Chapter 12: Noise and Vibration

12.1 INTRODUCTION

In this chapter, the Federal Railroad Administration (FRA) and NJ TRANSIT have assessed the potential noise and vibration impacts associated with the Preferred Alternative by comparing existing noise levels with the projected future noise levels at sensitive receptors near the Project site. This chapter evaluates the potential for adverse noise and vibration impacts from both construction and operation of the Preferred Alternative and presents potential measures to avoid, minimize, and mitigate noise impacts.

This chapter contains the following sections:

12.2 ANALYSIS METHODOLOGY

During development of this Environmental Impact Statement (EIS), FRA and NJ TRANSIT developed methodologies for evaluating the potential effects of the Hudson Tunnel Project in coordination with the Project's Cooperating and Participating Agencies (i.e., agencies with a permitting or review role for the Project). The methodologies used for analysis of noise and vibration are summarized in this chapter.

The analysis of noise and vibration was conducted following procedures described in the Federal Transit Administration (FTA) guidance manual, *Transit Noise and Vibration Impact Assessment*, FTA-VA-90-1003-06, May 2006. While the FRA is the lead agency for the environmental review of the Project, the procedures set forth in the FTA guidance manual have been adopted by the FRA for analysis of noise and vibration resulting from non-high-speed (i.e., 125 miles per hour or below) rail projects.

12.2.1 NOISE AND VIBRATION FUNDAMENTALS AND DEFINITIONS

12.2.1.1 AIRBORNE NOISE FUNDAMENTALS

Quantitative information on the effects of airborne noise on people is well documented. If sufficiently loud, noise may adversely affect people in several ways. For example, noise may interfere with human activities, such as sleep, speech communication, and tasks requiring concentration or coordination. It may also cause annoyance, hearing damage, and other physiological problems. Several noise scales and rating methods are used to quantify the effects of noise on people. These scales and methods consider such factors as loudness, duration, time of occurrence, and changes in noise level with time. However, all the stated effects of noise on people are subjective.

Sound pressure levels are measured in units called “decibels” (dB). The particular character of the noise that we hear is determined by the rate, or “frequency,” at which the air pressure fluctuates, or “oscillates.” Frequency defines the oscillation of sound pressure in terms of cycles per second. One cycle per second is known as 1 Hertz (Hz). People can hear over a relatively limited range of sound frequencies, generally between 20 Hz and 20,000 Hz, and the human ear does not perceive all frequencies equally well. High frequencies are more easily discerned and therefore more intrusive than many of the lower frequencies.

12.2.1.1.1 “A”-Weighted Sound Level (dBA)

To bring a uniform noise measurement that simulates people’s perception of loudness and annoyance, the decibel measurement is weighted to account for those frequencies most audible to the human ear. This is known as the A-weighted sound level, or dBA, and because of the weighting based on human perception, it is the most often used descriptor of noise levels where community noise is the issue. As shown in **Table 12-1**, the threshold of human hearing is defined as 0 dBA; very quiet conditions (e.g., a library) are approximately 40 dBA; levels between 50 dBA and 70 dBA define the range of normal daily activity; levels above 70 dBA are considered noisy, and then loud, intrusive, and deafening as the scale approaches 130 dBA. For most people to perceive an increase in noise, it must be at least 3 dBA. At 5 dBA, the change will be readily noticeable.[1] An increase of 10 dBA is generally perceived as a doubling of loudness.

Combinations of different sources are not additive in an arithmetic manner, due to the decibel scale’s logarithmic nature. For example, two noise sources—a vacuum cleaner operating at approximately 72 dBA and a telephone ringing at approximately 58 dBA—do not combine to create a noise level of 130 dBA, the equivalent of a jet airplane or air raid siren (see **Table 12-1**). In fact, the noise produced by the telephone ringing may be masked by the noise of the vacuum cleaner and not be heard. The logarithmic combination of these two noise sources would yield a noise level of 72.2 dBA.

12.2.1.1.2 Effects of Distance on Noise

Noise varies with distance. For example, highway traffic 50 feet away from a receptor (such as a person listening to the noise) typically produces sound levels of approximately 70 dBA. The same highway noise measures 66 dBA at a distance of 100 feet, assuming soft ground conditions (such as grass). This decrease is known as “drop-off.” The outdoor drop-off rate for a line source, such as a railway, is a decrease of approximately 4.5 dBA (for soft ground) for every doubling of distance between the noise source and receptor. For hard ground (such as

1 Bolt, Beranek and Newman, 1973.

concrete), the outdoor drop-off rate is 3 dBA for line sources. Assuming soft ground, for a point source, such as a stationary piece of construction equipment (e.g., a drill rig), the outdoor drop-off rate is a decrease of approximately 7.5 dBA for every doubling of distance between the noise source and receptor (for hard ground the outdoor drop-off rate is 6 dBA for point sources).

Table 12-1
Common Noise Levels

Sound Source	(dBA)
Military jet, air raid siren	130
Amplified rock music	110
Jet takeoff at 500 meters	100
Freight train at 30 meters	95
Train horn at 30 meters	90
Heavy truck at 15 meters	
Busy city street, loud shout	80
Busy traffic intersection	
Highway traffic at 15 meters, train	70
Predominantly industrial area	60
Light car traffic at 15 meters, city or commercial areas or residential areas close to industry	
Background noise in an office	50
Suburban areas with medium density transportation	
Public library	40
Soft whisper at 5 meters	30
Threshold of hearing	0

Note: A 10 dBA increase in level appears to double the loudness, and a 10 dBA decrease halves the apparent loudness.
Sources: Cowan, James P. Handbook of Environmental Acoustics. Van Nostrand Reinhold, New York, 1994. Egan, M. David, Architectural Acoustics. McGraw-Hill Book Company, 1988.

12.2.1.1.3 Noise Descriptors Used in Impact Assessment

The sound-pressure level unit of dBA describes a noise level at just one moment, but since very few noises are constant, other ways of describing noise over more extended periods have been developed. One way of describing fluctuating sound is to describe the fluctuating noise heard over a specific period as if it were a steady, unchanging sound (i.e., as if it were averaged over that time period). For this condition, a descriptor called the “equivalent sound level” (L_{eq}) can be computed. L_{eq} is the constant sound level that, in a given situation and period (e.g., 1 hour, denoted by $L_{eq(1)}$, or 24 hours, denoted as $L_{eq(24)}$), conveys the same sound energy as the actual time-varying sound.

A descriptor for cumulative 24-hour exposure is the day-night average sound level, abbreviated as L_{dn}. This is a 24-hour measurement that accounts for the moment-to-moment fluctuations in A-weighted noise levels due to all sound sources, combined. Mathematically, the L_{dn} noise level is the energy average of all $L_{eq(1)}$ noise levels over a 24-hour period, where nighttime noise levels (10 PM to 7 AM) are increased by 10 dBA before averaging because of increased noise sensitivity during nighttime when people are typically sleeping.

Following guidance in the FTA guidance manual, *Transit Noise and Vibration Impact Assessment*, either the maximum $L_{eq(1)}$ sound level or the L_{dn} sound level is used for operational noise impact assessment, depending on land use category as described below in Section 12.2.2. Also as specified in the FTA guidance manual, the 8-hour equivalent level, i.e., the $L_{eq(8)}$, and the 30-day average L_{dn} are used for construction noise impact assessment as described below in Section 12.2.2.2.

12.2.1.2 VIBRATION AND GROUND-BORNE NOISE FUNDAMENTALS

Fixed railway operations have the potential to produce high vibration levels, since railway vehicles contact a rigid steel rail with steel wheels. Train wheels rolling on the steel rails create vibration energy that is transmitted into the track support system. The amount of vibrational energy is strongly dependent on such factors as how smooth the wheels and rails are and the vehicle suspension system. The vibration of the track structure “excites” the adjacent ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. As the vibration propagates from the foundation through the remaining building structure, certain resonant, or natural, frequencies of various components of the building may be excited.

Vibrations consist of rapidly fluctuating motions in which there is no “net” movement. When an object vibrates, any point on the object is displaced from its initial “static” position equally in both directions so that the average of all its motion is zero. Any object can vibrate differently in three mutually independent directions: vertical, horizontal, and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced. In a sense, the human body responds to average vibration amplitude, which is usually expressed in terms of the root mean square (RMS) amplitude.

The effects of ground-borne vibration may include discernable movement of building floors, rattling of windows, and shaking of items on shelves or hanging on walls. In extreme cases, the vibration can cause damage to buildings. The vibration of floors and walls may cause perceptible vibration, rattling of such items as windows or dishes on shelves. The movement of building surfaces and objects within the building can also result in a low-frequency rumble noise. The rumble is the noise radiated from the motion of the room surfaces, even when the motion itself cannot be felt. This is called ground-borne noise.

For vibration, VdB are used to distinguish vibration decibels from noise decibels. All vibration levels are referenced to 1×10^{-6} inches per second as is recommended in FTA and FRA guidance.

12.2.1.2.1 Effect of Propagation Path

Vibrations are transmitted from the source to the ground, and propagate through the ground to the receptor. Soil conditions have a strong influence on the levels of ground-borne vibration. Stiff soils, such as some clay and rock, can transmit vibrations over substantial distances. Sandy soils, wetlands, and groundwater tend to absorb movement and thus reduce vibration transmission. Because subsurface conditions vary widely, measurement of actual vibration conditions, or transfer mobility, at the site can be the most practical way to address the variability of propagation conditions.

12.2.1.2.2 Human Response to Vibration Levels

Although the perceptibility threshold for ground-borne vibration is about 65 VdB, the typical threshold of human annoyance is 72 VdB. As a comparison, buses and trucks rarely create vibration that exceeds 72 VdB unless there are significant bumps in the road, and these vehicles are operating at moderate speeds. Vibration levels for typical human and structural responses and sources are shown in **Table 12-2**.

Table 12-2
Typical Levels of Ground-Borne Vibration

Human/Structural Response	Velocity Level (VdB)	Typical Sources (at 50 feet)
Threshold, minor cosmetic damage fragile buildings	100	Blasting from construction projects
		Bulldozers and other heavy tracked construction equipment
Difficulty with vibration-sensitive tasks, such as reading a video screen	90	Locomotive powered freight train
Residential annoyance, infrequent events	80	Rapid Transit Rail, upper range
		Commuter Rail, typical range
Residential annoyance, frequent events		Bus or Truck over bump
	70	Rapid Transit Rail, typical range
Limit for vibration-sensitive equipment. Approximate threshold for human perception of vibration		Bus or truck, typical
	60	Typical background vibration
	50	
Source: U.S. Dept. of Transportation, FTA, *Transit Noise and Vibration Impact Assessment,* May 2006.		

12.2.2 STANDARDS AND CRITERIA

12.2.2.1 OPERATIONAL AIRBORNE NOISE STANDARDS AND CRITERIA

Following the procedures set forth in the FTA guidance manual, airborne noise impacts can be analyzed using a screening procedure, a general noise assessment, and/or a detailed noise analysis. The screening procedure is performed first to determine whether any noise-sensitive receptors are within distances where impacts are likely to occur. When there are noise-sensitive receptors in locations where impacts are likely to occur, then a general noise assessment is performed to determine locations where noise impacts could occur. If this general assessment indicates that a potential for noise impact does exist, then a detailed noise analysis may be necessary. The FTA's detailed analysis methodology is used to predict impacts and evaluate the effectiveness of mitigation with greater precision than can be achieved with the general noise assessment.

12.2.2.1.1 FTA Noise Impact Criteria

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 12-3** describes the land use categories defined in the FTA report, and provides noise metrics used for determining operational noise impacts. As described in **Table 12-3**, 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 12-3
FTA's Land Use Category and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dBA)	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, May 2006.

FTA's noise impact criteria for transit projects, as presented in Figure 3-1 in the FTA guidance manual, are shown in **Figure 12-1**. 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 40 dBA, 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 50 dBA, and would create severe impacts if they were above approximately 55 dBA. For category 3, a project noise exposure level above approximately 55 dBA would be considered a moderate impact, and above approximately 60 dBA would be considered a severe impact. The 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.

