer
Transportation Planning, Noise & Vibration

BPH:FV<J:\01 PROJECTS\2015 jobs\14-15039-001-N01.BPH (Grand Niagara Noise)\Vibration Study\Report\[2016.01.06] Draft - Vibration Impact Study - Grand Niagara.doc>

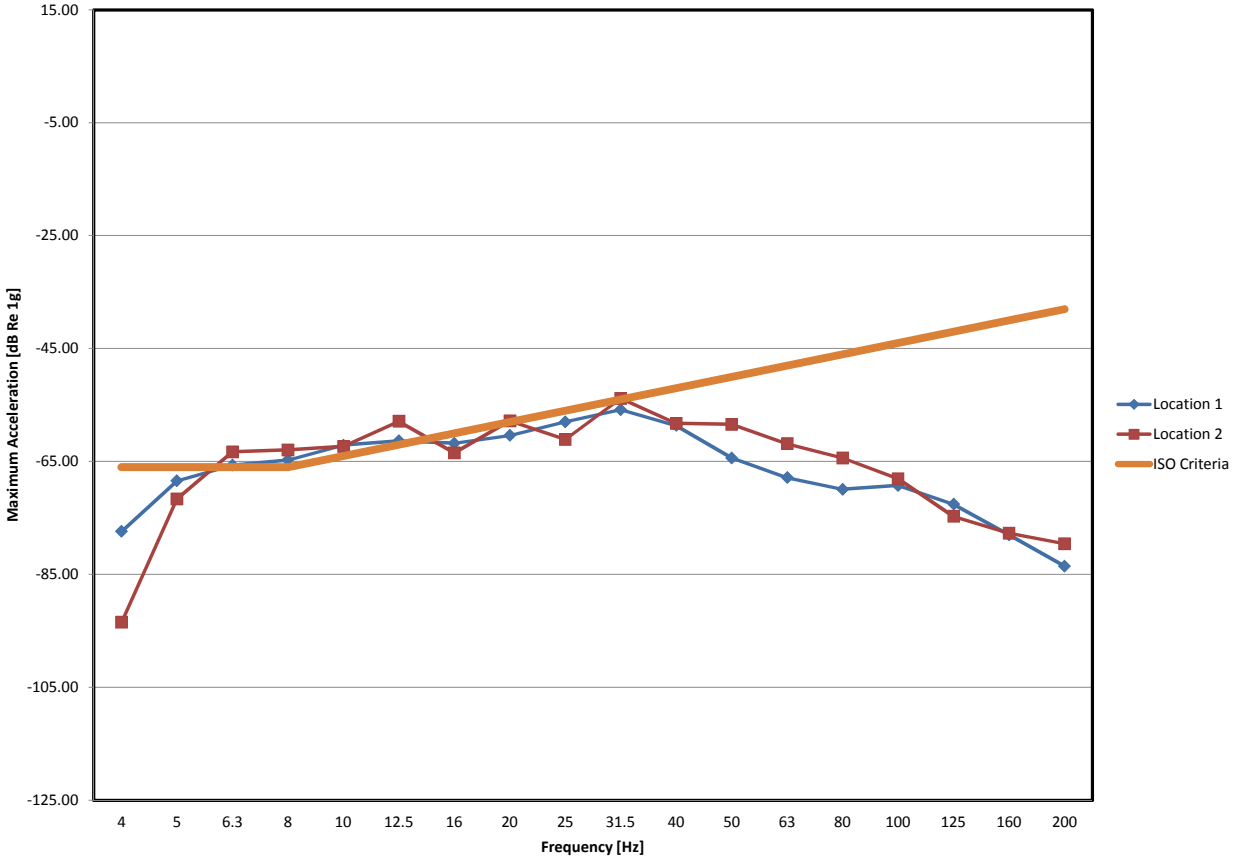
APPENDIX A

Train Pass-by Vibration Measurements

Table 1 - Maximum Vertical Vibration at Locations and 2

Frequency	Acceleration Location 1	Acceleration Location 2	Acceleration Location 3	Acceleration Location 4	Acceleration Location 5	ISO Criteria
4	-77.38	-93.47				-66.00
5	-68.43	-71.61				-66.00
6.3	-65.66	-63.30				-66.00
8	-64.74	-62.95				-66.00
10	-62.11	-62.34				-64.00
12.5	-61.35	-57.88				-62.00
16	-61.78	-63.45				-60.00
20	-60.37	-57.79				-58.00
25	-57.97	-61.10				-56.00
31.5	-55.81	-53.82				-54.00
40	-58.61	-58.26				-52.00
50	-64.38	-58.41				-50.00
63	-67.86	-61.84				-48.00
80	-69.92	-64.38				-46.00
100	-69.23	-68.04				-44.00
125	-72.56	-74.71				-42.00
160	-77.98	-77.68				-40.00
200	-83.51	-79.54				-38.00

FIGURE 2
Go Train Pass-bys Maximum Vertical Vibration at Locations 1 & 2



APPENDIX B

Correspondence with Rail Inspector

Bill Hoogeveen

From: Felipe Vernaza
Sent: Wednesday, January 06, 2016 10:56 AM
To: Bill Hoogeveen
Subject: FW: Rail corrugation

FYI

Regards,

Felipe Vernaza, P.Eng
Project Engineer
Noise and Vibration, Transportation Planning

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Please consider the environment before printing...

From: Doug Botting
Sent: December-16-15 10:31 AM
To: Felipe Vernaza
Subject: Re: Rail corrugation

Felipe

As per the pictures this is getting to the point that it should be addressed.

As per the pictures is this on tangent track
Normally occurs on the low rail of curve.

Doug

Sent from my BlackBerry 10 smartphone on the Rogers network.

From: Felipe Vernaza
Sent: Tuesday, December 15, 2015 3:48 PM
To: Doug Botting
Subject: Rail corrugation

Hi Doug,

We are undertaking a vibration study for the Grand Niagara Secondary Plan. A railway crosses the site, on which infrequent freight trains operate. These trains are causing a bit of vibration. One significant cause rail corrugation. Based on the attached pictures, can you please comment how badly the railway is corrugated? Is this severe or typical?

Thanks in advance!

Regards,

Felipe Vernaza, P.Eng
Project Engineer
Noise and Vibration, Transportation Planning

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