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APPENDIX H
NOISE AND VIBRATION

Appendix H provides additional information on the noise and vibration methodology used in preparing the Supplemental EA and contains the noise and vibration contour maps.

H.1 NOISE EMISSION LEVELS OF TRAIN NOISE SOURCES

The sound propagation modeling occurred in Cadna-A, a three-dimensional acoustical analysis software package designed for evaluating environmental noise from stationary and mobile sources. Cadna-A uses as the basis for its models the International Organization for Standardization (ISO) standard 9613-2, “Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation” (ISO 1996). This standard provides a widely accepted engineering method for the calculation of outdoor environmental noise levels.

The Federal Transit Administration’s (FTA’s) *Transit Noise and Vibration Impact Assessment* (FTA 2006) provides a method for computing sound levels from fixed-guideway (train) sources. These calculation methods were mathematically manipulated to derive input data that is compatible with the Cadna-A software package. These manipulations yielded a sound power level (symbol: $L_W$; abbreviation: SWL) and some adjustment factors, depending on the type of noise source.

Table H.1-1 shows the parameters derived for use in train-noise-source modeling. The Surface Transportation Board’s Office of Environmental Analysis (OEA) validated these parameters in abstract model scenarios and compared them with hand calculations using the FTA propagation equations. The Cadna-A results were found to under-predict levels by 0.1 to 1.0 A-weighted decibels (dBA). Therefore, a conservative 2 dBA is added to compensate.
### Table H.1-1. Train Noise Source Modeling Parameters

<table>
<thead>
<tr>
<th>Train Noise Source</th>
<th>Type</th>
<th>Quantity&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SWL&lt;sup&gt;b&lt;/sup&gt; (dBA)</th>
<th>Adjustment&lt;sup&gt;c&lt;/sup&gt; (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel-electric locomotives</td>
<td>Moving</td>
<td>$Q = V \times N_{\text{loco}}$</td>
<td>120 + 2 = 122</td>
<td>+ $C_{\text{throttle}}$</td>
</tr>
<tr>
<td>Railcars</td>
<td>Moving</td>
<td>$Q = V \times N_{\text{cars}}$</td>
<td>97 + 2 = 99</td>
<td>+ 30 log($S/S_{\text{ref}}$) + $C_{\text{track}}$</td>
</tr>
<tr>
<td>Locomotive warning horns</td>
<td>Moving</td>
<td>$Q = V$</td>
<td>142 + 2 = 144</td>
<td>+ 0</td>
</tr>
</tbody>
</table>

Where:

- $Q$ = Number of noise events for moving point sources
- $V$ = Train traffic volume (number of trains)
- $N_{\text{loco}}$ = Number of locomotives per train
- $N_{\text{cars}}$ = Number of railcars per train
- $S$ = Average speed of train
- $S_{\text{ref}}$ = Reference speed of 50 mph [80.5 km/h]
- $C_{\text{throttle}}$ = Adjustment for throttle setting: 0 to 5 = 0 dBA; 6 = 2 dBA; 7 = 4 dBA; 8 = 6 dBA
- $C_{\text{track}}$ = Adjustment for track conditions: continuous welded rail = 0 dBA; jointed track = 5 dBA


Notes:

- <sup>a</sup> Quantities are distributed among daytime (7:00 a.m. to 10:00 p.m.) and nighttime (10:00 p.m. to 7:00 a.m.) proportionately such that an average daytime hour and an average nighttime hour will have equal quantities.
- <sup>b</sup> Sound power level (SWL) derived from values in FTA’s Transit Noise and Vibration Impact Assessment (2006). The moving point-source adjustment +2 is to compensate for under-predicting levels by 0.1 to 1.0 A-weighted decibels (dBA) when computer model is validated against hand-calculations.
- <sup>c</sup> Adjustment formulas derived from detailed noise assessment formulas in FTA (2006). These are the remaining terms after balancing the FTA equation against the computer-modeling equation for each type of noise source.

