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APPENDIX L
NOISE AND VIBRATION ANALYSIS

L.1 Background

The Canadian National Railway Company and Grand Trunk Corporation (collectively, CN or the Applicants) are seeking authorization from the Surface Transportation Board (Board) to acquire control of EJ&E West Company, a wholly owned non-carrier subsidiary of Elgin, Joliet and Eastern Railway Company (EJ&E). Appendix L discusses the potential impacts of noise and vibration resulting from the proposed acquisition.

L.2 Noise and Vibration Methodology

The Applicants Proposed Action is to acquire control of EJ&E West Company and thereby interconnect all five of CN's rail lines within the Chicago area. The SEA evaluated the potential effects of the Proposed Action and other alternatives on noise levels along EJ&E and CN track segments where substantial changes in rail traffic are projected. Potential noise impacts could occur at any location where the Applicants' integrated operations would result in either a substantial increase in existing rail activities or new noise-producing activities. SEA used the methodology presented herein to evaluate the potential noise effects of the Proposed Action.

In the noise evaluation, SEA considered the principal sources of rail line noise, wayside noise, and horn noise. Wayside train noise refers collectively to all train-related operational noise adjacent to the right-of-way, excluding warning horn noise. Wayside noise results from steel train wheels contacting steel rails and from locomotive exhaust and engine noise.

Horn noise occurs in the vicinity of highway/rail at-grade crossings. Federal Railroad Administration (FRA) regulations require that engineers use locomotive horns while approaching all highway/rail at-grade crossings and for signaling movements of trains on the mainline and in yards to warn motorists, pedestrians, and railroad employees of approaching trains. The only exception to this is at-grade crossings that have been designated as quiet zones.

Potential sources of noise associated with rail yard facilities include locomotives, rail cars, trucks, train horns, and braking devices, known as retarders.

L.2.1 Applicable Regulations and Guidance

The Board's environmental regulations in Part 49 of the Code of Federal Regulations (CFR), Section 1105.7(e) (6) requires the analysis of potential noise impacts in those areas that would meet or exceed the Board's thresholds for environmental analysis as a result of the Proposed Action. SEA's methods for evaluating potential noise impacts focused on those locations. Table L.2-1 below, summarizes the Board's thresholds for environmental analysis of noise impacts.

Table L.2-1. Thresholds for Noise Impact Assessment	
Rail Line Segment	Rail traffic increase of 100%, as measured by gross ton-miles annually, or an increase of at least 8 trains per day
Rail Yard	100% increase (measured by carload activity)
Intermodal Facility	Increase in truck traffic greater than 10% of average annual daily traffic or 50 trucks per day.

L.2.2 Data Sources and Types

SEA used data from the following sources to conduct the noise analysis:

- Information about existing and proposed operations and proposed construction activities, as described in the Applicants' operating plan
- CN and EJ&E geographical information system (GIS) data identifying the location of the proposed track segments
- Aerial photographs showing communities adjacent to railroad facilities that could be affected by noise from increased rail activities
- Models of noise generated by various rail facilities
- Noise measurement data from this project, previous mergers, and other rail studies
- Information from site visits regarding ambient noise levels, land use, operating procedures, and buildings that may act as partial noise barriers
- Federal Highway Administration's (FHWA) Traffic Noise Model (TNM)
- U.S. Environmental Protection Agency (EPA) rail noise reports

L.2.3 Screening Process

The Board's regulations require noise impact analysis to determine if the Proposed Action would result in either of the following conditions:

- An increase in the day-night average sound level (L_{dn}) of 65 A-weighted decibels (dBA) or greater
- An increase in community noise exposure as measured by an L_{dn} noise level of 3 dBA or greater in areas already exposed to 65 dBA or more

When the estimated noise increase at a location exceeds these criteria, SEA estimated the number of affected noise-sensitive receptors, such as schools, libraries, residences, retirement communities, and nursing homes.

The unit dBA is a measure of noise used to compare the loudness of various sources. A-weighting approximates the manner in which the human ear responds to sounds. L_{dn} (day-night average sound level) is a measure of noise over a 24-hour period. The value of L_{dn} represents the energy average of the A-weighted sound level over a 24-hour period. L_{dn} includes an adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to nighttime noise. The effect of the nighttime adjustment is that one nighttime event, such as a train passing by between 10 p.m. and 7 a.m., is equivalent to ten similar events during the daytime.