12.2.2.2 CONSTRUCTION AIRBORNE NOISE STANDARDS AND CRITERIA

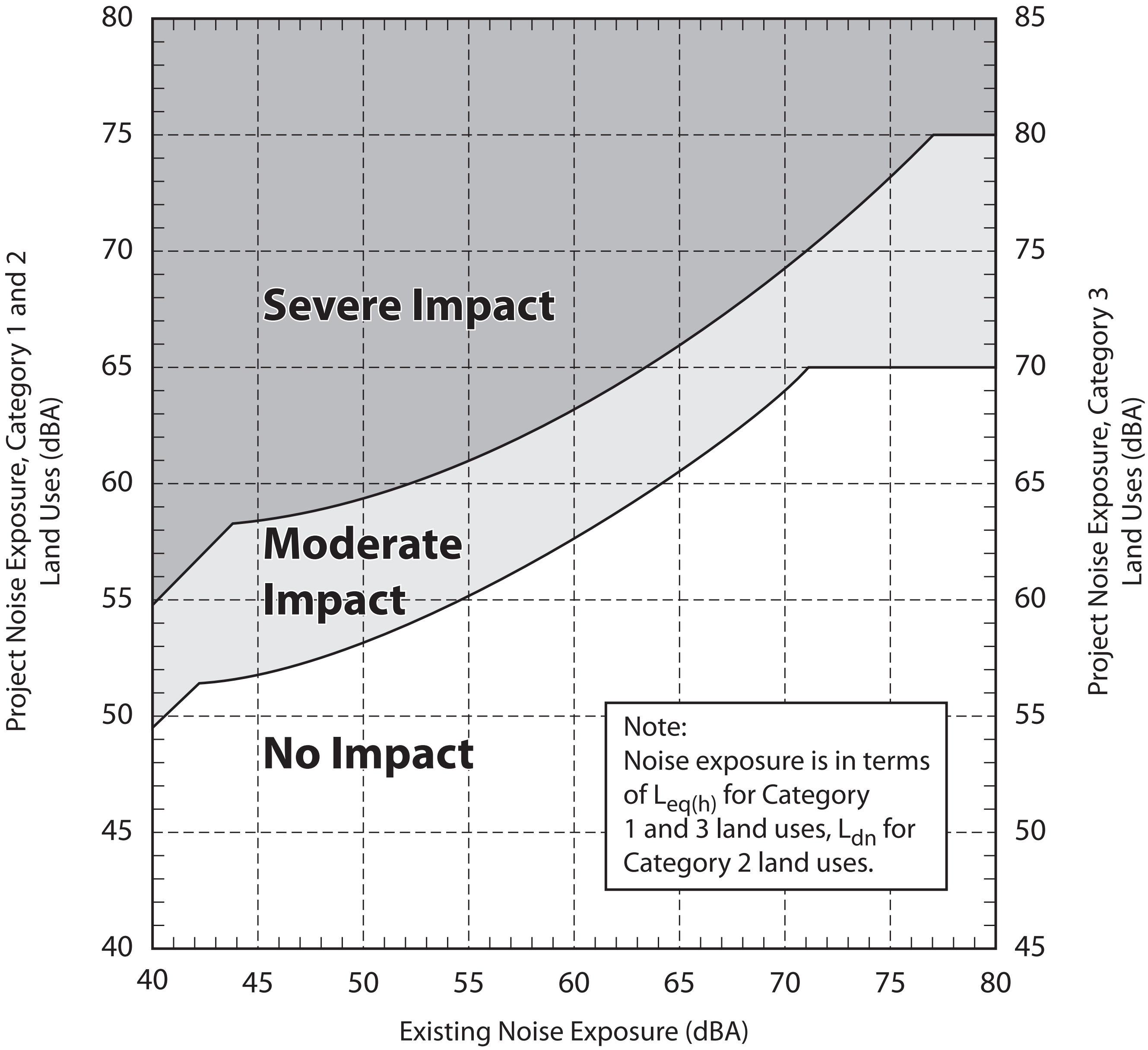
12.2.2.2.1 FTA Noise Impact Criteria

The FTA guidance manual specifies separate noise impact thresholds for daytime construction and nighttime construction and for the 30-day average construction noise level. The impact thresholds for construction are shown in **Table 12-4**.

Table 12-4
FTA Construction Noise Impact Criteria (in dBA)

Land Use	$L_{eq(8)}$		L_{dn}
	Day	Night	30-day Average
Residential	80	70	75[1]
Commercial	85	85	80[2]
Industrial	90	90	85[2]

Notes: [1] In urban areas with very high ambient noise levels (L_{dn} greater than 65 dBA), L_{dn} from construction operations should not exceed existing ambient + 10 dBA.
[2] 24 hour L_{eq}, not L_{dn}.



Source: Transit Noise and Vibration Impact Assessment, FTA-VA-90-1003-06, May 2006

FTA Noise Impact Criteria for Transit Projects

Figure 12-1

12.2.2.2.2 New York City CEQR Noise Impact Criteria

For receptors in New York City, the construction noise impact criteria from the New York City *CEQR Technical Manual* were also considered in the identification of adverse noise impacts. The *CEQR Technical Manual* was developed by New York City for evaluation of the environmental impacts of projects proposed in New York, based on local conditions and issues; these criteria for adverse impacts are well suited for evaluation of effects in New York City. Consideration of noise impacts using CEQR impact criteria will allow New York City agencies that will issue a permit or approval to use this analysis to meet their environmental review obligations under CEQR.

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.

Chapter 19, Section 421 of the *CEQR Technical Manual* states that the impact criteria for vehicular sources, using conditions without the proposed project, or the "No Action" noise level as the baseline, should be used for assessing construction effects. As recommended in Chapter 19, Section 410 of the *CEQR Technical Manual*, this study uses the following CEQR criteria to define a significant adverse noise impact from mobile and on-site construction activities:

- If the No Action noise level is less than 60 dBA $L_{eq(1)}$, a 5 dBA $L_{eq(1)}$ or greater increase would be considered significant per CEQR criteria.
- If the No Action noise level is between 60 dBA $L_{eq(1)}$ and 62 dBA $L_{eq(1)}$, a resultant $L_{eq(1)}$ of 65 dBA or greater would be considered a significant increase per CEQR criteria.
- If the No Action noise level is equal to or greater than 62 dBA $L_{eq(1)}$, or if the analysis period is a nighttime period (defined in the *CEQR* criteria as being between 10 PM and 7 AM), the incremental significant impact threshold would be 3 dBA $L_{eq(1)}$ per CEQR criteria.

Because future noise levels for the Project site and surrounding area in New York City without the Preferred Alternative will be comparable to existing noise levels in New York, with only moderate noise increases due to growth of vehicular traffic in the area as a result of the numerous new development projects anticipated, existing noise levels were used as a conservative representation of future noise levels in the No Action condition for the construction noise analysis.

12.2.2.3 OPERATIONAL VIBRATION AND GROUND-BORNE NOISE STANDARDS AND CRITERIA

To examine potential impacts during operation, the FTA guidance document (similar to the approach for assessing airborne noise) lays out a three-step approach for the analysis of vibration and ground-borne noise: a screening procedure, a general assessment methodology, and a detailed analysis methodology. The screening procedure is used to determine whether any vibration-sensitive receptors are within distances where impacts are likely to occur. The general assessment methodology is used to determine locations or rail segments where there is the potential for impacts. The detailed analysis methodology is used to predict impacts and evaluate the effectiveness of mitigation with greater precision than can be achieved with the general assessment.

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 12-5**. 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 12-5**) but a hypothetical project will not increase that level, then the project will not be considered to have an impact.

Table 12-5
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 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

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 are defined for these land uses that have special sensitivity to vibration and ground-borne noise.

12.2.2.4 CONSTRUCTION VIBRATION AND GROUND-BORNE NOISE STANDARDS AND CRITERIA

12.2.2.4.1 FTA Vibration Impact Criteria

Table 12-6 and **Table 12-7** 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 Preferred Alternative. Architectural damage includes cosmetic damage, such as cracked plaster, etc. Architectural damage is not considered potentially dangerous. As shown in **Table 12-7**, pile driving has the greatest potential to result in architectural damage to most building types. 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 (PPV) of 0.2 and 0.12 inches per second or 94 and 90 VdB.

Table 12-6
Vibration Source Levels for Construction Equipment

Equipment	PPV at 25 ft (in/sec)	Approximate L_v[1] at 25 ft
Pile Driver (impact)	0.644 – 1.518	104 – 112
Pile Driver (sonic)	0.170 – 0.734	93 - 105
Blasting	>0.400[2]	>100[2]
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: [1] RMS velocity in decibels (VdB) re 1 micro-inch/second
[2] Estimated minimum based on approximately 0.75 pounds explosive
Source: *Transit Noise and Vibration Impact Assessment*, FTA-VA-90-1003-06, May 2006.

Table 12-7
Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approximate L_v*
I. Reinforced-concrete, steel or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	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-VA-90-1003-06, May 2006.

12.2.2.4.2 NYCDOB Construction Vibration Evaluation Criteria

Specifications for construction-generated vibration are set forth in the New York City Department of Buildings' (NYCDOB) Technical Policies and Procedures Notice (TPPN #10/88). As per TPPN #10/88, PPV from project construction is not permitted to exceed the vibration damage threshold criterion of 0.5 inches per second at historic structures. While NYCDOB does not provide a definition of "historic structures," it is generally interpreted to mean a nationally or locally listed landmark structure or a contributing structure in a listed historic district. For buildings that are not historic, the 0.5 inches per second threshold is often used as a conservative criterion to evaluate vibration although non-historic buildings are typically able to safely withstand PPV up to 2.0 inches per second as specified by U.S. Bureau of Mines vibration evaluation criteria.

12.2.3 ANALYSIS METHODOLOGY

12.2.3.1 AIRBORNE NOISE

12.2.3.1.1 Construction Impacts

FRA and NJ TRANSIT analyzed airborne noise associated with construction of the Preferred Alternative using the detailed analysis procedures described in the FTA guidance manual to the extent possible based on the conceptual construction information available. **Appendix 12** includes an illustration of the conceptual staging site layouts that were analyzed in this chapter, with the potential locations of different kinds of construction equipment on each staging site. Noise due to the operation of construction equipment on-site at a specific receptor location near a construction site was calculated by computing the sum of the noise produced by all major pieces of equipment operating at the construction site. For each piece of equipment the noise levels at a receptor site is a function of:

- The noise emission level of the equipment;
- A usage factor, which accounts for the percentage of time the equipment is operating;
- The distance between the piece of equipment and the receptor;
- Topography and ground effects; and
- Shielding.

Similarly, noise levels due to construction traffic are a function of:

- The noise emission levels of the type of vehicle (e.g., auto, light-duty truck, heavy-duty truck, bus)
- Vehicular speed;
- The distance between the roadway and the receptor;
- Topography and ground effects; and
- Shielding.

For the analysis, FRA and NJ TRANSIT assumed a confluence of worst-case conditions—peak Project-generated construction traffic, peak construction, and lowest ambient noise levels for existing conditions, all operating simultaneously during the construction periods. This methodology resulted in a conservative estimate of impacts. FRA and NJ TRANSIT compared the projected construction noise levels at each receptor to the FTA construction noise impact criteria to determine the potential for construction noise impacts. The identification of impacts at receptors near the Project construction work areas considered the magnitude of construction noise at the receptors as well as the duration of construction at the adjacent work area.

12.2.3.1.2 Operational Impacts

For the analysis of operational airborne noise, FRA and NJ TRANSIT used the following procedures:

- Identification of noise-sensitive land uses (e.g., residential, church, certain parks) within the screening distance from the alignment and selection of representative noise receptor sites.
- Determination of existing noise levels at the selected receptor sites by performing field measurements and using acoustical fundamentals. For sites at which direct access to conduct noise level measurements was not available, measurements performed at a nearby location with a comparable level of non-rail noise were used to represent existing noise levels.
- At selected noise receptor sites that experience existing rail noise, calculation of existing rail noise levels at each receptor site for each analysis time period using FTA's Chicago Rail Efficiency and Transportation Efficiency (CREATE) model and data associated with the existing conditions on the railway. These calculated rail noise levels were then subtracted from measured existing noise levels to determine the non-rail component of the noise level (e.g., noise from vehicular traffic, aircraft, parking lots, etc.) at each site.
- Calculation of future rail noise levels resulting from the Preferred Alternative according to the CREATE model.
- Calculation of future noise levels resulting from operation of the proposed fan plants included in the Preferred Alternative based on manufacturer's specifications for the proposed ventilation equipment.
- Determination of future noise levels with the Preferred Alternative at each receptor site as the sum of calculated rail noise level, ventilation shaft fan plant noise level, and the calculated non-rail noise level.
- Determination of the Project noise exposure at each receptor site, using the future noise levels for the Preferred Alternative.
- Comparison of the Project noise exposure for the Preferred Alternative to the FTA criteria to identify potential impacts.