The locomotives and railcars were entered as moving point-sources in the sound propagation model, divided into rail line segments and subsegments. OEA modeled horn noise at all public at-grade crossings (no quiet zones were identified along the rail lines) as moving point-sources.

### H.2 SHELTERING

After completing calculations for both existing and proposed train operations, the output of the sound propagation model (that is, noise contours) was imported into the geographic information system (GIS) database. Obstructions that interrupt the line-of-sight to train sound sources provide a measure of shielding and correspondingly reduce sound levels. Therefore, the
shielding effects due to intervening buildings were applied within the GIS database (that is, noise contours were adjusted).

This analysis incorporated the shielding elements of the Federal Railroad Administration (FRA) horn noise model (FRA 2000). Aerial photographs were used to identify built-up areas where buildings are likely to provide shielding. In locations with a contiguous built-up area adjacent to the rail line, for example, where the rail line passes through cities and towns, assumptions associated with the FRA’s “Light Suburban” shielding condition described below were used to apply shielding values to the sound propagation model results and adjust the noise contours.

The FRA horn noise model uses generalized shielding conditions rather than calculating the shielding due to particular obstructions (FRA 2000). FRA identifies the following shielding conditions:

- Dense Urban
- Light Urban
- Dense Suburban
- Light Suburban
- Rural
- No Shielding

Table H.2-1 shows the assumptions associated with the above shielding conditions.

### Table H.2-1. Shielding Condition Parameters

<table>
<thead>
<tr>
<th>Building Density</th>
<th>Building Environment</th>
<th>Shielding Value (dBA)</th>
<th>Shielding Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense</td>
<td>Urban</td>
<td>None</td>
<td>&lt; 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0</td>
<td>100 to 300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.5</td>
<td>300 to 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.0</td>
<td>500 to 700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.5</td>
<td>700 to 900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.0</td>
<td>&gt; 900</td>
</tr>
<tr>
<td>Light</td>
<td>Suburban</td>
<td>None</td>
<td>&lt; 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0</td>
<td>200 to 400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.5</td>
<td>400 to 600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.0</td>
<td>600 to 800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.5</td>
<td>800 to 1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.0</td>
<td>&gt; 1,000</td>
</tr>
<tr>
<td>Rural</td>
<td>Rural</td>
<td>None</td>
<td>&lt; 300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0</td>
<td>300 to 500</td>
</tr>
<tr>
<td></td>
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<td>6.5</td>
<td>400 to 600</td>
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<td>8.0</td>
<td>500 to 700</td>
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<td>11.0</td>
<td>700 to 900</td>
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<tr>
<td></td>
<td></td>
<td>9.0</td>
<td>&gt; 1,000</td>
</tr>
</tbody>
</table>

Notes:

- Shielding condition is a combination of building density and building environment, such as the shielding condition “Dense Suburban.”
- Rural shielding conditions only use “Light” building density. There is no “Dense Rural” shielding condition.

### H.3 Noise and Vibration Contours

The analysis generated project-related noise and vibration contours overlaid on publicly available digital aerial photography. The 72-VdB contours for the rail lines and special track intersections are overlaid on aerial photographs in Attachment H-1.
H.4 REFERENCES


Legend
- 70 dBA Ldn and 5 dBA increase Receptor under the Proposed Action
- 65 dBA Ldn and 3 dBA increase Receptor under the Proposed Action
- Indianapolis Terminal Subdivision – Louisville Secondary Branch
- 65 dBA Ldn Contour under Existing Conditions
- 72 VdB Contour under Existing and Proposed Conditions
- County Boundary
- City Boundary

Noise and Vibration Analysis
Segment CSXT-06a
Legend

- 70 dBA Ldn and 5 dBA increase Receptor under the Proposed Action
- 65 dBA Ldn and 3 dBA increase Receptor under the Proposed Action
- 65 dBA Ldn Contour under Existing Conditions
- 72 VdB Contour under Existing and Proposed Conditions
- Louisville Connection
- County Boundary
- City Boundary

Noise and Vibration Analysis
Segment CSXT-01a

dBA = Noise Decibels
VdB = Vibration Decibels