In general, an increase in L_{dn} of 3 dBA requires one of the following: 1) a 100 percent increase in rail traffic, 2) a substantial change in operating conditions or equipment, or 3) a shift of daytime operations to nighttime hours. Because of the weighting factor applied to nighttime noise, nighttime noise often dominates L_{dn}. Assuming a typical separation distance of 100 feet from the rail line to residences, an L_{dn} level of 65 dBA from rail operations usually requires four or more trains per day. Near a highway/rail at-grade crossing, where the engineers sound the train horns at full volume, four trains per day can generate an L_{dn} level greater than 65 dBA at distances up to 250 feet from the tracks.

Because the Proposed Action is projected to involve a substantial increases and changes in the type of rail traffic using the EJ&E tracks, existing (monitored) noise levels were compared with predicted future noise levels.

L.2.4 Analytical Methods and Guidance

L.2.4.1 Noise Assessment Approach

The following steps outline SEA's approach for the assessment of potential noise impacts.

1) SEA compiled and reviewed available information to identify potential noise impacts on the rail line segments. Digital aerial photographs and GIS technologies were used for the initial identification of noise-sensitive receptors. Where there may be confusion about whether specific buildings are residential or used for other noise-sensitive activities, the land use was verified with site visits.
2) Existing noise levels were measured in areas along the corridor that represent existing train operations, land uses, and terrain.
3) SEA identified models for estimating noise for each of the following potentially significant noise sources: 1) freight and passenger train operations on mainline sections of track, and 2) audible warning signals at highway/rail at-grade crossings. SEA based the models on available data from previous rail projects and the literature, and on data collected for this project.
4) SEA used the following information to estimate the existing and future noise exposure in terms of L_{dn}: 1) the locations of noise sources, 2) distances and propagation paths to noise-sensitive receptors, and 3) future operations on a proposed rail line segment.

Because noise from rail operations may cause localized impacts, SEA considered the following factors in conducting a detailed assessment of noise impacts: 1) the location of the noise sources in relation to receptors, 2) the specific equipment used at the facility, 3) the number of daytime and nighttime operations, 4) the operating modes of the equipment, 5) any acoustical shielding between receptors and noise sources, and 6) the existing levels of background noise.

To determine potential noise impacts, SEA overlaid noise contours on aerial photographs using GIS. The GIS software was used to count sensitive receptors within the contour zones, and a site visit was performed to verify the existence and location of the receptors. Using this procedure, SEA estimated the total number of noise-sensitive receptors where the operations on a proposed rail line segment would likely increase noise exposure to potentially significant levels.

L.2.4.2 Rail Line Segments

SEA estimated the number of noise-sensitive receptors within the existing and projected L_{dn} 65 dBA contours or where there would be a 3 dBA increase in L_{dn} in areas already exposed to 65 dBA L_{dn} or greater by:

- Identifying noise-sensitive receptors in the project area using GIS
- Calculating the distances to L_{dn} 65 dBA based on projected train operations for both mainline sections and highway/rail at-grade crossing zones
- Estimating the distances from the tracks where the L_{dn} would increase by 3 dBA or more in areas already exposed to 65 dBA L_{dn} or greater. This estimated 3 dBA increase

contours will be based on projected train operations for both mainline sections and highway/rail at-grade crossing zones and measurements of the existing background noise. According to EPA research, approximately 75 percent of Americans live in an environment where noise from traffic alone exceeds an L_{dn} of 55 dBA.[1]

- Developing contours to overlay on aerial photographs in GIS by using the calculated distances to L_{dn} 65 dBA and to the 3 dBA increase point. SEA will make adjustments to the contours to account for the effects of acoustic shielding by intervening buildings. SEA will base these adjustments on the approach often used for highway noise projections; Table L.2-2 below, provides the acoustical shielding adjustments.

TABLE L.2-2. ADJUSTMENTS FOR ACOUSTICAL SHIELDING BY ROWS OF BUILDINGS

Percent of Row Occupied by Buildings	Attenuation (dB)		
	First Row	Subsequent Rows	Maximum
Less than 40%	0.0	0.0	0.0
40 to 65%	3.0	1.5	10.0
65 to 90%	5.0	1.5	10.0
Greater than 90%	Analyze by using standard barrier attenuation models		

Source: FHWA. Federal Highway Traffic Noise Prediction Model, FHWA-RD-77-108, by T.M. Barry and J.A. Reagan, December 1978.