12.2.3.2 VIBRATION AND GROUND-BORNE NOISE

12.2.3.2.1 Construction Impacts

Following the general analysis procedures described in the FTA guidance manual, for each construction work area using impact equipment (i.e., pile drivers or rock excavation equipment), vibration levels were projected to nearby receptors and compared to FTA vibration impact criteria.

12.2.3.2.2 Operational Impacts

The FTA vibration analysis methodology begins with a vibration screening to determine whether any vibration-sensitive receptors are within a distance where an impact is likely to occur. According to the FTA screening methodology, potential impacts may occur if high-sensitivity vibration receptors are within 600 feet of the centerline of a commuter rail mainline, residential receptors are within 200 feet from the track centerline, or institutional/office receptors are located within 120 feet from the track centerline. For the Preferred Alternative, residences are located within the screening distance of the Preferred Alternative.

For each receptor identified within the screening distances, future rail vibration levels with the Preferred Alternative were calculated according to the FTA guidance manual's general analysis methodology. The predicted vibration levels were compared to the FTA vibration shown above in

Table 12-5 to identify potential operational vibration impacts associated with the Preferred Alternative.

12.2.3.3 SELECTION OF RECEPTOR LOCATIONS

The study area for the operational airborne noise study includes receptors within the FTA guidance manual screening distances of the proposed new surface tracks in the Meadowlands in New Jersey and the new fan plants in New Jersey and New York. The study area for the construction airborne noise study includes receptors within the FTA guidance manual screening distances of the new surface tracks in New Jersey and the fan plant buildings and construction staging areas in New York and New Jersey. The study area for the operational and construction vibration and ground-borne noise studies includes receptors within the FTA guidance manual screening distances above the proposed new tunnel on either side of the Hudson River.

12.2.3.4 METHODOLOGY AND EQUIPMENT USED FOR NOISE SURVEY

Noise measurements were taken using Brüel & Kjær Noise Level Meters Type 2260 and 2250, Brüel & Kjær Sound Level Calibrators Type 4231, and Brüel & Kjær ½-inch microphones Type 4189. Instruments were mounted at a height of approximately 5 feet above the ground. The meters were calibrated before and after readings using Brüel & Kjær Type 4231 sound level calibrators using the appropriate adaptors. The sound meters digitally recorded the data and displayed the data at the end of the measurement period in units of dBA. Measured quantities included L_{eq}, L_1, L_{10}, L_{50}, and L_{90}. Windscreens were used during all sound measurements except for calibration. All measurement procedures conformed to the requirements of ANSI Standard S1.13-2005.

12.3 AFFECTED ENVIRONMENT: EXISTING CONDITIONS

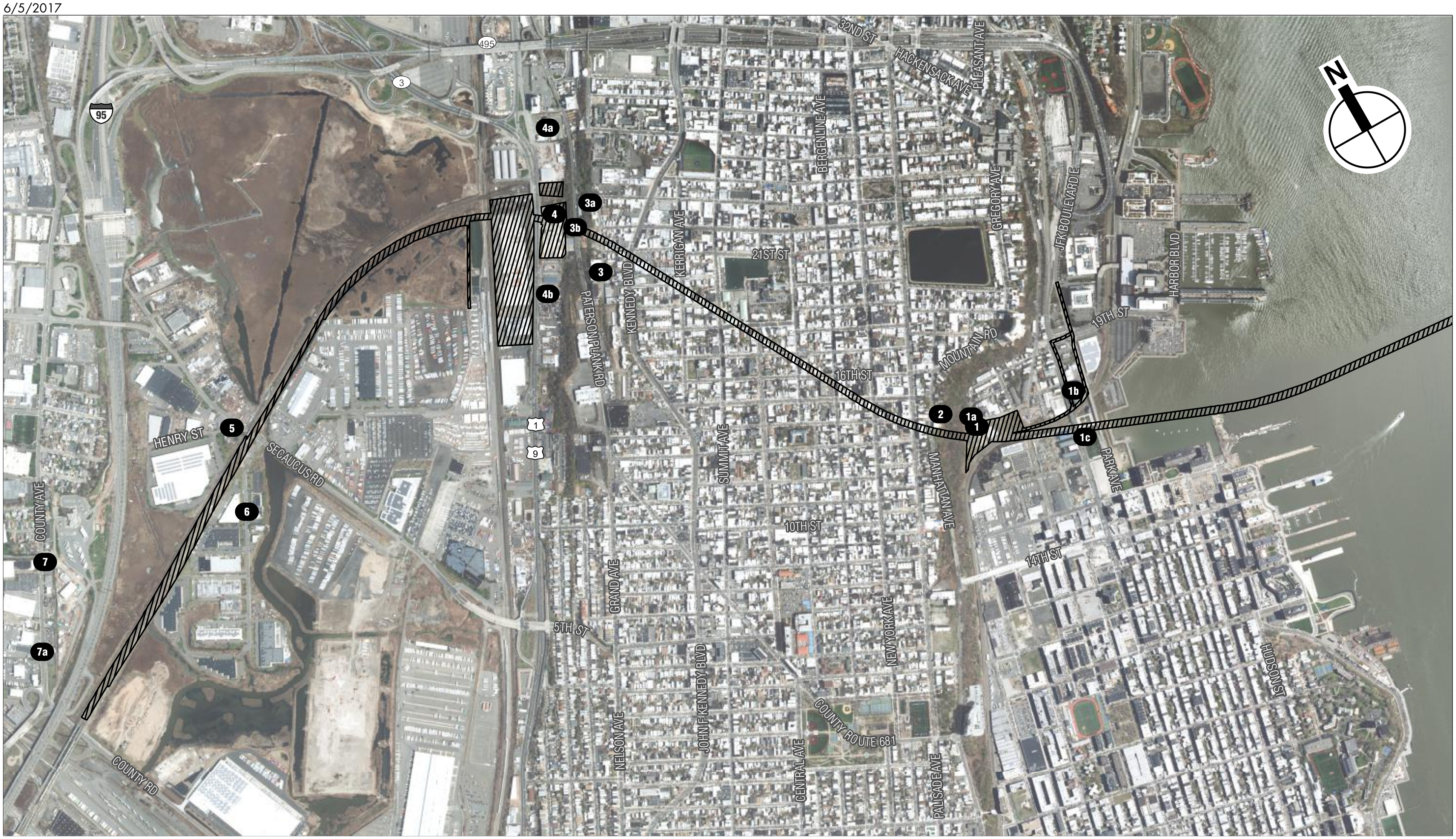
12.3.1 NEW JERSEY

12.3.1.1 NOISE RECEPTOR LOCATIONS

Fifteen receptor sites in New Jersey were selected to represent noise-sensitive locations that would have the greatest potential to experience noise level increases resulting from the Preferred Alternative. The receptors are representative of existing land uses in the Project area and were chosen to provide geographic coverage of the areas where noise impacts may occur. The 15 receptor locations were selected at the closest developed land uses to the new surface tracks in the Meadowlands, the new Hudson River Tunnel portal at Tonnelle Avenue, the Hoboken fan plant, and each of the construction staging areas in New Jersey. For this reason, each receptor studied would be more likely to experience noise impacts from Project activities than other sites in their general locations. The locations of the 15 receptor sites are listed in **Table 12-8** and shown in **Figure 12-2**.

12.3.1.2 MEASURED NOISE LEVELS

Noise measurements were conducted at survey locations to represent each of the receptors in **Table 12-8**. Data from the surveys were utilized to determine existing noise levels according to the FTA guidelines, using the noise level descriptor for each receptor's land use category per **Table 12-3**. At receptor sites 1, 4, and 7, 24-hour continuous noise level measurements were conducted, as indicated in **Table 12-9**, below. For the remaining residential receptors, 24-hour measurements could not be conducted due to site access and security. Instead, one-hour spot noise measurements were conducted during the AM peak, midday, and late-night time periods. Noise levels from these three measurements were combined to estimate the existing L_{dn} following the guidelines in Appendix D of the FTA manual. At receptor site 6, one-hour spot noise level measurements were conducted during the peak AM time period, which represents the peak (i.e., 6/5/2017



Project Site

1 *Noise Receptor*

0 2,000 FEET

HUDSON TUNNEL PROJECT

New Jersey Noise Receptor Locations

Figure 12-2

worst-case) period of noise production for the Project, since this is when peak vehicle activities would occur. Noise level measurements were conducted on October 26 and November 1, 2, 3, 4, 14, 15, and 18, 2016.

Table 12-8
Noise Receptor Locations in New Jersey

Receptor	Location[1]	Land Use Represented	FTA Land Use Category	Noise Descriptor
1	77 West 18th St, Weehawken	Noise survey location representing Site 1a	2	L_{dn}
1a	78 West 18th St, Weehawken	Residential	2	L_{dn}
1b[2]	1700 Park Ave, Weehawken	Residential	2	L_{dn}
1c[2]	1600 Park, Hoboken	Recreational	3	Daytime $L_{eq(1h)}$
2	1404 Manhattan Ave, Union City	Residential	2	L_{dn}
3	2001 Grand Ave, North Bergen	Residential	2	L_{dn}
3a	2215 Grand Ave, North Bergen	Residential	2	L_{dn}
3b	2200 Paterson Plank Rd, North Bergen	Residential	2	L_{dn}
4	2432 Tonnelle Ave, North Bergen	Noise survey location representing Site 4a	2	L_{dn}
4a	2600 Tonnelle Ave, North Bergen	Hotel	2	L_{dn}
4b	2000 Tonnelle Ave, North Bergen	Religious	3	Daytime $L_{eq(1h)}$
5	Henry St (near Secaucus Rd on north side of NEC), Secaucus	Residential	2	L_{dn}
6	200 Penhorn Ave, Secaucus	Religious	3	Daytime $L_{eq(1h)}$
7	148 County Rd, Secaucus	Residential	2	L_{dn}
7a	58 County Rd, Secaucus	Residential	2	L_{dn}

Notes: [1] See **Figure 12-2** for locations.
[2] These receptors were outside the screening distance for the operational noise analysis, but were in proximity to construction work areas; therefore were included in the construction noise analysis only.

Existing noise at receptors 3a through 7a includes noise generated by existing rail operations along the Northeast Corridor (NEC). Additionally, existing noise levels at all receptors include noise generated by other sources including vehicular traffic, aircraft overflights, and nearby mechanical equipment. The CREATE rail model, along with existing conditions rail traffic data, was used to determine the level of rail noise at each receptor location. To determine the level of non-rail noise at each receptor, noise levels were measured at or near the receptor site, and the calculated rail noise (obtained using the CREATE rail model) was subtracted from the measured level. At receptor sites 1a, 1b, 1c, 3a, 3b, 4a, 4b, and 7a, measurements conducted at nearby locations with comparable levels of non-rail noise were used to estimate existing noise levels. In some cases, the measurement location was up to a few hundred feet away from the receptor location. The total existing noise level at each noise receptor site was determined by combining the existing condition rail noise level (calculated using the CREATE model) with the calculated non-rail noise level.

Table 12-9 shows the calculated rail noise, calculated non-rail noise, and existing noise levels (which are the sum of the rail and non-rail noise components) at each New Jersey receptor site. These values were calculated following the procedures described above.

Table 12-9
Existing Noise Levels in New Jersey (in dBA)

Site	FTA Land Use Category	Noise Descriptor	Measurements Performed	Calculated Rail Noise Level Component	Calculated Non-Rail Noise Level Component	Existing Noise Level
1a	2	L_{dn}	Based on 24-hour at Site 1	0	60	60
1b	2	L_{dn}	Based on 24-hour at Site 1	0	60	60
1c	3	Daytime $L_{eq(1h)}$	Based on 24-hour at Site 1	0	57	57
2	2	L_{dn}	AM peak, midday, late night	0	63	63
3	2	L_{dn}	AM peak, midday, late night	53	53	56
3a	2	L_{dn}	Based on Site 3	56	0	56
3b	2	L_{dn}	Based on Site 3	56	0	56
4a	2	L_{dn}	Based on 24-hour at Site 4	64	71	72
4b	3	Daytime $L_{eq(1h)}$	Based on 24-hour at Site 4	57	67	68
5	2	L_{dn}	AM peak, midday, late night	78	0	78
6	3	Daytime $L_{eq(1h)}$	AM peak	59	66	66
7a	2	L_{dn}	24-hour	63	78	78

Note: Field measurements were performed by AKRF, Inc. on October 26 and November 1, 2, 3, 4, 14, 15, and 18, 2016.

