APPENDIX K
NOISE AND VIBRATION IMPACTS ASSESSMENT METHODOLOGY

K. NOISE AND VIBRATION

This appendix describes the methods the Surface Transportation Board's Section of Environmental Analysis (SEA) used to model the potential effects of noise and vibration from construction and operation of the proposed Port MacKenzie Rail Extension.

K.1 Wayside Noise Model Methodology

Wayside noise collectively refers to noise generated by railcars and locomotives (that is, without including horn noise). SEA used noise measurements from past noise studies, including the *Final Environmental Impact Statement for the Conrail Acquisition* (STB, 1998a) and *Draft Environmental Assessment for the Canadian National/Illinois Central Acquisition Environmental Assessment* (STB, 1998b), as the basis for the wayside noise level projections for the Port MacKenzie Rail Extension project.

The basic equation used for the wayside noise model is:

$$SEL_{cars} = L_{eqref} + 10\log(T_{passby}) + 30\log(S/S_{ref})$$

For locomotives, which can be modeled as moving monopole point sources, the corresponding equation is as follows:

$$SEL_{locos} = SEL_{ref} + 10\log(N_{locos}) – 10\log(S/S_{ref})$$

The total train sound exposure level is computed by logarithmically adding SEL_{locos} and SEL_{cars}

$$DNL_{100'} = SEL + 10\log(N_d + 10*N_n) – 49.4$$
$$DNL = DNL_{100'} + 15\log(100/D)$$

The parameters that apply to the equations above are:

SEL_{cars} = Sound Exposure Level of railcars
L_{eqref} = Level Equivalent of railcar
T_{passby} = Train passby time, in seconds
S = Train speed, in miles per hour
S_{ref} = Reference train speed
SEL_{locos} = Sound Exposure Level of locomotive
SEL_{ref} = Reference Sound Exposure Level of locomotive
DNL = Day-night average noise level
N_{locos} = Number of locomotives
N_d = Number of trains during daytime
N_n = Number of trains during nighttime
D = Distance from tracks, in feet

Table K-1 shows the reference wayside noise levels used in this study and Figure K-1 shows the wayside noise frequency spectrum used in the calculations.

Table K-1
Reference Wayside Noise Levels

Description	Average Level (dBA)[a]
Locomotive SEL[b] (40 miles per hour at 100 feet)[c]	95
Railcar L_{eq}[d,e]	82

[a] dBA = A-weighted decibels.
[b] SEL = sound exposure level.
[c] Source: STB, 1998a.
[d] L_{eq} = level equivalent.
[e] Source: STB, 1998b.

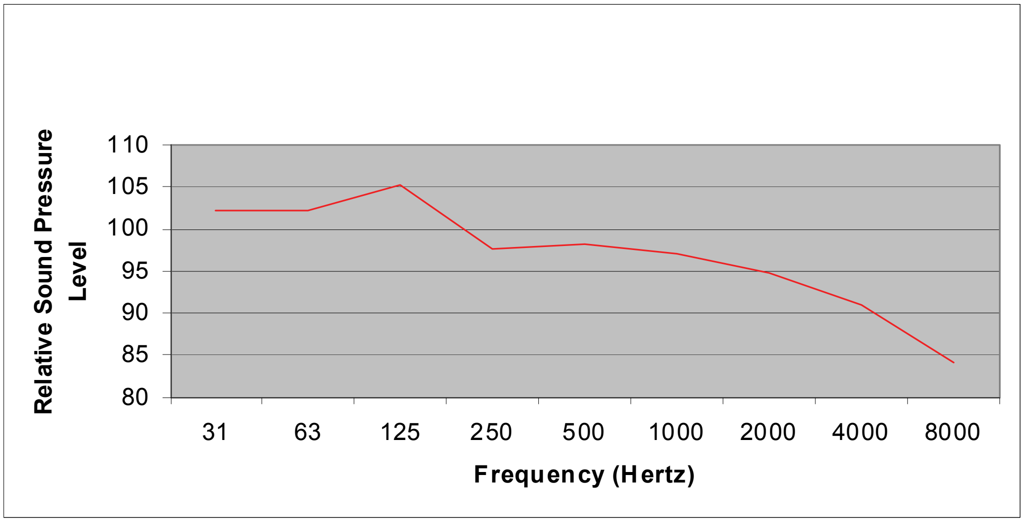


Figure K-1. Wayside Noise Spectrum
(STB, 2002)

K.2 Horn Noise Model Methodology

Freight train horn noise levels can vary for a variety of reasons, including the manner in which an engineer sounds the horn. Consequently, it is important to base horn noise reference levels on a large sample size. A substantial amount of horn noise data are available from the *Draft Environmental Impact Statement, Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings* (FRA, 1999), hereinafter referred to as the 1999 Federal Railroad Administration Draft Environmental Impact Statement (EIS).