L.2.4.3 Construction Activities

While the construction of proposed rail line connections could cause some increase in noise exposure at nearby noise-sensitive receptors, any noise impacts would occur for a limited duration. Construction noise generally does not create any permanent noise increase. In addition, noise-producing activities would be limited to daytime hours. For these reasons, SEA did not conduct quantitative noise analyses for the construction of proposed rail line connections.

L.2.4.4 Noise Projection Models

This section describes the noise models that SEA used for this project. All of the models described in this section are common acoustic models defined in acoustics literature. Each model estimates noise from a specific source, such as freight cars, based on a reference noise level that SEA derived from measurements performed along the existing EJ&E and CN corridors. The following sections describe the noise models for: 1) through trains (wayside noise), and 2) highway/rail at-grade crossings (including both train horns and crossing bells at the highway/rail at-grade crossings).

L.2.4.5 Rail Line Segments

The main sources of noise from through-trains include the following: 1) steel wheels of the locomotives and rail cars rolling on steel rails (referred to as wheel-to-rail noise); 2) locomotive engine, exhaust, and fan noise; and 3) train horns at highway/rail at-grade crossings. The Wayside Noise discussion focuses on models SEA used for estimating wheel-to-rail and locomotive engine noise while the Highway/Rail At-Grade Crossings discusses the model for horns at highway/rail at-grade crossings. SEA used a separate model for the horn noise because they are much louder than the normal wheel-to-rail and locomotive engine noise.

[1] EPA. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA/ONAC 550/9-94-004, March 1974.

Wayside Noise

Wheel-to-rail noise is the dominant noise source from freight cars and—together with noise from the locomotive—is collectively referred to as wayside noise. Wayside noise levels can increase by as much as 15 dBA when wheels or rails are in poor condition.

The main components of locomotive noise include the exhaust of the diesel engines, cooling fans, general engine noise, and wheel/rail interaction. Noise associated with engine exhaust and cooling fans usually dominates and is dependent on the throttle setting (most locomotives have eight throttle settings), not on locomotive speed.

Tests have shown locomotive noise to change by approximately 2 dBA for each one-step change in throttle setting. As the engineer moves the locomotive throttle from notch one to notch eight, noise levels increase by an average of 16 dBA. Because locomotive engineers constantly adjust throttle setting as necessary, only rough estimates of throttle settings are usually available for noise projections. SEA assumed a base throttle position of six unless they obtain more specific information.

The noise models compute Maximum Sound Level (L_{max}), Sound Exposure Level (SEL), L_{dn}, and other noise measures for varying distances from the track, train speeds, and schedules. The model uses the average L_{eq} for rail cars. The standard approach to projecting freight car noise is to model freight cars as moving, incoherent, dipole line sources. The basic equations that SEA used are as follows:

1) $L_{max} = Kc + 10\,log[\alpha + 0.5*sin(2\alpha)] - 10\,log(y) - 10\,log(s/s_{ref}) - c_g - c_s$

2) $K_c = Lmax_{-ref} - 10\,log[\alpha_{ref} + 0.5*sin(2\alpha_{ref})] - 10\,log(y_{ref})$

3) $SEL_{cars} = Lmax + 10\,log(len/c_s) - 10\,log[2\alpha + sin(2\alpha)] + 3.3$

SEA used the following equations to model locomotives as moving monopole point sources:

4) $L_{max} = KL + 10\,log(2\alpha) - 10\,log(y) + 10\,log(s/s_{ref}) - c_g - c_a - c_s$

5) $K_L = Lmax_{-ref} - 10\,log(2\alpha_{ref} / y_{ref})$

6) $SEL_{locos} = Lmax + 10\,log(len/c_s) - 10\,log(2\alpha) + 3.3$

The total SEL for a train is the decibel sum of SEL_{Cars} and SEL_{locos} and L_{dn} is calculated from the total SEL using the following equation:

7) $L_{dn} = SEL_{total} + 10\,log(N_{day} + 10*N_{night}) - 49.4$

The parameters in the above equations are:

y	=	Observer perpendicular distance from track centerline (feet)
y_{ref}	=	Reference observer distance from track centerline (feet)
len	=	Train length (feet)
len_{ref}	=	Reference train length (feet)
α	=	$tan^{-1}(len/2/y)$
α_{ref}	=	$tan^{-1}(len_{ref}/2/y_{ref})$
s	=	Train speed (miles per hour)
s_{ref}	=	Reference train speed (miles per hour)

L_{max}	=	Maximum sound level during train pass-by (dBA)
$L_{max\text{-}ref}$	=	Maximum sound level during train pass-by for reference conditions (dBA)
c_g	=	Excess ground attenuation (dBA)
cs	=	Excess shielding attenuation (dBA)
N_{day}	=	Number of trains in daytime hours (7 a.m. to 10 p.m.)
N_{night}	=	Number of trains in nighttime hours (10 p.m. to 7 a.m.)

The standard train for this analysis will be 2.2 locomotives and 4,080 feet of rail cars for a total train length of 4,243 feet.

Typical L_{dn} vs. Distance for Rail Line Segments, Figure L.2-1 below, shows the L_{dn} levels as a function of distance from the track centerline for different numbers of trains (5,043 feet long) per day traveling at 40 miles per hour.

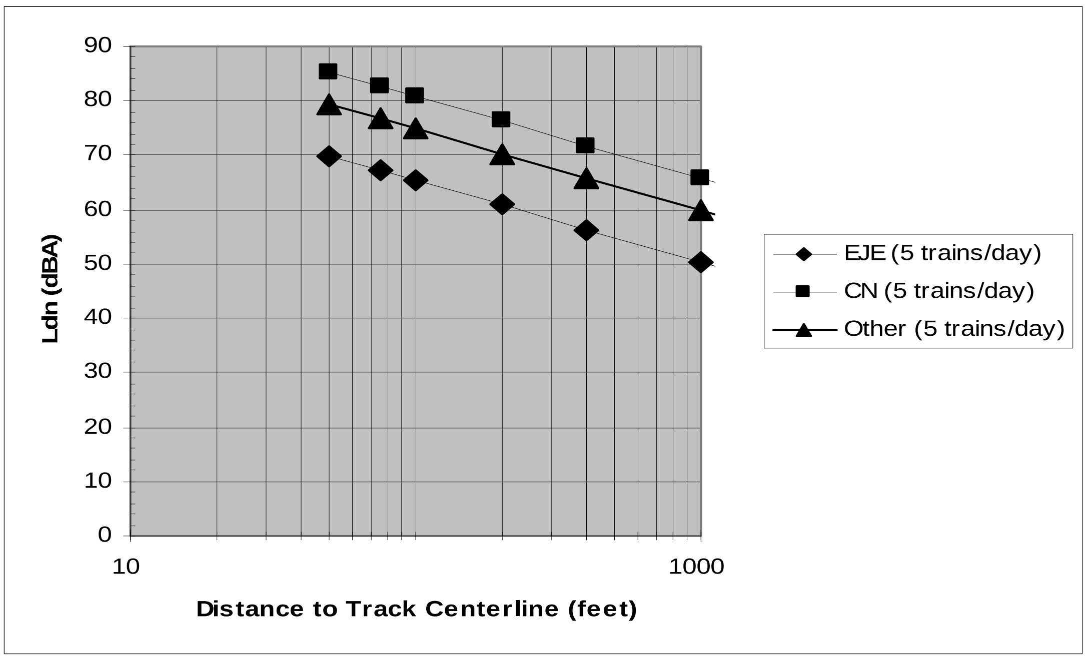

Figure L.2-1. Typical L_{dn} vs. Distance for Rail Line Segments

As an initial screening of noise effects, SEA assumed that trains would be equally likely to pass at any hour of the day; for example an average of nine out of 24 trains would pass during the nighttime hours. For the initial screening, SEA assumed no acoustic shielding from rows of single-family residential building parallel to the tracks. This is a conservative assumption that ensured that few potential noise impacts were left out with this approach.

Following the initial screening, SEA developed more detailed noise projections for rail line segments where the Board's criteria for determining adverse noise effects were exceeded. The more detailed projections incorporate the scheduled times for the trains and trackage rights trains into the calculation of L_{dn}. The number of trains during the nighttime hours is important because in the calculation of L_{dn}, one nighttime train is equivalent to ten daytime trains. Assuming there would be no trains during the nighttime hours would reduce the projected L_{dn} levels by more than 6 dBA.

