Appendix E Noise and Vibration Technical Report

Appendix E: Noise and Vibration

E.1 INTRODUCTION

This appendix provides additional detail on the methodology and assumptions used to prepare the noise and vibration analysis of the Western Rail Yard Infrastructure Project (see Chapter 8, "Noise and Vibration").

E.2 REGULATORY CONTEXT

E.2.1 OPERATIONAL AIRBORNE NOISE

E.2.1.1 *FTA GUIDANCE MANUAL*

FRA considered impact criteria from both FTA and *CEQR Technical Manual* guidance in evaluating operational airborne noise impacts.

The FTA guidance manual defines noise criteria based on the specific type of land use that would be affected, with explicit operational noise impact criteria for three land use categories. These impact criteria are based on either peak 1-hour L_{eq} or 24-hour L_{dn} values. **Table E-1** describes the land use categories defined in the FTA report, and provides noise metrics used for determining operational noise impacts. As described in **Table E-1**, categories 1 and 3—which include land uses that are noise-sensitive, but where people do not sleep—require examination using the 1-hour L_{eq} descriptor for the noisiest peak hour. Category 2, which includes residences, hospitals, and other locations where nighttime sensitivity to noise is very important, requires examination using the 24-hour L_{dn} descriptor.

Table E-1
FTA's Land Use Category and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dB(A))	Description of Land Use Category
1	Outdoor $L_{eq(h)}$*	Tracts of land where quiet is an essential element in the intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels, where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor $L_{eq(h)}$*	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, and churches, where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for study or meditation associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.
Note: * L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity. **Source:** *Transit Noise and Vibration Impact Assessment*, FTA, September 2018.		

FTA's noise impact criteria for transit projects are shown in Figure 3-2 in the FTA guidance manual, (see Figure 5-1 in Appendix B, "Methodology Report"). The FTA impact criteria are keyed to the noise level generated by the project (called "project noise exposure") in locations of varying existing noise levels. Two types of impacts—moderate and severe—are defined for each land use category, depending on existing noise levels. Thus, where existing noise levels are 55 dB(A), for land use categories 1 and 2, the respective L_{eq} and L_{dn} noise exposure from the project would create moderate impacts if they were above approximately 55 dB(A), and would create severe impacts if they were above approximately 61 dB(A). For category 3, a project noise exposure level above approximately 60 dB(A) would be considered a moderate impact, and above approximately 66 dB(A) would be considered a severe impact. The qualitative difference between "severe impact" and "moderate impact" is that a severe impact occurs when a change in noise level occurs that a significant percentage of people would find annoying, while a moderate impact occurs when a change in noise level occurs that is noticeable to most people but not necessarily sufficient to result in strong adverse reactions from the community. Evaluation of operational airborne noise using FTA's noise impact criteria present a conservative evaluation under the *CEQR Technical Manual* noise impact criteria, and a separate evaluation is not necessary.

E.2.1.2 *NEW YORK CITY NOISE CONTROL CODE AND MECHANICAL CODE*

Operation of mechanical equipment associated with the Preferred Alternative, including fan plants and substation equipment, must meet both the airborne noise requirements listed in the New York City Noise Control Code (NYCNCC) and the New York City Mechanical Code section MC 928. The NYCNCC section §24-227 states that noise from an individual circulation device, including fans, must be less than 42 dB(A) when measured 3 feet inside an open window or terrace door of a receiving property dwelling unit. The cumulative noise from all circulation devices shall not exceed 45 dB(A) when measured 3 feet inside an open window or terrace door of a receiving property dwelling unit. Maximum permissible octave band limits for such equipment is provided in §24-232.

Additionally, mechanical equipment must satisfy the requirements of the New York City Mechanical Code section 928.3, "Minimum structure-borne noise and vibration isolation requirements" which delineates vibration isolation requirements.

E.2.2 **OPERATIONAL VIBRATION**

E.2.2.1 *FTA GUIDANCE MANUAL*

The FTA criteria for environmental impact from ground-borne vibration and noise are based on the maximum levels for a single event. The impact criteria as defined in the FTA guidance manual are shown in **Table E-2**. The criteria for acceptable ground-borne vibration are expressed in terms of RMS velocity levels in decibels and the criteria for acceptable ground-borne noise are expressed in terms of A-weighted sound level. As shown in the table, the FTA methodology provides three different impact criteria—one for "infrequent" events, when there are fewer than 30 vibration events per day, one for "occasional" events, when there are between 30 and 70 vibration events per day, and one for "frequent" events, when there are more than 70 vibration events per day. These impacts occur only if a project causes ground-borne noise or vibration levels that are higher than existing vibration levels. Thus, if the vibration level for a building in Category 1 is already 70 VdB (5 VdB above the 65 VdB threshold listed in **Table E-2**) but a hypothetical project will not increase that level, then the project will not be considered to have an impact.