12.3.1.3 VIBRATION RECEPTOR LOCATIONS

As described above, FRA and NJ TRANSIT identified residential receptors within the FTA guidance manual's vibration analysis screening distances from the Preferred Alternative. This included six receptors in New Jersey: receptors 1a, 1b, 3a, 3b, 4b, and 5. Additionally, FRA and NJ TRANSIT evaluated the potential vibration effects at the proposed future Rebuild By Design flood wall along Park Avenue in Weehawken (receptor 1d), under which the Preferred Alternative tunnel passes. These receptors used for the vibration analyses are listed in **Table 12-10**.

Table 12-10
Vibration Receptor Locations in New Jersey

Receptor	Location[1]	Distance/Relation to Vibration Source
1a	78 West 18th St, Weehawken	130 feet from Hoboken shaft and fan plant site
1b[2]	1700 Park Ave, Weehawken	281 feet from Willow Avenue underpinning
1d	Rebuild By Design Flood Protection Wall	Approximately 40 to 100 feet above new tunnel
3a	2215 Grand Ave, North Bergen	100 feet above new tunnel
3b[2]	2200 Paterson Plank Rd, North Bergen	345 feet from tunnel portal
4b[2]	2000 Tonnelle Ave, North Bergen	620 feet from tunnel portal, 118 feet from staging area
5	Henry St (near Secaucus Rd on north side of NEC), Secaucus	105 feet from new on-structure track

Notes: [1] See **Figure 12-2** for locations.
[2] Receptors outside the screening distance for the operational vibration analysis, but in proximity to construction work areas, so included in the construction vibration analysis only.

12.3.2 HUDSON RIVER

There are no noise or vibration receptors within the Hudson River that would have the potential to experience adverse impacts as a result of the Preferred Alternative. The nearest upland area or structure to the work area within the river would be the bulkhead along the west side of Manhattan, approximately 700 feet to the east. At this distance, noise produced by construction of the Preferred Alternative would not have the potential to appreciably increase noise levels, and vibration produced by construction of the Preferred Alternative would not have the potential to result in damage, even to fragile structures. For discussion of construction noise and vibration effects on the in-water environment, please see Chapter 11, "Natural Resources," Section 11.6.3.1.3.

12.3.3 NEW YORK

12.3.3.1 NOISE RECEPTOR LOCATIONS

In New York, FRA and NJ TRANSIT selected six receptor sites to represent noise-sensitive locations that would have the greatest potential to experience noise level increases resulting from the Preferred Alternative. The receptors are representative of existing land uses in the Project area and provide geographic coverage of the areas where noise impacts may occur. FRA and NJ TRANSIT selected the six receptor locations at the closest developed land uses to the proposed Twelfth Avenue fan plant in New York, the in-water construction work site, and the construction staging areas in New York. These receptors included one receptor, receptor 8a, where a future development is proposed as part of the Block 675 East project (see discussion in Section 12.4 below). For this reason, each receptor would yield maximum noise impacts (i.e., other potential receptor sites in the general location of the selected receptors would have lesser impacts). The locations of the six receptor sites are listed in **Table 12-11** and shown in **Figure 12-3**.

Table 12-11
Noise Receptor Locations in New York

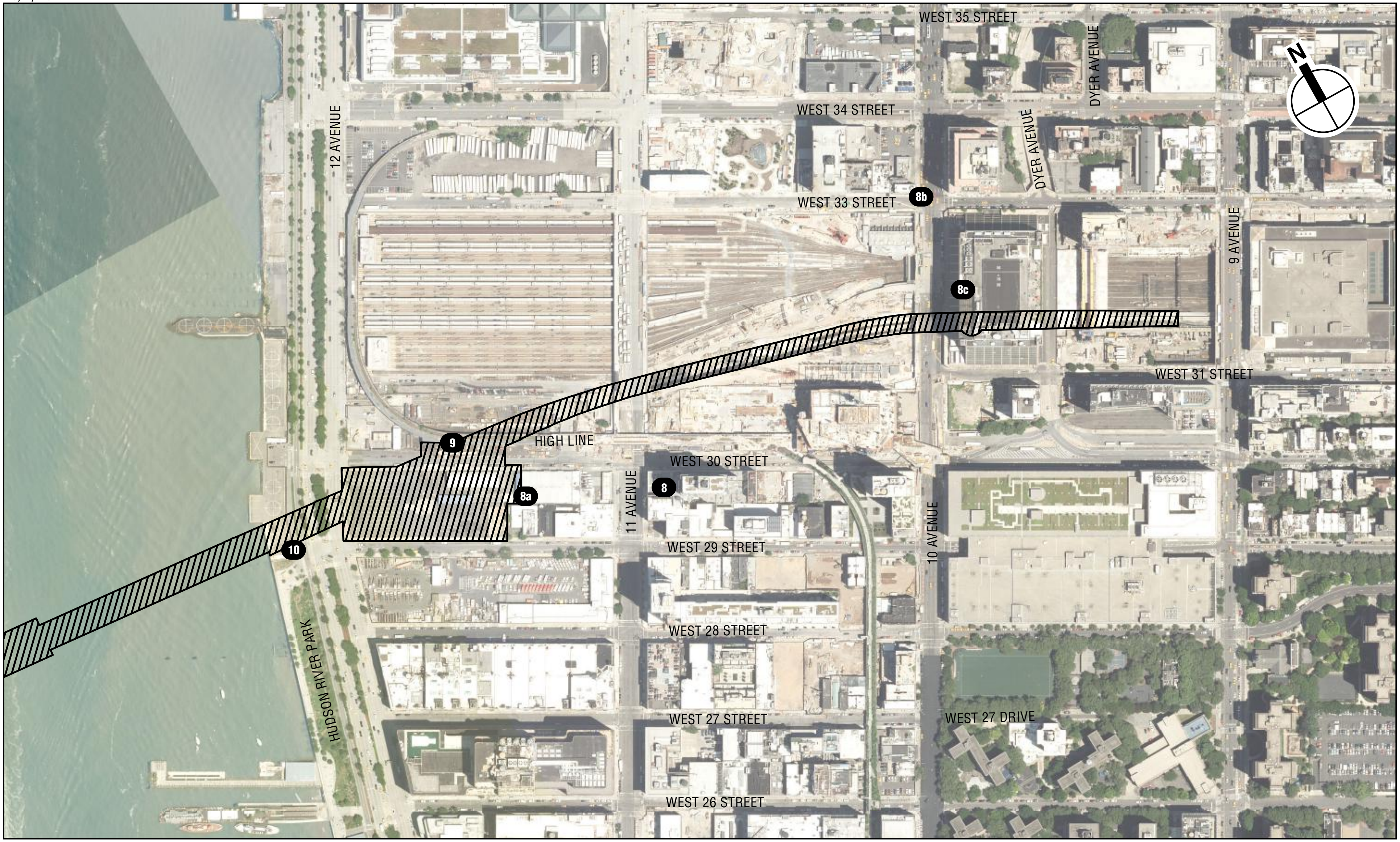
Receptor*	Location	Land Use Represented	FTA Land Use Category	Noise Descriptor
8	312 Eleventh Ave	Residential	2	L_{dn}
8a	606 West 30th St	Future Residential	2	L_{dn}
8b	413 Tenth Ave	Residential	2	L_{dn}
8c	450 West 33rd St	Commercial	3	Daytime $L_{eq(1h)}$
9	High Line Park	Recreational	3	Daytime $L_{eq(1h)}$
10	Hudson River Park	Recreational	3	Daytime $L_{eq(1h)}$

Note: * See **Figure 12-3** for locations.

12.3.3.2 MEASURED NOISE LEVELS

FRA and NJ TRANSIT conducted noise measurements at survey locations to represent each of the receptors in **Table 12-11** and analyzed data from the surveys to determine existing noise levels according to the FTA guidelines (using the noise level descriptor for each receptor's land use category per **Table 12-3**). At the receptor sites in New York, FRA and NJ TRANSIT could not conduct 24-hour measurements due to issues of site access and security. Instead, one-hour spot noise measurements were conducted during the AM peak, midday, and late-night time periods. At receptor sites 9 and 10, one-hour spot noise level measurements were conducted during the peak AM time period. Noise level measurements were conducted on October 26 and November 1, 2, 3, 4, 14, 15, and 18, 2016.

6/2/2017



Project Site

Noise Receptor

0 500 FEET

HUDSON TUNNEL PROJECT

New York Noise Receptor Locations

Figure 12-3

Existing noise levels at all receptors include noise generated by other sources including vehicular traffic, aircraft overflights, nearby mechanical equipment, etc. FRA and NJ TRANSIT used the CREATE rail model, along with existing conditions rail traffic data, to determine the level of rail noise at each receptor location. To determine the level of non-rail noise at each receptor, FRA and NJ TRANSIT measured noise levels at or near the receptor site, and subtracted the calculated rail noise (obtained using the CREATE rail model) from the measured level. At receptor sites 8a, 8b, and 8c, measurements conducted at nearby locations with comparable levels of non-rail noise were used to estimate existing noise levels. In some cases, the measurement location was up to a few hundred feet away from the receptor location. The total existing noise level at each noise receptor site was determined by combining the existing condition rail noise level (calculated using the CREATE model) with the calculated non-rail noise level.

Table 12-12 shows the calculated rail noise, calculated non-rail noise, and existing noise levels (which are the sum of the rail and non-rail noise components) at each New York receptor site. FRA and NJ TRANSIT calculated these values following the procedures described above.

Table 12-12
Existing Noise Levels in New York (in dBA)

Site	FTA Land Use Category	Noise Descriptor	Measurements Performed	Calculated Rail Noise Level Component	Calculated Non-Rail Noise Level Component	Existing Noise Level
8	2	L_{dn}	AM peak, midday, late night	0	78	78
8a	2	L_{dn}	Based on Site 8	0	78	78
8b	2	L_{dn}	Based on Site 8	0	78	78
8c	3	Daytime $L_{eq(1h)}$	Based on Site 8	0	72	72
9	3	Daytime $L_{eq(1h)}$	AM peak	0	71	71
10	3	Daytime $L_{eq(1h)}$	AM peak	0	73	73

Note: Field measurements were performed by AKRF, Inc. on October 26 and November 1, 2, 3, 4, 14, 15, and 18, 2016.

12.3.3.3 VIBRATION RECEPTOR LOCATIONS

FRA and NJ TRANSIT identified residential receptors within the FTA guidance manual's vibration analysis screening distances from the Preferred Alternative. This included one residential building in Manhattan: receptor 8a. This receptor is listed in **Table 12-13**.

Table 12-13
Vibration Receptor Locations in New York

Receptor*	Location	Distance/Relation to Vibration Source
8a	450 West 33rd St	50 feet above new tunnel on existing rail right of way

Note: * See **Figure 12-3** for locations.

12.4 AFFECTED ENVIRONMENT: FUTURE CONDITIONS

In the future, train traffic on the NEC will increase slightly and rail speed will remain constant for Amtrak and NJ TRANSIT trains. This will result in very small noise level increases and/or a slight increase in the frequency of vibration events at some of the receptors included in the analysis.

In addition, by the 2030 analysis year, a number of development projects will occur in the Project vicinity in New Jersey and New York. As detailed in Chapter 6, “Land Use, Zoning, and Public Policy,” Section 6A.4, these include the Rebuild By Design project in Hoboken, New Jersey, and numerous new developments in the New York study area, new development will occur on the same block as the proposed Twelfth Avenue staging area—the block between West 29th and West 30th Streets, Eleventh and Twelfth Avenues (Manhattan Block 675). The New York City Department of City Planning (NYDCDP) is currently evaluating a possible rezoning of the eastern end of the block. The rezoning, referred to as the Block 675 East project, would permit a range of commercial uses, as well as residential and community facility uses on the east end of the block. As a result of the rezoning, two new high-rise buildings are anticipated on the east end of the block near Eleventh Avenue. NYCDCP issued a Draft Scope of Work for an EIS for Block 675 East on April 14, 2017.[2]

12.5 IMPACTS OF NO ACTION ALTERNATIVE

Under the No Action Alternative, construction of the Preferred Alternative would not occur. The No Action Alternative would not include major sustained construction, and the typical maintenance of the North River Tunnel under the No Action Alternative would also not have the potential to result in adverse noise or vibration impacts.