Table L.2-3, Distances from Track Centerline to L_{dn} of 65 dBA for Wayside Noise below, presents the approximate distances from the track centerline to an L_{dn} of 65 dBA as a function of the number of trains per day.

TABLE L.2-3. DISTANCES FROM TRACK CENTERLINE TO L_{DN} OF 65 DBA FOR WAYSIDE NOISE	
Average Number of Trains per Day	Distance to Ldn = 65 dBA (feet) a
1	40
2	60
4	90
6	120

Notes:
[a] This distance applies to a 5,043-foot-long train (2.2 locomotives), traveling at a speed of 40 miles per hour. Distances are rounded to the nearest 10 feet.

Because the reference quantities SEA used in equations one through six are based on numerous measurements of train noise, the curves in and the distances presented in Table L.2-13 represent typical field conditions. However, a number of factors can cause higher levels of L_{dn}. These factors include the following: 1) a concentration of trains during the nighttime hours, 2) locomotives operating at throttle settings higher than six, 3) wheel or rail conditions being worse than normal, or 4) train horns being sounded on a regular basis.

Highway/Rail At-Grade Crossings

Before approaching most highway/rail at-grade crossings, freight trains are required to sound their horns. The exact manner in which engineers sound the horns varies depending on local and state ordinances. Train horns typically dominate noise exposure near any highway/rail at-grade crossing. Additional noise sources associated with highway/rail at-grade crossings include the grade crossing bells that start sounding just before the gates are lowered, as well as the idling traffic that must wait at the crossing. The idling traffic noise is usually insignificant compared to the horn noise.

The key parameters needed to project noise exposure from horns are the: 1) horn sound level, 2) duration of the horn noise, 3) distance of the receiver from the tracks, and 4) number of trains during the daytime and nighttime hours. FRA Regulation 229.129, "Audible Warning Device," requires all lead locomotives to have an audible warning device that produces a minimum sound level of 96 dBA and a maximum of 110 dBA at a distance of 100 feet in front of the locomotive. Most freight train audible warning devices are air horns. Adjusting the air pressure or adjusting the size of the metering orifice can regulate the maximum sound level of the air horns. In practice, maximum sound levels are typically 105 to 110 dBA at 100 feet in front of the trains, well above the 96 dBA minimum required by the regulations. Under the FRA's Train Horn Rule, locomotive engineers must sound train horns for a minimum of 15 seconds and a maximum of 20 seconds in advance of all public grade crossings, except if a train is traveling faster than 45 miles per hour, at which time engineers will not sound the horn until it is within 0.250 mile of the crossing, even if the advance warning is less than 15 seconds.

SEA used the noise projection model developed for the FRA study of the use of locomotive horns at highway/rail at-grade crossings.[2] This model uses a reference SEL (developed empirically using field measurements at numerous grade crossings) for a typical train horn event at a highway/rail at-grade crossing to estimate the noise exposure contours near and along a typical railroad line. Based on the

[2] FRA, "Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings, Draft Environmental Impact Statement," December 1999.

measurement data, FRA concluded that noise exposure from horns sounding at highway/rail at-grade crossings increases in the last 0.125 mile before the grade crossing.

Figure L.2-2, SEL Model below, shows average SEL as a function of distance from a grade crossing that FRA used. The SEL is 107 dBA from 0.250 mile (1320 feet) before the grade crossing until 0.125 mile (660 feet) before the grade crossing. Starting at 0.125 mile before the crossing, SEL increases linearly reaching 110 dBA at the grade crossing.