Federal Railroad Administration (FRA) data indicate that horn noise levels increase from the point at which the horn is sounded 0.40 kilometer (0.25 mile) from the grade crossing to when it stops sounding at the grade crossing. In the first 0.201 kilometer (0.125 mile) segment, the energy average sound exposure level measured at a distance of 30 meters (100 feet) from the tracks was found to be 107 dBA and 110 dBA in the second 0.201 kilometer (0.125 mile) segment. The 1999 FRA Draft EIS simplified the horn noise contour shape as a five-sided polygon, when it is actually a teardrop shape. The *Final Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Texas* (STB, 2003) discusses this subject in detail. SEA used the more accurate teardrop horn noise contour shape for this analysis. The attenuation or drop-off rate of horn noise is assumed to be 4.5 dBA per doubling of distance away from the tracks (FRA, 1999).

Table K-2 lists the reference horn noise levels used in this study, and Figure K-2 shows the horn noise spectrum used in the calculations.

Table K-2
Reference Horn Noise Levels

Description	Average Level (dBA)[a]
Horn SEL[b] 1st 0.25 mile[c]	110
Horn SEL 2nd 0.25 mile[c]	107

[a] dBA = A-weighted decibels.
[b] SEL = sound exposure level.
[c] Source: FRA, 1999.

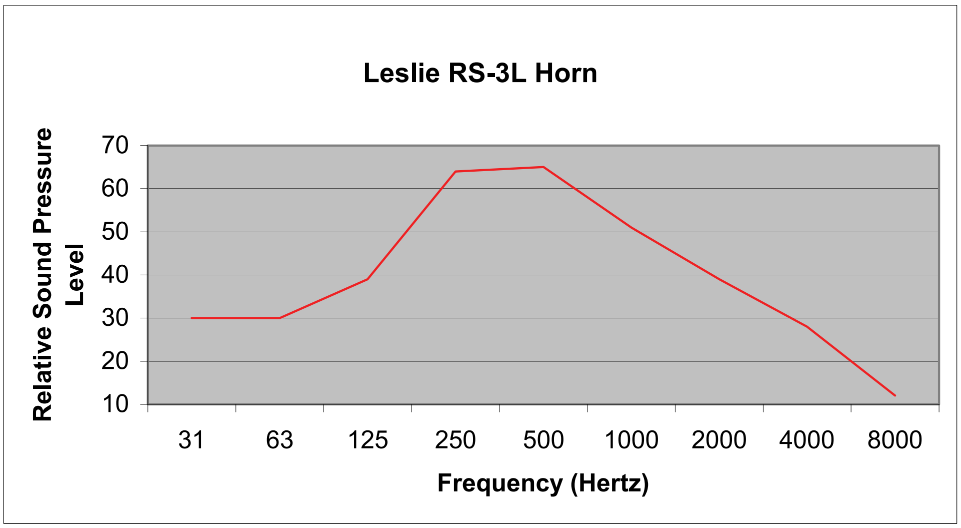


Figure K-2. Horn Noise Spectrum
(STB, 2002)

K.3 Rail Line Operations Vibration Analysis Methodology

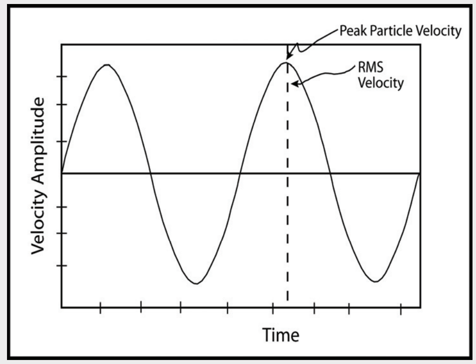
SEA based the vibration methodology on Federal Transit Administration (FTA) methods (*Transit Noise and Vibration Impact Assessment, Federal Transit Administration* [FTA, 2006]). Vibration level due to train passbys is approximately proportional to:

$$V = 20 \times \log(\text{speed}/\text{speed}_{ref})$$

Where

- V is the ground-borne vibration velocity.
- speed is the train speed.
- speed_{ref} is the reference speed of the train relative to its corresponding vibration level.