Table E-2
Ground-Borne Vibration and Ground-Borne Noise
Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch/sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	N/A[4]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dB(A)	38 dB(A)	43 dB(A)
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dB(A)	43 dB(A)	48 dB(A)

Notes:
[1] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
[2] "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
[3] "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail systems.
[4] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
[5] Vibration-sensitive equipment is not sensitive to ground-borne noise.

The limits are specified for the three land use categories defined below:

- **Category 1: High Sensitivity** – Buildings where low ambient vibration is essential for the operations within the building, which may be well below levels associated with human annoyance. Typical land uses are vibration-sensitive research and manufacturing, hospitals, and university research operations.
- **Category 2: Residential** – This category covers all residential land uses and any buildings where people sleep, such as hotels and hospitals. No differentiation is made between different types of residential areas. This is primarily because ground-borne vibration and noise are experienced indoors and building occupants have practically no means to reduce their exposure. Even in a noisy urban area, the bedrooms often will be quiet in buildings that have effective noise insulation and tightly closed windows. Hence, an occupant of a bedroom in a noisy urban area is likely to be just as sensitive to ground-borne noise and vibration as someone in a quiet suburban area.
- **Category 3: Institutional** – This category includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference.

There are some buildings, such as concert halls, TV and recording studios, auditoriums, and theaters that can be very sensitive to vibration and ground-borne noise, but do not fit into any of these three categories. Special vibration level thresholds, shown in **Table E-3**, are defined in the FTA guidance manual for these land uses that have special sensitivity to vibration and ground-borne noise.

Table E-3
Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special Buildings

Type of Building or Room	GBV Impact Levels (VdB re 1 micro-inch/sec)		GBN Impact Levels (dB re 20 micro Pascals)	
	Frequent Events[1]	Occasional or Infrequent Events[2]	Frequent Events[1]	Occasional or Infrequent Events[2]
Concert Halls	65 VdB	65 VdB	25 dB(A)	25 dB(A)
TV Studios	65 VdB	65 VdB	25 dB(A)	25 dB(A)
Recording Studios	65 VdB	65 VdB	25 dB(A)	25 dB(A)
Auditoriums	72 VdB	80 VdB	30 dB(A)	38 dB(A)
Theaters	72 VdB	80 VdB	35 dB(A)	43 dB(A)

Notes:
[1] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
[2] "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.
[3] If the building will rarely be occupied when the trains are operating, there is no need to consider impact.

E.2.3 CONSTRUCTION AIRBORNE NOISE

E.2.3.1 *FTA GUIDANCE MANUAL*

The FTA guidance manual, general assessment procedure, specifies screening-level noise impact thresholds for daytime construction and night-time construction. The impact thresholds for construction are 90 dB(A) ($L_{eq,\ 1h}$) during daytime hours and 80 dB(A) ($L_{eq,\ 1h}$) during nighttime hours at residential receptors, assessed for the two noisiest pieces of equipment for each stage of construction. The impact threshold for commercial and industrial receptors, is 100 dB(A) ($L_{eq,\ 1h}$) during daytime or night-time construction.

E.2.3.2 *CEQR TECHNICAL MANUAL*

Chapter 22, Section 100, of the *CEQR Technical Manual* breaks construction duration into "short-term" and "long-term" and states that construction noise is not likely to require analysis unless it "affects a sensitive receptor over a long period of time." Consequently, the construction noise analysis considers both the potential for construction of a project to create high noise levels (the "intensity"), and whether construction noise would occur for an extended period of time (the "duration") in evaluating potential construction noise effects. As recommended in the *CEQR Technical Manual* the above-described operational noise impact criteria are considered in examining the intensity of construction noise. The concept of short-term and long-term is considered in evaluating the duration of construction noise.

The noise impact criteria described in Chapter 19, Section 410 of the *CEQR Technical Manual* serve as a screening-level threshold for potential construction noise impacts. If construction of the proposed project would not result in any exceedances of these criteria at a given receptor, then that receptor would not have the potential to experience a significant construction noise impact. The screening-level noise impact criteria for mobile and on-site construction activities are as follows:

If the No Action noise level is less than 60 dB(A) $L_{eq(1)}$, a 5 dB(A) $L_{eq(1)}$ or greater increase would require further consideration.