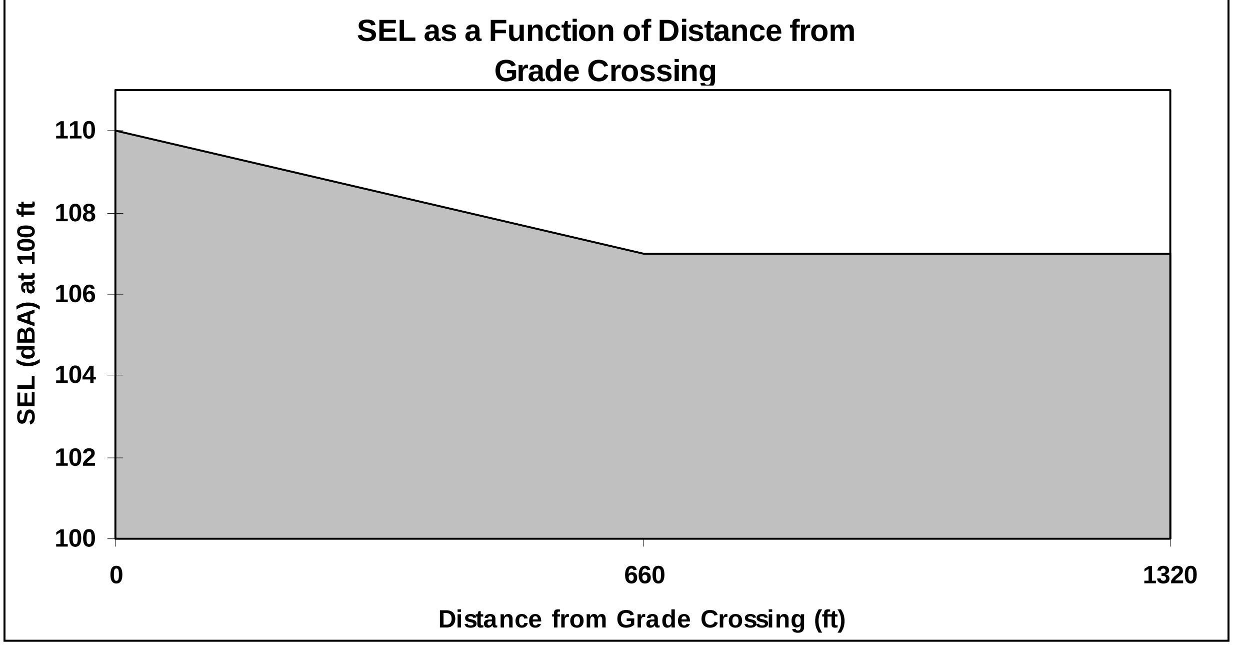

Figure L.2-2. SEL Model

The FRA model assumes an average attenuation of horn noise SEL of 4.5 decibels for every doubling of distance. This means that if the SEL is 110 dBA at 100 feet from the tracks, the SEL will be 105.5 dBA at a distance of 200 feet and 101 dBA at a distance of 400 feet. The 4.5 decibel attenuation for every distance doubling assumes propagation over soft ground but does not include any factor for acoustic shielding by intervening buildings. FRA found in their assessment that ignoring acoustic shielding can lead to very inaccurate estimates of the impacts from train horn noise.

FRA accounted for acoustic shielding by assuming that a typical condition for an at-grade crossing with adjacent noise-sensitive land uses is rows of buildings at distances of 200, 400, 600, 800 and 1,000 feet from the tracks with the percentage of each row occupied by buildings ranging from 40 to 65 percent.

Assuming a volume of 20 trains per day, with 1) no acoustic shielding, and 2) the approximate shielding adjustments, the L_{dn} 65 dBA contour would be approximately 750 feet from the tracks. With acoustic shielding the distance is reduced to approximately 400 feet.

L.3 Vibration Methodology

L.3.1 Railroad Vibration

SEA evaluated the potential effects of the Proposed Action on ground-borne vibration. The interaction of steel wheels rolling on steel rails causes ground-borne vibration that propagates from the track structure through the ground to nearby buildings. There are various means through which the vibration can be intrusive to building occupants, including perceptible vibration, rattling of windows and hanging items, or as a low-frequency rumble caused by sound radiated from vibration in walls, floors, and ceilings. It is extremely rare for ground-borne vibration generated by freight trains to be sufficient to cause damage, even minor cosmetic damage.

Vibration impacts could occur at any location where the Proposed Action would result in either a substantial increase in existing rail activities or new vibration-producing activities. The thresholds for vibration impact are based on the criteria given in the Federal Transit Administration (FTA) document, "Transit Noise and Vibration Impact Assessment" (FTA report FTA-VA-90-1003-06, May 2006), referred to herein as the FTA Guidance Manual. The FTA noise criteria are founded on well-documented research on community reaction to noise. Virtually identical noise and vibration impact criteria are included in the FRA document "High-Speed Ground Transportation Noise and Vibration Impact Assessment" (October 2005).