12.6 CONSTRUCTION IMPACTS OF THE PREFERRED ALTERNATIVE

12.6.1 OVERVIEW

Construction of the Preferred Alternative would include construction of the new tracks, portal, tunnel, and fan plants for the new Hudson River Tunnel alignment south of the existing North River Tunnel, as well as the rehabilitation of the existing North River Tunnel, as described in detail in Chapter 2, “Project Alternatives and Description of the Preferred Alternative.” Collectively, the construction activities associated with the Preferred Alternative, as described in detail in Chapter 3, “Construction Methods and Activities,” would have the potential to result in noise and vibration along the construction alignments, and at the various staging areas used to facilitate construction of the Preferred Alternative.

Construction noise could potentially be generated by both operation of on-site construction equipment and construction-related vehicles (e.g., delivery trucks, dump trucks, etc.) traveling to and from the construction work areas. Construction vibration could potentially be generated by operation of on-site construction equipment. FRA and NJ TRANSIT examined the potential effects of these sources in the noise and vibration analyses described below.

12.6.2 NEW JERSEY

12.6.2.1 CONSTRUCTION NOISE

12.6.2.1.1 Surface Track Construction

Construction of the New Jersey surface tracks, including construction of new embankments and viaduct structures, would include the use of construction equipment along the proposed alignment in proximity to existing noise receptor locations. Construction noise levels at the surrounding noise

[2] https://www1.nyc.gov/site/planning/applicants/scoping-documents.page.

receptors, i.e., receptors 5, 6, and 7a, were calculated according to the methodology described in Section 12.2. Calculated construction noise levels are shown in **Table 12-14**.

Table 12-14
Worst-Case Construction Noise Levels Near Surface Tracks(in dBA)

Site		FTA Land Use Category	8-Hour L_{eq} – Day	8-Hour L_{eq} – Night	30-Day Average L_{dn}
5	Henry St, Secaucus	2	**94***	**85***	**92***
6	200 Penhorn Ave, Secaucus	3	83	74	**81***[1]
7a	58 County Rd, Secaucus	2	74	65	73

Notes: [1] 24 hour L_{eq}, not L_{dn}.
Exceedances of the FTA guidance manual construction noise impact thresholds are shown in **bold** with an asterisk (*****) (refer to **Table 12-4,** above).

Construction of the New Jersey surface tracks would produce noise levels that exceed the impact thresholds identified in **Table 12-4** at receptor 5, located on Henry Street near Secaucus Road on the north side of the NEC, and at receptor 6, located on Penhorn Avenue south of the NEC. Construction along the New Jersey surface track would use impact pile drivers, which are the dominant source of construction noise. The pile hammers used as part of this construction stage would move along the surface track alignment and would operate at the closest point to each receptor only for a limited time. Consequently, the noise levels shown above in **Table 12-14**, which represent worst-case noise levels with equipment at its closest point to the receptor, would not persist throughout the approximately two years of construction for this segment of the Preferred Alternative. When pile hammers and associated equipment are operating further away from the receptors, noise levels would be lower. When pile operations are at least 550 feet from the receptors, the construction noise levels at the receptors would be less than the FTA construction impact criteria. Since less than approximately 1/10 of the total area of pile driving for the surface and on-structure track construction is within this distance, noise levels would exceed the impact criteria for only a very limited portion of the construction period at these receptors, likely less than one month. Consequently, while construction noise associated with the Preferred Alternative may be audible and intrusive, especially during the nighttime hours, it would not constitute an adverse construction noise impact according to FTA criteria at receptors 5, 6, and 7a.

At receptors other than those described above, which would be farther from the construction work areas, construction noise may at times be audible, but the construction noise levels would be lower than those shown in **Table 12-14** and would not constitute adverse noise impacts according to FTA criteria.

12.6.2.1.2 Construction of New Tunnel and Related Elements at the Tonnelle Avenue Staging Area

12.6.2.1.2.1 Trucking Activities

Construction at the Tonnelle Avenue staging area would include truck access to the site via Tonnelle Avenue. The construction trucks, including concrete mixer trucks, materials delivery trucks, and dump trucks for spoils removal, would pass by residences on Tonnelle Avenue between 10th Street and Secaucus Road at a rate of up to approximately 12 to 24 trucks per hour during the daytime and evening hours (i.e., from 7 AM to 10 PM). This would produce L_{eq} noise levels in the mid to high 80s dBA, which would exceed the construction noise impact threshold for residential uses. This would occur over the course of the approximately four years of construction at the Tonnelle Avenue tunnel portal and staging area and would consequently constitute an adverse noise impact according to FTA criteria at the residences along the truck routes to and from this construction work area, located in the vicinity of Tonnelle Avenue at 10th Street.

12.6.2.1.2.2 Noise at the Construction Sites

Construction at the new tunnel portal along Tonnelle Avenue would include the use of construction equipment at the construction staging area on Tonnelle Avenue close to existing noise receptor locations. Construction noise levels at the surrounding noise receptors, i.e., receptors 3, 3a, 3b, 4a, and 4b were calculated according to the methodology described in Section 12.2. Calculated construction noise levels are shown in **Table 12-15**.

Table 12-15
Worst-Case Construction Noise Levels
Near Tonnelle Avenue (in dBA)

Site		FTA Land Use Category	8-Hour L_{eq} – Day	8-Hour L_{eq} – Night	30-Day Average L_{dn}
3	2001 Grand Ave, North Bergen	2	**81***	**74***	**80***
3a	2215 Grand Ave, North Bergen	2	**81***	**74***	**80***
3b	2200 Paterson Plank Rd, North Bergen	2	**82***	**73***	**81***
4a	2600 Tonnelle Ave, North Bergen	2	73	68	74
4b	2000 Tonnelle Ave, North Bergen	3	84	80	**83***[1]

Notes: [1] 24 hour L_{eq}, not L_{dn}.
* Exceedances of the FTA guidance manual construction noise impact thresholds are shown in **bold** with an asterisk (*****) (refer to **Table 12-4,** above).

Construction at the Tonnelle Avenue tunnel portal would produce noise levels that exceed the residential impact thresholds identified in **Table 12-4** at receptor 3, 3a, and 3b and the institutional impact thresholds at receptor 4b. Construction activities at the Tonnelle Avenue tunnel portal would include pile driving with impact pile drivers, which are the dominant source of construction noise. Ventilation fans for tunnel excavation would also be a primary contributor of noise at these receptors. Additional equipment that would contribute to elevated noise levels includes tractors, compressors, forklifts, cherry pickers, cranes, and front end loaders. Pile driving operations would occur for approximately eight months during work on the Tonnelle Avenue bridge and two months at the new tunnel portal. When pile driving is not occurring, construction noise at these receptors would be lower, but would still exceed FTA construction noise impact criteria as a result of the operation of ventilation fans for the tunneling. Because the fans would operate constantly throughout the tunnel mining operations, noise levels exceeding FTA construction noise impact criteria would persist throughout the approximately one year of tunnel mining from this area. Based on the high levels of noise predicted to occur for an extended duration (approximately 2.5 years) at receptors 3, 3a, and 3b, residential receptors along Paterson Plank Road and along Grand Avenue between 19th Street and 23rd Street and the Hindu temple on Tonnelle Avenue approximately 150 feet south of the staging area are predicted to experience adverse construction noise impacts.

At receptors other than those described above, which would be farther from the construction work areas, construction noise may at times be audible, but the construction noise levels would be lower than those shown in **Table 12-15** and would not constitute adverse noise impacts, as noise levels drop off with increases in distance from noise sources.

12.6.2.1.3 Hoboken Staging Area

12.6.2.1.3.1 Trucking Activities

Construction at the Hoboken staging area would include truck access to the site via West 19th Street, Willow Avenue, Park Avenue, and a site access road south of West 18th Street that would be constructed specifically to allow construction trucks to access the site without using local streets. The construction trucks, including concrete mixer trucks, materials delivery trucks, and dump trucks for spoils removal, would pass by residences on Willow Avenue south of West 19th Street and on Park Avenue south of West 19th Street at a rate of up to approximately 12 to 24 trucks per hour during the daytime hours (i.e., from 7 AM to 10 PM). This would produce L_{eq} noise levels in the mid to high 80s dBA, which would exceed the construction noise impact threshold for residential uses. This would occur over the course of the approximately four years of construction at the Hoboken staging area and would consequently constitute an adverse noise impact at the residences along the truck routes to and from this construction work area—i.e., residences along the Park Avenue service road and Willow Avenue service road and Willow Avenue between the Hudson-Bergen Light Rail (HBLR) right-of-way and West 19th Street.

12.6.2.1.3.2 Noise at the Construction Sites

Construction at the Hoboken staging area would include the use of construction equipment at the staging area, as well as along Willow Avenue south of the HBLR right-of-way where Willow Avenue would be underpinned. Calculated construction noise levels for receptors near the staging area and Willow Avenue underpinning site are shown in **Table 12-16**.

Table 12-16
Worst-Case Construction Noise Levels
Near Hoboken Shaft Site (in dBA)

Site		FTA Land Use Category	8-Hour L_{eq} – Day	8-Hour L_{eq} – Night	30-Day Average L_{dn}
1a	78 West 18th St, Weehawken	2	79	**72***	**78***
1b	1700 Park Ave, Weehawken	2	71	62	70
1c	1600 Park, Hoboken	3	**89***	80	**88***[1]
2	1404 Manhattan Ave, Union City	2	79	**73***	**79***

Notes: [1] 24 hour L_{eq}, not L_{dn}.
* Exceedances of the FTA guidance manual construction noise impact thresholds are shown in **bold** with an asterisk (*****) (refer to **Table 12-4,** above).

Construction at the Hoboken staging area would produce noise levels that exceed the impact thresholds identified in **Table 12-4** at receptors 1a, 1c, and 2. Construction at the shaft site would use impact pile drivers, which are the dominant source of construction noise. Additional equipment that contributes to elevated noise levels includes cherry pickers, cranes, and front end loaders. This analysis assumes the use of a 25-foot-tall noise barrier along the north boundary of the Hoboken staging area, which would shield the residences in Weehawken along West 18th Street, West 19th Street, and Chestnut Street west of Grand Street, as represented by receptor 1a, from construction noise on the site, and the noise levels in **Table 12-16** include the presence of this wall. This is the height of the wall that was previously proposed by the Access to the Region's Core (ARC) Project.

Pile driving at the Hoboken shaft would occur over approximately five months, meaning that at the residences along West 18th Street, West 19th Street, and Chestnut Street west of Grand Street and the residences on Manhattan Avenue overlooking the staging area, noise levels would exceed the FTA impact criteria for up to approximately five months when pile driving is occurring in the shaft. Outside of these limited times, when pile driving is not occurring, construction noise at these buildings would be audible and noticeable but would not exceed the FTA construction noise impact thresholds. Additionally, these buildings were determined based on field observations to be constructed with standard façade construction techniques, including insulated glass windows and window air conditioning units, which would provide approximately 25 dBA window/wall attenuation, resulting in substantially lower noise levels inside the residences. Consequently, while construction noise associated with the Preferred Alternative may be audible and intrusive, especially during the nighttime hours, it would not constitute an adverse construction noise impact at these receptors.

As noted, the above construction noise projections assume the use of a 25-foot-tall noise barrier along the north boundary of the Hoboken staging area, which would shield the residences in Weehawken along West 18th Street, West 19th Street, and Chestnut Street west of Grand Street, as represented by receptor 1a, from construction noise on the site. If this barrier were constructed at a lower height, the projected noise levels for site 1a in **Table 12-16** would be higher and would exceed FTA noise impact thresholds. Specifically, noise levels would be approximately 2 dBA higher for a 16-foot-tall barrier, approximately 4 dBA higher for a 12-foot-tall barrier, and approximately 6 dBA higher for an 8-foot-tall barrier. Any of these shorter barrier heights would cause the daytime 8-hour L_{eq} noise level generated by construction to exceed the FTA construction noise impact threshold, in addition to the exceedance of the nighttime 8-hour L_{eq} noise level and 30-day average L_{dn} noise level with a 25-foot-high barrier as discussed above.