Published (FTA) ground-borne vibration levels are adjusted for train speed by this equation and distance from the rail line to estimate vibration levels at receptor locations.



Peak particle velocity (PPV): instantaneous positive or negative peak of a vibration signal, measured as a distance per time.

Root-mean-square (RMS) velocity (VdB) is a measure of ground vibration in decibels used to compare vibration from various sources.

There are two ground-vibration impacts of general concern: annoyance to humans and damage to buildings. In special cases, activities that are highly sensitive to vibration, such as micro-electronics fabrication facilities, are evaluated separately. There are two measurements corresponding to human annoyance and building damage for evaluating ground vibration – peak particle velocity (PPV) and root-mean square (RMS) velocity. PPV is the maximum instantaneous positive or negative peak of the vibration signal, measured as a distance per time (such as millimeters or inches per second). This measurement has been used historically to evaluate shock-wave type vibrations from actions like blasting, pile driving, and mining activities, and their relationship to building damage. RMS is an average, or smoothed, vibration amplitude, commonly measured over 1-second intervals. It is expressed on a log scale in decibels (VdB) referenced to 0.000001 x 10^{-6} inch per second and is not to be confused with noise decibels. It is more suitable for addressing human annoyance and characterizing background vibration conditions because it better represents the response time of humans to ground vibration signals.

K.4 Construction Noise and Vibration Analysis Methodology

SEA based the construction noise impact assessment on FTA methods (*Transit Noise and Vibration Impact Assessment, Federal Transit Administration* [FTA, 2006]) General Assessment construction noise guidelines, shown in Table K-3.

Table K-3
Federal Transit Administration General Assessment Construction Noise Guidelines

	1-hour L_{eq} (dBA)[a]	
Land Use	**Day**	**Night**
Residential	90	80
Commercial	100	100
Industrial	100	100

[a] L_{eq} = level equivalent; dBA = A-weighted decibels.

The FTA General Assessment for construction noise is used when details of the construction schedule are not known. The method calls for estimating combined noise levels from the two noisiest pieces of construction equipment and determining locations which would exceed the noise guidelines in Table K-3.

Construction vibration levels are estimated according to the following equation:

$$PPV_{equipment} = PPV_{ref} \text{ x } (25/D)^{1.5}$$

Where

- $PPV_{equipment}$ is the peak particle velocity in in/sec of the equipment adjusted for distance.
- PPV_{ref} is the reference vibration level in in/sec at 25 feet.
- D is the distance from the equipment to the receptor.

Estimated construction vibration levels are then compared with building damage criterion.

K.5 References

FRA (Federal Railroad Administration). 1999. Draft Environmental Impact Statement, Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings.

FTA (Federal Transit Administration). 2006. Transit Noise and Vibration Assessment. (FTA-VA-90-1003-06.) May.

STB (Surface Transportation Board). 2003. Final Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Texas. May.

STB. 2002. Draft Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Texas. December.

STB. 1998a. Final Environmental Impact Statement No. 980194, Conrail Acquisition (Finance Docket No. 33388) by CSX Corporation and CSX Transportation Inc., and Norfolk Southern Corporation and Norfolk Southern Railway Company (NS). July.

STB. 1998b. Draft Environmental Assessment Canadian National/Illinois Central Railroad Acquisition. December.

K.6 Glossary

Ambient noise	The sum of all noise (from human and naturally occurring sources) at a specific location over a specific time is called ambient noise.
Day-night average sound level	The energy average of ***A-weighted decibel*** sound levels over 24 hours, which includes a 10 decibel adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to noise during the night. The effect of nighttime adjustment is that one nighttime event, such as a train passing by between 10 p.m. and 7 a.m., is equivalent to 10 similar events during the daytime.
Decibel (dB)	A standard unit for measuring sound pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is nominally the lowest sound pressure that people can hear.
Decibel, A-weighted (dBA)	A measure of noise level used to compare noise from various sources. A-weighting approximates the frequency response of the human ear.
Hertz (Hz)	A unit of frequency equal to one cycle per second.
Peak particle velocity (PPV)	The maximum instantaneous positive or negative peak of the vibration signal, measured as a distance per unit time (such as millimeters or inches per second). This measurement has been used historically to evaluate shock-wave type vibrations from actions like blasting, pile driving, and mining activities, and their relationship to building damage.
Root-mean-square vibration velocity (VdB)	An average or smoothed vibration amplitude, commonly measured over 1-second intervals. It is expressed on a log scale in decibels (VdB) referenced to 0.000001 inch per second and is not to be confused with noise *decibels*.