The following steps outline SEA's approach for identifying locations where the Proposed Action would potentially cause vibration impacts:

1) Measure vibration from existing EJ&E traffic. Ground-borne vibration from existing EJ&E train traffic was measured at representative locations along the EJ&E corridor. A minimum of four to six train events are necessary to develop an accurate estimate of train vibration at a specific site. Because of the limited number of train operations on the EJ&E corridor, SEA used a calibrated impact vibration source to supplement the train vibration data. This process allows SEA to characterize train vibration at a specific site without requiring the field team to be at the site for an extended period.

2) Measure vibration from CN trains. Ground-borne vibration was measured at representative locations along CN lines that carry the rail traffic that CN plans to reroute to the EJ&E lines.

3) Develop prediction models. SEA used the measurements collected in the previous step to develop vibration prediction models for each community in which there are vibration-sensitive receptors within 500 feet of the EJ&E tracks and a substantial increase in train traffic is forecasted. For this assessment, a substantial increase is defined as a minimum of eight trains per day or a 100 percent increase in million gross tons (MGT) hauled.

4) Predict vibration levels. Existing and future levels of ground-borne vibration from train traffic were predicted using information on distances to vibration-sensitive receptors and existing and future operating plans.

5) Count vibration-sensitive receptors. SEA counted the number of vibration-sensitive receptors where a substantial increase in the vibration impact is predicted. Aerial photographs, land use parcel data, and GIS software were used to estimate the number of vibration-sensitive receptors, including residences, schools, and places of worship, where a substantial increase in vibration impact is likely because of the Proposed Action and other alternatives.

L.3.2 Vibration Impact Thresholds

The FRA/FTA vibration criteria used for this analysis are based on the maximum level of ground-borne vibration that would be caused by a typical train pass-by. The FTA/FRA vibration criteria are designed to prevent annoyance from operations and are far below the damage thresholds for normal structures. Table L.3-1 below, presents the criteria for a General Vibration Impact Assessment. General impact assessment thresholds vary with land use and train frequency. FTA defines three land use categories for vibration impact. Vibration Category 1 applies to buildings that house vibration-sensitive equipment, such as high-resolution electron microscopes; Category 2 covers residential land uses; and Category 3 addresses institutional land uses such as schools, libraries, and churches. An important difference between noise and vibration impact criteria is that vibration criteria are applicable *only* to indoor spaces. This is because ground-borne vibration is rarely intrusive to observers who are outdoors.

The vibration criteria do not incorporate any factor to account for the number of trains per day—with one exception: occasional and infrequent service. The FTA impact assessment thresholds for occasional service are 3 velocity decibels (VdB) higher than for frequent service. For infrequent service, the FTA impact thresholds are 8 VdB higher than for frequent service. FTA defines occasional service to be between 30 and 70 trains per day and infrequent service to be less than 30 trains per day. The FTA/FRA vibration criteria are designed for rail transit and passenger trains and the implicit assumption is that the vibration when these types of trains pass will last a maximum of 10 to 20 seconds. This is in contrast to freight trains where the vibration can last for several minutes.

The predicted future CN traffic on the EJ&E lines is between 20 and 30 trains per day. To account for the longer duration of freight train vibrations than is assumed in the FTA criteria, rail car vibration has been evaluated using the thresholds applicable to frequent events and the locomotive vibration has been evaluated using the thresholds applicable to infrequent events. Vibration from locomotives ranges from 0 to 10 decibels higher than vibration from rail cars.

TABLE L.3-1. CRITERIA FOR GENERAL VIBRATION IMPACT ASSESSMENT

Land Use Category	Ground-borne Vibration (VdB re 1 µin/sec)		
	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
Category 1: Buildings where vibration would interfere with interior operations.	65	65	65
Category 2: Residences and buildings where people normally sleep.	72	75	80
Category 3: Institutional land uses with primarily daytime use.	75	78	83

Source: FTA, May 2006

Notes:

[a] Frequent events is defined as more than 70 vibration events per day.
[b] Occasional events is defined as between 30 and 70 events per day.
[c] Infrequent events is defined as less than 30 events per day.