At Willow Avenue the Preferred Alternative would involve short-term construction activity associated with underpinning (supporting) the foundation of the Willow Avenue viaduct. The underpinning would include installation of piles, which will be drilled into place rather than driven, to reduce noise levels. Pile drilling at the Willow Avenue underpinning work area would occur over approximately three months, meaning that 1600 Park, represented by receptor 1c, would experience noise levels that exceed the FTA impact criteria for up to approximately four months. Noise levels would also exceed the FTA impact criteria at two other parks nearby: a future park to be developed as part of the Rebuild By Design project at Harborside/Hoboken Cove Park and the Hudson River Waterfront Walkway (see Chapter 8, "Open Space and Recreational Resources"). Outside of this short period when pile drilling is occurring, construction noise at this park may be audible and noticeable but would not exceed the FTA construction noise impact thresholds. Due to the relatively short duration of these exceedances, while construction noise associated with the Preferred Alternative may be audible and intrusive at times, it would not constitute an adverse construction noise impact at this receptor or the other two parks.

In addition, as discussed in Chapter 3, "Construction Methods and Activities," Section 3.3.3.3, to shift trucks farther from the 10-story residential building on the east side of the Willow Avenue (the Gateway building at 1700 Park Avenue), the truck route could use a wider curve from the temporary construction road, which would require underpinning the Willow Avenue viaduct to allow a support pier to be moved. This would involve some pile drilling immediately adjacent to the residential building in order to underpin the viaduct.

At receptors other than those described above, which would be further from the construction work areas, construction noise may at times be audible, but the construction noise levels would be lower than those shown in **Table 12-16** and would not constitute adverse noise impacts.

12.6.2.1.4 North River Tunnel Rehabilitation

12.6.2.1.4.1 Trucking Activities

Rehabilitation of the North River Tunnel would include truck access to the site via Tonnelle Avenue. The construction trucks, including concrete mixer trucks, materials delivery trucks, and dump trucks for debris removal, would pass by residences on Tonnelle Avenue between 10th

Street and Secaucus Road at a rate of up to approximately 12 to 24 trucks per hour during the daytime hours (i.e., from 7 AM to 10 PM). This would produce L_{eq} noise levels in the mid to high 80s dBA, which would exceed the construction noise impact threshold for residential uses. This would occur over the course of the approximately four years of repair and restoration of the North River Tunnel and would consequently constitute an adverse noise impact at the residences along the truck routes to and from this construction work area.

12.6.2.1.4.2 Noise at the Construction Sites

Rehabilitation of the North River Tunnel would include the use of construction equipment at the construction staging area on Tonnelle Avenue close to existing noise receptor locations. Construction noise levels at the surrounding noise receptors, i.e., receptors 3, 3a, 3b, 4a, and 4b, were calculated according to the methodology described in Section 12.2. Calculated construction noise levels are shown in **Table 12-17**.

Table 12-17
Worst-Case Construction Noise Levels
During North River Tunnel Rehabilitation (in dBA)

Site		FTA Land Use Category	8-Hour L_{eq} – Day	8-Hour L_{eq} – Night	30-day Average L_{dn}
3	2001 Grand Ave, North Bergen	2	74	**71***	**79***
3a	2215 Grand Ave, North Bergen	2	76	**74***	**82***
3b	2200 Paterson Plank Rd, North Bergen	2	74	**72***	**80***
4a	2600 Tonnelle Ave, North Bergen	2	74	**72***	**80***
4b	2000 Tonnelle Ave, North Bergen	3	80	77	79 [1]

Notes: [1] 24 hour L_{eq}, not L_{dn}.
* Exceedances of the FTA guidance manual construction noise impact thresholds are shown in **bold** with an asterisk (*****) (refer to **Table 12-4,** above).

Rehabilitation work at the Tonnelle Avenue tunnel portal would produce noise levels that exceed the residential impact thresholds identified in **Table 12-4** at receptors 3, 3a, 3b, and 4a. Repair and restoration work at the Tonnelle Avenue tunnel portal would use ventilation fans, which are the dominant source of construction noise. Additional equipment that contributes to elevated noise levels includes tractors, compressors, forklifts, cherry pickers, cranes, and front end loaders. Since the ventilation fans would operate constantly throughout the two 10-hour work shifts, six days per week of the repair and restoration work, the predicted noise levels shown in **Table 12-17** would occur constantly throughout the approximately four years of repair and restoration of the North River Tunnel. Based on the high levels of noise predicted to occur for an extended duration at receptors 3, 3a, and 3b, residential receptors along Paterson Plank Road and along Grand Avenue between 19th Street and 23rd Street are predicted to experience adverse construction noise impacts during the repair and restoration work for the North River Tunnel.

12.6.2.2 CONSTRUCTION VIBRATION

Construction-related vehicles including worker vehicles and/or materials and equipment deliveries generally do not have the potential to result in vibration levels that could result in building damage and/or human annoyance and consequently do not typically result in adverse construction vibration impacts. However, equipment operating within the Project area and/or in construction staging areas could potentially produce vibration levels that result in damage and/or annoyance. The equipment used in construction of the Preferred Alternative that would have the greatest potential to result in elevated vibration levels include impact and vibratory pile drivers, pile drilling rigs, and earth-moving equipment such as bulldozers. Vibration levels produced by these pieces of equipment are shown in **Table 12-6**. Based on the general vibration analysis techniques described in the FTA guidance manual, for each construction work area, FRA and NJ TRANSIT determined the maximum vibration levels produced by the equipment used in that area for the nearest receptor locations and compared them to the vibration evaluation criteria shown above in **Table 12-5** for human annoyance and **Table 12-7** for potential building damage.

12.6.2.2.1 Surface Track Construction

The nearest vibration receptor to the construction work area for the surface track construction between Secaucus and the new tunnel portal would be the residences on Henry Street (near Secaucus Road on the north side of the NEC), referred to above as vibration receptor 5. This receptor is approximately 110 feet from the nearest point of the construction work area. Impact pile driving would occur within this work area and would have the greatest potential to produce high levels of vibration. Pile driving within this work zone would produce approximately 0.164 inches per second PPV and 93 VdB at this receptor when it is occurring at its closest point to the receptor. This vibration would be perceptible and would exceed the threshold for human annoyance from vibration, although it would not have the potential to result in damage to the buildings. Vibration resulting from pile driving would exceed the threshold for potential human annoyance at the Henry Street residences any time that it occurred within approximately 550 feet of the residences, which constitutes less than 1/5 of the total area of pile driving for the surface and on-structure track construction. Since the pile driving would not result in vibration at a level that could potentially result in damage to the buildings on Henry Street and because it would result in potentially annoying vibration only over a very limited portion of the construction activity, it would not have the potential to result in an adverse construction vibration impact. At other receptors further from the work area than the Henry Street residences, vibration levels would be lower and would also not constitute adverse vibration impacts.

12.6.2.2.2 Construction of New Tunnel and Related Elements at the Tonnelle Avenue Staging Areas

The nearest vibration receptor to the construction work area for the new tunnel portal, Tonnelle Avenue underpass, and associated construction staging areas would be the residences on Paterson Plank Road, referred to above as receptor 3b (approximately 345 feet from the nearest point of the construction work area), and the religious use at 2000 Tonnelle Avenue, referred to above as receptor 4b (approximately 620 feet from the tunnel portal and 115 feet from the staging area on Tonnelle Avenue). Pile driving would occur within the work area at the tunnel portal and would have the greatest potential to produce high levels of vibration. General staging activities would occur in the staging area on Tonnelle Avenue potentially including the use of bulldozers. Pile driving within this work zone would produce approximately 0.014 inches per second PPV and 71 VdB at receptor 3b when it would occur at its closest point to the receptor. General construction staging activity would produce approximately 0.009 inches per second PPV and 67 VdB at receptor 4b when it would occur at its closest point to the receptor. These levels of vibration would be perceptible but would not exceed the threshold for human annoyance from vibration nor would they have the potential to result in damage to the buildings. At other receptors further from the work area than these receptors, vibration levels would be lower and would also not constitute adverse vibration impacts. Consequently, construction at the tunnel portal, Tonnelle Avenue underpass, and associated staging areas would not have the potential to result in adverse construction vibration impacts.

12.6.2.2.3 Hoboken Staging Area

The nearest vibration receptor to the construction work area for the Hoboken shaft and fan plant and associated construction staging area would be the residences north of West 18th Street near Grand Street in Hoboken, referred to above in the noise analysis as receptor 1a. This receptor is approximately 130 feet from the nearest point of the construction work area. Impact pile driving would occur within this work area and would have the greatest potential to produce high levels of vibration. Pile driving within this work zone would produce approximately 0.128 inches per second PPV and 91 VdB at this receptor when it is occurring at its closest point to the receptor. This vibration would be perceptible and would exceed the threshold for human annoyance from vibration, although it would not have the potential to result in damage to the buildings. Vibration resulting from pile driving would exceed the threshold for potential human annoyance at the West 18th Street residences any time that it occurred within approximately 550 feet of the residences, which constitutes the entirety of the work area for this construction. Furthermore, vibration above the threshold of human annoyance would extend approximately 550 feet north of the work area's northern boundary, encompassing all residences on West 18th Street and Chestnut Street west of Grand Street. Pile driving at the Hoboken Shaft site would occur over approximately five months meaning that these residences could experience vibration levels exceeding the human annoyance threshold for five months. While vibration could be noticeable and potentially intrusive during this time, since the pile driving would not result in vibration at a level that could potentially result in damage to the buildings north of the shaft site and because it would result in potentially annoying vibration only over a very limited portion of the construction activity, it would not have the potential to result in an adverse construction vibration impact. At other receptors further from the work area than these residences, vibration levels would be lower and would also not constitute adverse impacts.

In addition to pile installation at the Hoboken shaft site, drilled piles would be installed under the Willow Avenue overpass over the existing rail tracks in proximity to 1721 Willow Avenue, a residential building, referred to above in the noise analysis as receptor 1b. This building, at a distance of approximately 280 feet from the pile installation area, would experience a maximum of approximately 0.007 inches per second PPV and 65VdB when pile drilling is occurring at the closest point to the residence. This vibration would be imperceptible to barely perceptible and would not exceed the threshold for human annoyance from vibration nor have the potential to result in damage to the buildings.

The future Rebuild By Design flood wall along Park Avenue in Weehawken would be constructed over the site of the Preferred Alternative new tunnel alignment, and would have structural elements extending as deep as approximately 40 to 100 feet above the new tunnel alignment. As the tunnel boring machine (TBM) moves along the tunnel alignment, it has the potential to result in vibration at receptors above. Predicted levels of vibration for the TBM presented in Chapter 5.07 of the Access to the Region's Core (ARC) Final Environmental Impact Statement (FEIS), which is incorporated by reference into this analysis, are representative of those that would occur from TBM work associated with the Preferred Alternative, since the tunnel mining operations included in the Preferred Alternative are essentially identical to those included in the ARC Project as studied in the FEIS.[3] The ARC FEIS vibration analysis indicates that the largest diameter TBM (8 meters) at the most shallow depth (16 feet) in bedrock would produce a PPV of 0.319 inches per second. This level of vibration would not have the potential to result in structural damage to a newly constructed flood protection wall. Furthermore, since the TBM typically progresses at a pace of approximately 30 feet per day, the vibration would not last for more than two days at most at this location. Consequently, vibration from the TBM does not have the potential to result in an adverse construction vibration impact at this location.

3 FTA and NJ TRANSIT, Access to the Region's Core Project FEIS, October 2008, Chapter 5.02 and Appendix 5.7.

At other receptors further from the work area than the West 18th Street, Chestnut Avenue, and Willow Avenue residences, vibration levels would be lower and would also not constitute adverse vibration impacts.