If the No Action noise level is between 60 dB(A) $L_{eq(1)}$ and 62 dB(A) $L_{eq(1)}$, a resultant $L_{eq(1)}$ of 65 dB(A) or greater would require further consideration.

If the No Action noise level is equal to or greater than 62 dB(A) $L_{eq(1)}$, or if the analysis period is a nighttime period (defined in the *CEQR Technical Manual* criteria as being between 10:00 PM and 7:00 AM), the threshold requiring further consideration would be a 3 dB(A) $L_{eq(1)}$ or greater increase.

If construction of the Preferred Alternative would result in exceedances of these noise impact criteria at a receptor, then further consideration of the intensity and duration of construction noise is warranted at that receptor. Generally, exceedances of these criteria on work days for 24 consecutive months or longer are considered to be significant impacts.

E.2.3.3 *NYC NOISE CONTROL CODE*

Construction of the Preferred Alternative would be required to follow the NYCNCC for construction noise control measures discussed below. Specific noise control measures would be incorporated in noise mitigation plan(s) required under the NYCNCC.

As per Local Law 113 of 2005, §24-228(a) *Construction, Exhausts, and other Devices,* "Sound, other than impulsive sound, attributable to the source or sources, that exceeds 85 dB(A) as measured 50 or more feet from the source or sources at a point outside the property line where the source or sources are located or as measured 50 or more feet from the source or sources on a public right-of-way" or "Impulsive sound, attributable to the source, that is 15 dB(A) or more above the ambient sound level as measured at any point within a receiving property or as measured at a distance of 15 feet or more from the source on a public right-of-way" is prohibited.

Construction equipment that meets the sound level standards specified in Subchapter 5 of the NYCNCC would be utilized.

E.2.4 **CONSTRUCTION VIBRATION**

E.2.4.1 *FTA GUIDANCE MANUAL*

Table E-4 and Table E-5 show architectural and structural damage risk and perceptibility thresholds for residential and historic structures in proximity to the types of construction activities that would occur during construction of the Proposed Action. Architectural damage includes cosmetic damage, such as cracked plaster, etc. Architectural damage is not considered potentially dangerous. As shown in **Table E-4**, pile driving has the greatest potential to result in architectural damage to most building types. While not shown in the table, controlled blasting also can result in high vibration levels in excess of 100 VdB with resultant damage to existing structures. Most other construction activities require very small (i.e., less than 25 feet) distances between the structure and the construction equipment or the presence of highly fragile buildings for impacts to occur. For fragile and highly fragile buildings respectively, FTA recommends a limit of peak particle velocities of 0.2 and 0.12 inches per second or 94 and 90 VdB.

Table E-4
Vibration Source Levels for Construction Equipment

Equipment	PPV at 25 ft (in/sec)	Approximate L_{v}* at 25 ft
Pile Driver (impact)	0.644	104
Pile Driver (sonic)	0.170	93
Clam Shovel drop (slurry wall)	0.202	94
Hydromill (slurry wall in soil)	0.008	66
Hydromill (slurry wall in rock)	0.017	75
Vibratory Roller	0.210	94
Hoe Ram	0.089	87
Large bulldozer	0.089	87
Caisson drilling	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58

Note: * RMS velocity in decibels (VdB) re 1 micro-inch/second
Source: *Transit Noise and Vibration Impact Assessment*, FTA Report No. 0123, September 2018

Table E-5
Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approximate L_{v}*
I. Reinforced-concrete, steel or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Note: * RMS velocity in decibels (VdB) re 1 micro-inch/second
Source: *Transit Noise and Vibration Impact Assessment*, FTA Report No. 0123, September 2018.

E.3 ANALYSIS METHODOLOGY

E.3.1 CONSTRUCTION VEHICLE NOISE

As shown in Section 8.5.3.1.2 of the EIS, noise from construction vehicles was calculated using proportional modeling according to the *CEQR Technical Manual* guidance in Section 332.1 Equation 19.1. This technique can be utilized at receptors where vehicle traffic is the dominant source of existing noise and compares existing traffic volumes to traffic volumes including the addition of construction vehicles to calculate the predicted incremental change in noise levels. Vehicular traffic volumes are converted into Passenger Car Equivalent (PCE) values, for which one medium-duty truck (having a gross weight between 9,900 and 26,400 pounds) is assumed to generate the noise equivalent of 13 cars, and one heavy-duty truck (having a gross weight of more than 26,400 pounds) is assumed to generate the noise equivalent of 47 cars, and one bus (vehicles designed to carry more than nine passengers) is assumed to generate the noise equivalent of 18 cars. The incremental change in noise levels due to construction vehicles is calculated using the following equation:

Incremental change in noise levels = 10 * $\log_{10}$ ((C PCE + EX PCE) / EX PCE)
where:
C PCE = Construction Vehicle PCE
EX PCE = Existing PCE

It follows that if the Construction PCE is equal to the Existing PCE (i.e., a 100 percent increase in PCE during construction), the resulting incremental change in noise levels would be 3 dB(A).