Some buildings—such as concert halls, recording studios, and theaters—can be very sensitive to vibration but do not fit into any of the three categories listed in Table L.3-1 above. Due to the sensitivity of these buildings, they usually warrant special attention during the environmental evaluation of a transit project. Table L.3-2 below, presents criteria for acceptable levels of ground-borne vibration for various types of special buildings.

TABLE L.3-2. GENERAL VIBRATION IMPACT ASSESSMENT LIMITS FOR SPECIAL BUILDINGS		
Type of Building or Room	Ground-borne Vibration Impact Levels (VdB re 1 µin/sec)	
	Frequent Events[a]	Occasional or Infrequent Events[b]
Concert Halls	65	65
TV Studios	65	65
Recording Studios	65	65
Auditoriums	72	80
Theaters	72	80

Source: FTA, May 2006.
Notes:
[a] Frequent events is defined as more than 70 vibration events per day.
[b] Occasional and infrequent events are defined as fewer than 70 and 30 vibration events, respectively, per day.

For a detailed analysis, the 2006 version of the FTA Guidance Manual includes a separate set of vibration impact criteria that are based on the one-third octave band spectrum of the predicted vibration. Figure L.3-1 below, illustrates this set of criteria. The Residential Night curve is used to evaluate residential land uses and the VC-A through VC-E curves are used to evaluate buildings where vibration-sensitive equipment is located. Impact occurs if any part of the vibration spectrum protrudes above the criterion curve. As long as the entire one-third octave band spectrum is below the curve, vibration mitigation is not required.

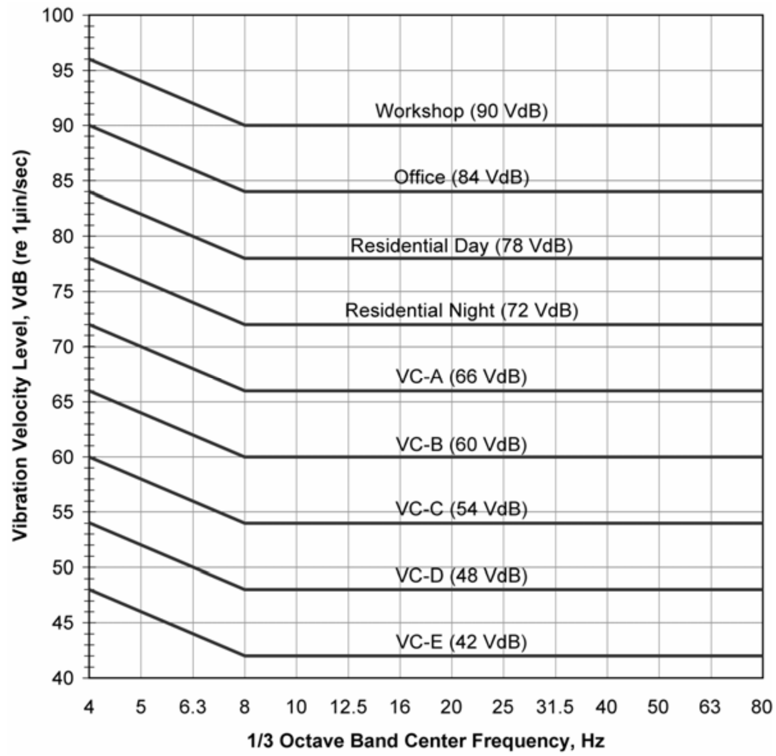

Figure L.3-1. FTA Criteria for Detailed Vibration Analysis

Using the Detailed Vibration Analysis curves to assess residential and institutional impacts allows higher vibration levels before impact occurs. For example, if the predicted vibration level is 72 VdB—right at the General Assessment impact threshold—the vibration spectrum will be between 0 and 5 decibels below the Residential Night curve.

L.3.3 Construction Noise and Vibration

While the construction of new connections, sidings, and double-track sections associated with the Proposed Action could intermittently create vibration that is perceptible inside buildings near the construction site, SEA anticipates the vibration will always be well below what is required to cause even minor cosmetic damage to buildings. In addition, the construction would be subject to any noise and vibration limits that are in the municipal codes of the cities in which the proposed construction would occur. For these reasons, SEA has not performed a quantitative vibration analysis for the construction activities associated with the Proposed Action.