12.6.2.2.4 Tunnel Boring Machine Operation along the Tunnel Alignment

As the TBM moves along the tunnel alignment, it has the potential to result in vibration at receptors above. Predicted levels of vibration for the TBM presented in Chapter 5.07 of the ARC FEIS are representative of those that would occur from TBM work associated with the Preferred Alternative, since the tunnel mining operations included in the Preferred Alternative are essentially identical to those included in the ARC Project as studied in the FEIS. The FEIS vibration analysis indicates that the largest diameter TBM (8 meters) at the most shallow depth (16 feet) in bedrock would produce a PPV of 0.319 inches per second. This level of vibration would not have the potential to result in building damage, but may be perceptible and annoying to humans in buildings directly over the tunnel alignment. However, since the TBM typically progresses at a pace of approximately 30 feet per day, the perceptible vibration does not last for more than at most two days at any one receptor. At deeper portions of the tunnel alignment, vibration levels would be substantially lower. Consequently, vibration from the TBM does not have the potential to result in an adverse construction vibration impact.

12.6.2.2.5 North River Tunnel Rehabilitation

The nearest vibration receptor to the construction work area for rehabilitation of the North River Tunnel would be the hotel on Tonnelle Avenue, referred to above in the noise analysis as receptor 4a. This receptor is approximately 580 feet from the nearest point of the construction work area. Use of a hydraulic demolition hammer would occur within this work area and would have the greatest potential to produce high levels of vibration. Pile driving within this work zone would produce approximately 0.001 inches per second PPV and 46 VdB at this receptor when it is occurring at its closest point to the receptor. Additionally, the maximum vibration-producing activity that would occur within the North River Tunnel would be demolition of the bench walls using jackhammers. At the shallowest point of the tunnel below a receptor (i.e., approximately 80 feet), this activity would produce approximately 0.006 inches per second PPV and 64 VdB at the receptor immediately above. These vibration levels would not be perceptible and would not exceed the threshold for human annoyance from vibration nor have the potential to result in damage to the buildings. At other receptors further from the work area than the Tonnelle Avenue hotel or residences immediately above the tunnel, vibration levels would be lower and would also not constitute adverse vibration impacts. Consequently, repair and restoration of the North River Tunnel would not have the potential to result in adverse construction vibration impacts.

12.6.3 NEW YORK

12.6.3.1 CONSTRUCTION NOISE

12.6.3.1.1 Manhattan Waterfront Area and Twelfth Avenue Shaft Site

12.6.3.1.1.1 Trucking Activities

Construction at the Manhattan waterfront area and Twelfth Avenue shaft site would include truck access to the work areas via Twelfth Avenue, Eleventh Avenue, Tenth Avenue, Dyer Avenue, West 40th Street, West 34th Street, West 30th Street, and West 29th Street. The construction trucks, including concrete mixer trucks, materials delivery trucks, and dump trucks for spoils removal, would pass by residences and open space receptors (i.e., Hudson River Park and the High Line) on these roadways at a rate of up to approximately 3 trucks per hour during the daytime hours (i.e., from 7 AM to 10 PM). This would produce L_{eq} noise levels in the mid to high 70s dBA, which would not exceed the construction noise impact threshold for residential or open space uses and would be comparable to existing noise levels in this area of New York City. The noise level increment resulting from the truck activity would also not exceed the *CEQR Technical Manual* noise impact criteria. Consequently, construction truck activity associated with this construction work area would not have the potential to result in adverse construction noise impacts in New York.

12.6.3.1.1.2 Noise at the Construction Sites

Construction at the waterfront and Twelfth Avenue shaft site would include the use of construction equipment along the proposed tunnel alignment close to existing noise receptor locations. FRA and NJ TRANSIT calculated construction noise levels at the surrounding noise receptors, i.e., receptors 8, 8a, 8b, 8c, 9, and 10 according to the methodology described above in Section 12.2.3.1.1. This analysis assumes the use of a 15-foot-tall noise barrier around the construction site. Calculated construction noise levels are shown in **Table 12-18**.

Table 12-18
Worst-Case Construction Noise Levels Near Manhattan Construction Sites (in dBA)

Site		FTA Land Use Category	8-Hour L_{eq} – Day	8-Hour L_{eq} – Night	30-day Average L_{dn}
8	312 Eleventh Ave	2	79	70	**77***
8a	606 West 30th St	2	**97***	**88***	**95***
8b	413 Tenth Ave	2	69	60	67
8c	450 West 33rd St	3	81	72	79 [1]
9	High Line Park	3	**97***	**88***	**95***[1]
10	Hudson River Park	3	72	63	70 [1]

Notes: [1] 24 hour L_{eq}, not L_{dn}
* Exceedances of the FTA guidance manual construction noise impact thresholds are shown in **bold** with an asterisk (*****) (refer to **Table 12-4,** above).

Construction at the Manhattan waterfront and Twelfth Avenue shaft site would produce noise levels at receptors 8b, 8c, and 10 that would be noticeable and audible, but would be below the FTA impact criteria and would consequently not constitute adverse impacts.

Construction at the Manhattan waterfront and Twelfth Avenue shaft site would produce noise levels that exceed the residential impact thresholds identified in **Table 12-4** at receptors 8, 8a and 9. Construction at the Manhattan waterfront and Twelfth Avenue shaft site would include use of impact pile hammers, which are the dominant source of construction noise. Additional equipment that contributes to elevated noise levels includes cherry pickers, compressors, and front end loaders.

Pile driving at the Twelfth Avenue shaft and as part of the West 30th Street cut-and-cover work would occur over approximately five months and seven months, respectively. If the two new residential buildings proposed at the east end of the block between West 29th and West 30th Streets (606 West 30th Street, which is receptor 8a, and the adjacent 601 West 29th Street) are completed and occupied prior to the start of pile driving at this site, these residences would experience noise levels that exceed the FTA impact criteria for up to approximately 12 months. When pile driving is not occurring, construction noise at these buildings would be audible and noticeable, but it would not exceed the FTA construction noise impact thresholds. Additionally, both new residential buildings will be constructed with contemporary façade construction techniques, including insulated glass windows, which would provide approximately 30 dBA window/wall attenuation, resulting in substantially lower noise levels inside the residential units.

The portion of the High Line that runs along West 30th Street, which is represented by receptor 9, would have the potential to experience noise levels that exceed the FTA impact criteria when pile driving is occurring (a total of up to 12 months, including 5 months of pile driving at the Twelfth Avenue shaft and 7 months of pile driving during the cut and cover work on West 30th Street). When pile driving is not occurring construction noise at this location would be audible and noticeable, but it would not exceed the FTA construction noise impact thresholds. The High Line is a linear park approximately 1.45 miles long, and the rest of the park would not experience elevated levels of noise as a result of construction. Therefore, visitors to this open space area would consequently be able to enjoy the remainder without experiencing elevated noise levels resulting from construction of the Preferred Alternative. Furthermore, work at the Twelfth Avenue shaft is based on only five days per week, so users of the High Line would not experience construction noise on weekends, which are the primary days of use for this area. For these reasons (noise levels this high for only one year and only on weekdays, and only in a limited area of the High Line), while construction noise associated with the Preferred Alternative may be audible and intrusive at times, it would not constitute an adverse construction noise impact at this receptor.

At receptors 8 and 8a, noise levels resulting from pile driving activity would exceed the *CEQR Technical Manual* noise impact criteria, even though they are below the FTA construction noise impact criteria. However, since pile driving activity associated with the Twelfth Avenue shaft and West 30th Street cut-and-cover work would occur for a period shorter than two years, these exceedances would not constitute adverse construction noise impacts according to *CEQR Technical Manual* noise impact criteria. Additionally, these residential buildings are (or will be) constructed with contemporary façade construction techniques, including insulated glass windows, which would provide approximately 30 dBA window/wall attenuation, resulting in substantially lower noise levels inside the residential units.

At receptors other than those described above, which would be farther from the construction work areas, construction noise may at times be audible, but the construction noise levels would be lower than those shown in the construction noise analysis and would not constitute adverse noise impacts.

As described in Chapter 3, “Construction Methods and Activities,” Section 3.3.7.2, it is possible that construction at the Twelfth Avenue shaft site would delay the construction of a one-story parking garage and potential Emergency Medical Services (EMS) station that are part of a private development project being planned at 601 West 29th Street, at the eastern end of the block. In that event, construction of the garage and potential EMS facility would occur after completion of construction for the Hudson River Tunnel on the Twelfth Avenue shaft site (2026). This EIS analyzes the impacts associated with this potential delay in the schedule for construction and completion of the one-story parking garage and potential EMS facility that could result because of the Hudson Tunnel Project.

The delay in the construction schedule for the garage and potential EMS facility would extend the duration of construction activities occurring adjacent to the two new residential buildings at the east end of Block 675 that would result from the Block 675 East rezoning. With the Block 675 rezoning, the two new residential buildings are anticipated for completion in 2021. These two buildings would therefore be located next to construction activities for the Preferred Alternative on the Twelfth Avenue staging site for five years. If construction of the parking lot and potential EMS facility on Block 675 Lot 12 is delayed, this would add another 18 months of construction activity adjacent to these two new residential buildings.

Construction of the Block 675 Lot 12 parking garage and EMS facility is anticipated to take approximately 18 months, 12 months of which would include excavation and concrete operations. The activities that would occur during that construction would produce noise levels in the mid to high 70s dBA at the two new residential buildings (601 West 29th Street and 606 West 30th Street). These noise levels would be less than the maximum levels shown in **Table 12-18**, but would still likely result in a noticeable increase over baseline noise levels for the new residences (as represented by receptor 8a). The adverse noise impacts at that receptor would occur for up to approximately 12 months longer than without this garage construction, i.e., a total of up to approximately 24 months including both the Preferred Alternative and the garage construction.

12.6.3.2 CONSTRUCTION VIBRATION

Construction-related vehicles including worker vehicles and/or materials/equipment deliveries generally do not have the potential to result in vibration levels that could result in building damage and/or human annoyance and consequently do not typically result in adverse construction vibration impacts. However, equipment operating within the Project area and/or in construction staging areas could potentially produce vibration levels that result in damage and/or annoyance. The equipment used in construction of the Preferred Alternative that would have the greatest potential to result in elevated vibration levels include impact pile drivers, pile drilling rigs, and earth-moving equipment such as bulldozers. Vibration levels produced by these pieces of equipment are shown in **Table 12-6**, above. Based on the general vibration analysis techniques described in the FTA guidance manual, for each construction work area, the maximum vibration levels produced by the equipment used in that area were determined for the nearest receptor locations and compared to the vibration evaluation criteria shown above in **Table 12-5** for human annoyance and **Table 12-7** for potential building damage.

12.6.3.2.1 Manhattan Waterfront Area

The nearest vibration receptors to the construction Manhattan waterfront work area (i.e., from the Hudson River to Twelfth Avenue between West 29th and West 30th Streets) would be Hudson River Park and the High Line, referred to in the noise analysis above as receptors 10 and 9, respectively. Construction activity in this work area would consist primarily of ground freezing and removal and backfilling, neither of which have the potential to result in substantial levels of vibration. Consequently, construction in this area would not have the potential to result in adverse vibration impacts at these receptors or others. In addition, as described in Chapter 9, “Historic and Archaeological Resources,” monitoring will be implemented at the Hudson River bulkhead in Hudson River Park to monitor the structure for movement/tilt and settlement during construction of the new tunnel nearby.

12.6.3.2.2 Twelfth Avenue Shaft and Fan Plant

The nearest vibration receptor to the construction work area for the Twelfth Avenue shaft and fan plant and associated construction staging area would be the future residence to be constructed at 606 West 30th Street and the High Line, referred to in the noise analysis above as receptors 8a and 9, respectively. The nearest point of the 606 West 30th Street receptor is approximately 56 feet from the nearest point of the construction work area and the nearest point of the High Line is approximately 44 feet from the nearest point of the construction work area. Impact pile driving would occur within this work area and would have the greatest potential to produce high levels of vibration.

Pile driving within this work zone would produce approximately 0.453 inches per second PPV and 101 VdB at 606 West 30th Street when it is occurring at its closest point to the receptor. This vibration would be perceptible and would exceed the threshold for human annoyance from vibration, although it would not have the potential to result in damage to the building. Vibration resulting from pile driving would exceed the threshold for potential human annoyance at 606 West 30th Street within approximately 550 feet of the receptor, which would constitute nearly all of the Twelfth Avenue shaft site and the West 30th Street cut-and-cover work area. Pile driving would occur for a total of 12 months near this receptor—five months at the Twelfth Avenue shaft and seven months at West 30th Street. The current Project schedule anticipates this work occurring prior to the 2021 completion date for the new residential building at 606 West 30th Street, but if the new building is completed and occupied first, the pile driving would experience vibration levels exceeding the human annoyance threshold for up to approximately a year. Since the pile driving would result in potentially annoying vibration only over a limited duration of approximately a year, it would not have the potential to result in an adverse construction vibration impact at 606 West 30th Street.