E.4 AFFECTED ENVIRONMENT

E.4.1 EXISTING NOISE LEVELS

As discussed in Section 8.4.3 of the EIS, the High Line was closed to the public west of Eleventh Avenue during the noise monitoring period. Therefore, existing noise levels during the weekday AM period at the High Line were estimated by utilizing a 1-hour measurement previously collected on November 3, 2016. The existing noise levels at Site 1 during the weekday midday and Saturday midday time periods were estimated by applying an adjustment factor to the weekday AM measurement. The adjustment factor was equal to the incremental change in noise between the respective time periods at Site 3, as shown in **Table E-6** below.

Table E-6
Determination of Existing Noise Levels at Site 1 (in dB(A))

	Weekday AM	Weekday Mid-day	Saturday Mid-day
Measured noise levels at Site 3 on October 24 and 27, 2020	69.6	70.4	66.4
Incremental change in existing noise levels between weekday AM and other time periods at Site 3 (Adjustment Factor)	N/A	0.8	-3.2
Measured noise levels at Site 1 on November 3, 2016	71.1	N/A	N/A
Adjusted existing noise levels for Site 1 used in EIS analysis	71.1	71.8	67.9

Note:
[1] See Figure 8-1 for noise monitoring site locations.

E.5 ENVIRONMENTAL CONSEQUENCES

E.5.1 CONSTRUCTION IMPACTS OF THE PREFERRED ALTERNATIVE

E.5.1.1 *CONSTRUCTION NOISE*

As discussed in Section 8.5.3.1.1 of the EIS, the construction noise levels at each receptor during each stage of Platform construction and Tunnel Encasement were calculated using the construction noise general assessment from the FTA guidance manual. FRA conducted a general assessment for construction noise assuming operation of hoe rams, which would be the loudest piece of equipment, and for drill rigs, which would represent the time periods outside of hoe ram usage. The construction noise levels during each stage of construction are shown in **Tables E-7 and E-8**.

Table E-7
General Assessment Construction Noise Levels – Hoe Ram (in dB(A))

Receptor Site[1]		Platform Construction[2]							Tunnel Encasement
		Stage 1A	Stage 1B	Stage 1C	Stage 1D	Stage 2E	Stage 2F	Stage 2G	
1	The High Line (P)	75	75	75	75	76	79	81	94
2a	15 Hudson Yards	70	71	71	72	73	73	74	77
2b	312 Eleventh Ave	68	68	69	70	70	71	72	75
2c	35 Hudson Yards	73	73	73	73	73	72	72	71
2d	55 Hudson Yards (C)	73	73	72	72	71	70	70	69
2e	3 Hudson Blvd (C)	71	71	70	69	69	68	67	67
3a	601 West 29th Street	69	70	70	71	72	75	77	80
3b	610 West 30th Street	69	70	71	72	73	73	75	84

Notes:
[1] See Figure 8-1 for receptor locations.
[2] See Figure 3-5 for Platform Construction stages
[3] The Project Sponsor has estimated that construction of the Platform would occur 6 days a week during daytime and nighttime hours, while the remaining construction would not typically include Saturday or nighttime activities.

Table E-8
General Assessment Construction Noise Levels – Drill Rig (in dB(A))

Receptor Site[1]		Platform Construction[2]							Tunnel Encasement
		Stage 1A	Stage 1B	Stage 1C	Stage 1D	Stage 2E	Stage 2F	Stage 2G	
1	The High Line (P)	70	70	70	70	71	74	76	89
2a	15 Hudson Yards	65	66	66	67	68	68	69	72
2b	312 Eleventh Ave	63	63	64	65	65	66	67	70
2c	35 Hudson Yards	68	68	68	68	68	67	67	66
2d	55 Hudson Yards (C)	68	68	67	67	66	65	65	64
2e	3 Hudson Blvd (C)	66	66	65	64	64	63	62	62
3a	601 West 29th Street	64	65	65	66	67	70	72	75
3b	610 West 30th Street	64	65	66	67	68	68	70	79

Notes:
[1] See Figure 8-1 for receptor locations.
[2] See Figure 3-5 for Platform Construction stages
[3] The Project Sponsor has estimated that construction of the Platform would occur 6 days a week during daytime and nighttime hours, while the remaining construction would not typically include Saturday or nighttime activities.

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