Pile driving within this work zone would have the potential to produce up to approximately 0.650 inches per second PPV and 105 VdB at the High Line when it is occurring at its closest point to the receptor. As described in Chapter 9, "Historic and Archeological Resources," Section 9.6.3.1.3, the High Line is a historic structure and the Project Sponsor will develop and implement a Construction Protection Plan for construction activities near the High Line to protect it from accidental damage during construction of the Preferred Alternative. Consequently, construction of the Preferred Alternative would not have the potential to produce vibration levels at the High Line that would have the potential to cause damage to the structure.

Vibration resulting from pile driving would exceed the threshold for potential human annoyance at portions of the High Line within approximately 550 feet pile driving activity, which would be a relatively small portion of the full extent of the High Line. Furthermore, at an urban outdoor open space area, people would typically be less sensitive to vibration than in a residence. Because vibration at this receptor would not have the potential to result in structural damage, because it would potentially result in annoyance only for a limited period of less than one year, and because the receptor is an urban outdoor space where people would typically be less sensitive to vibration, the predicted level of vibration would not have the potential to result in an adverse construction vibration impact.

At other receptors further from the work area than 606 West 30th Street or the High Line, vibration levels would be lower and would also not constitute adverse impacts.

12.7 PERMANENT IMPACTS OF THE PREFERRED ALTERNATIVE

12.7.1 OVERVIEW

The Preferred Alternative would consist of a new two-track tunnel, parallel to the North River Tunnel, extending from the NEC in Secaucus, New Jersey, beneath the Palisades (North Bergen and Union City) and the Hoboken waterfront area, and beneath the Hudson River to connect to the existing approach tracks at Penn Station New York (PSNY). Potential sources of noise included in the Preferred Alternative would be the new surface and on-structure track extending from Secaucus east of County Road to the new tunnel portal and the new ventilation shafts and associated fan plants located above the tunnel on West 18th Street in Hoboken and at Twelfth Avenue in Manhattan. Potential sources of vibration included in the Preferred Alternative would be the same surface and on-structure track in New Jersey as well as the new Hudson River Tunnel. FRA and NJ TRANSIT examined the potential effects of these sources in the noise and vibration analyses described below.

At each of the noise receptor sites identified and described in Section 12.3 above, FRA and NJ TRANSIT calculated Project noise exposure associated with the Preferred Alternative based on the contribution of each element of the Preferred Alternative (e.g., surface or on-structure rail tracks, ventilation fan plants) within the screening distance from the receptor. FRA and

NJ TRANSIT compared the Project noise exposure at each receptor to FTA's noise impact criteria to identify potential impacts.

The analysis of noise from the ventilation fan plants assumes the fan plants would produce an L_{eq} of 65 dBA at 50 feet from the plant, consistent with the FTA guidance manual's screening distance for ventilation shafts. The design for the fan plants included in the Preferred Alternative includes fan silencers. The final design of the fan plant would need to ensure that the silencers' performance results in noise emission of 65 dBA or less at a distance of 50 feet from the fan plant for the design to be consistent with the results of this analysis.

At each of the vibration receptor sites identified and described in Section 12.3 above, FRA and NJ TRANSIT calculated vibration levels resulting from rail operations included in the Preferred Alternative for the nearest Project element (i.e., surface or on-structure rail tracks or the new tunnel). FRA and NJ TRANSIT compared the calculated vibration levels at each receptor to FTA's vibration impact criteria to identify potential impacts.

12.7.2 NEW JERSEY

12.7.2.1 NOISE

FRA and NJ TRANSIT analyzed the potential noise effects of the Preferred Alternative at the receptors in the New Jersey using the methodology described above. **Table 12-19** shows the noise levels and incremental change in noise levels for the Preferred Alternative. Noise levels shown for the Preferred Alternative in **Table 12-19** are the sum of the rail noise components (i.e., surface or on-structure railway and ventilation fan plant) and the non-rail noise component (which is assumed to be the same level calculated for existing conditions). The Preferred Alternative noise exposure is the level of noise that would be produced by operation of the Preferred Alternative, and is compared to the impact criteria to determine whether this alternative could potentially result in a noise impact.

As shown in **Table 12-19**, the Project noise exposure (i.e., the noise generated by the Project) for the Preferred Alternative at receptors near the new and existing tunnel portal (receptor sites 3, 3a, 3b, 4a, 4b) and near the new surface tracks (receptors 5, 6, and 7a) would not constitute a moderate or a severe impact according to FTA noise impact criteria. Additionally, incremental changes in noise levels between the Preferred Alternative and existing condition would be less than 2 dBA at these receptors, which would be imperceptible to barely perceptible. Consequently, the Preferred Alternative would not result in any adverse noise impacts at these receptor sites.

At receptor site 1a, which is representative of the residences along West 18th Street in Hoboken within 200 feet of the Hoboken ventilation shaft fan plant, operation of the Hoboken fan plant would result in a Project noise exposure (i.e., Project-generated noise) at a level that would constitute a moderate impact but not a severe impact according to FTA noise impact criteria. The incremental change in noise level between the Preferred Alternative and existing condition at this location would be 4 dBA, which would be perceptible to readily noticeable. However, this analysis considers the condition in which all fans included in the ventilation shaft fan plant are operating at maximum load, which would occur only during emergencies. Typical use of the ventilation fans would be passive or include only some units, which would not result in noise levels above the impact thresholds. The fan plant will include silencers and dampers that will effectively reduce noise levels from this operation. Consequently, the Preferred Alternative would not result in any adverse noise impacts at this receptor site.

Table 12-19
New Jersey Preferred Alternative Noise Levels (in dBA)

Site	FTA Land Use Category	Existing Noise Level	Moderate Impact Threshold[1]	Severe Impact Threshold[1]	Preferred Alternative Noise Exposure (Project-Generated Noise)	Total Preferred Alternative Noise Level	Preferred Alternative Noise Level Increment	Impact[2]?
1a	2	60	58	64	62	64	4	Moderate Impact
3	2	56	56	63	52	58	2	No Impact
3a	2	56	56	63	47	56	1	No Impact
3b	2	56	56	63	46	56	0	No Impact
4a	2	72	66	72	0	72	0	No Impact
4b	3	68	68	74	57	68	0	No Impact
5	2	78	66	76	0	78	0	No Impact
6	3	66	67	73	52	67	0	No Impact
7a	2	78	66	76	0	78	0	No Impact

Notes: [1] Impact criteria are based on the existing noise level, as shown in **Figure 12-1**.
[2] The noise exposure for the Preferred Alternative is compared to the FTA moderate impact and severe impact thresholds to determine whether a moderate impact and/or severe impact are predicted to occur; severe impacts are considered adverse impacts and moderate impacts may or may not be considered adverse impacts depending on site-specific context.

Other receptors in New Jersey (receptor 7, near the surface tracks, and receptors above the tunnel, including 1b, 1c, and 2) were not within the screening distance from any permanent noise-producing Project elements and would consequently also not experience an adverse noise impact as a result of the Preferred Alternative.

Consequently, the Preferred Alternative would not have the potential to result in adverse noise impacts at receptors in New Jersey.

12.7.2.2 VIBRATION AND GROUND-BORNE NOISE

As described above, there are receptors located within the screening distance from the Preferred Alternative; therefore, a general vibration analysis was conducted for the Preferred Alternative. Two residential receptors in New Jersey were identified for this general analysis methodology.

FRA and NJ TRANSIT calculated vibration levels resulting from rail activity with the Preferred Alternative for these receptors using the general vibration assessment methodology previously described. At receptor 3a, which is proximate to the new tunnel included in the Preferred Alternative but not the existing rail alignment, the frequency of rail activity in Preferred Alternative would fall into the “frequent events” category as described above in **Table 12-5**. At receptor 5, which is proximate to the existing rail alignment, the frequency of rail activity in the existing condition, No Action Alternative, or Preferred Alternative would fall into the “frequent events” category. Consequently, the vibration impact threshold is 72 VdB and the ground-borne noise impact threshold is 35 dBA for category 2 uses (i.e., residences). **Table 12-20** shows the results of the general vibration assessment for receptors in New Jersey.

Table 12-20
New Jersey Operational Vibration and Ground-Borne Noise Analysis Results

Receptor	Alternative	Vibration Levels (VdB)			Ground-Borne Noise Levels (dBA)		
		Impact Threshold	Rail-Generated Level	Impact?	Impact Threshold	Rail-Generated Level	Impact?
3a	Existing	72	n/a	No Impact	35	n/a	No Impact
	No Action	72	n/a	No Impact	35	n/a	No Impact
	Preferred	72	60	No Impact	35	10	No Impact
5	Existing	72	74	Moderate Impact	35	20	No Impact
	No Action	72	74	Moderate Impact	35	20	No Impact
	Preferred	72	74	Moderate Impact	35	20	No Impact

As shown in **Table 12-20**, the calculated vibration and ground-borne noise levels resulting from rail activities associated with the Preferred Alternative would be less than the impact thresholds at receptor 3a. This receptor location represents the closest sensitive locations in New Jersey to the new tunnel included in the Preferred Alternative. At other locations and other sensitive receptors that are farther from the tunnel, vibration and ground-borne noise levels would be lower and consequently would also not exceed the vibration impact threshold.

Also as shown in **Table 12-20**, the calculated ground-borne noise level resulting from rail activities associated with the Preferred Alternative would be less than the impact thresholds at receptor 5. However, the calculated levels of vibration resulting from rail activity would constitute moderate impacts in the existing condition, No Action Alternative, and Preferred Alternative. The Preferred Alternative would not result in changes to train volume or speed as compared to the No Action Alternative. Consequently, there would be no change to the classification of the frequency of events at receptor 5 from the existing condition of "frequent events." Since the Preferred Alternative would not have the potential to increase vibration levels at this receptor or result in more frequent events, the vibration levels in the "moderate impact" range would not constitute an adverse impact.

Consequently, the Preferred Alternative would not result adverse vibration or ground-borne noise impacts at receptors in New Jersey.

12.7.3 NEW YORK

12.7.3.1 NOISE

The potential noise effects of the Preferred Alternative at the receptors in the New York were analyzed using the methodology described in Section 12.2. **Table 12-21** shows the noise levels and incremental change in noise levels for the Preferred Alternative. Noise levels shown for the Preferred Alternative in **Table 12-21** result from the operation of the new Twelfth Avenue ventilation fan plant, which is the only above-ground noise-producing Project element in New York, together with the measured existing conditions noise level.

Table 12-21
New York Preferred Alternative Noise Levels (in dBA)

Site	FTA Land Use Category	Existing Noise Level	Moderate Impact Threshold[1]	Severe Impact Threshold[1]	Preferred Alternative Noise Exposure (Project-Generated Noise)	Total Preferred Alternative Noise Level	Preferred Alternative Noise Level Increment	Impact?[2]
8a	2	78	66	76	52	78	0	No Impact
9	3	71	66	71	61	71	0	No Impact
10	3	73	66	72	59	73	0	No Impact

Notes: [1] Impact criteria are based on the existing noise level, as shown in **Figure 12-1**.
[2] The noise exposure for the Preferred Alternative is compared to the FTA moderate impact and severe impact thresholds to determine whether a moderate impact and/or severe impact are predicted to occur; severe impacts are considered adverse impacts and moderate impacts may or may not be considered adverse impacts depending on site-specific context.

As shown in **Table 12-21**, the Project noise exposure predicted for the Preferred Alternative at Hudson River Park, the High Line, and the proposed residential buildings at the east end of the block between West 29th and 30th Streets, Eleventh and Twelfth Avenues (receptor sites 8a, 9, and 10) would not result in a moderate or a severe impact according to FTA noise impact criteria. Additionally, incremental changes in noise levels between the Preferred Alternative and existing conditions would be less than 1 dBA at these receptors, which would be imperceptible. Consequently, operation of the new Twelfth Avenue fan plant would not result in any adverse noise impacts at these receptor sites. Moreover, the fan plant will include silencers and dampers that will effectively reduce noise levels from this operation.

Other receptors in New York were not within the screening distance from any permanent noise-producing Project elements and would consequently also not experience an adverse noise impact as a result of the Preferred Alternative.

Consequently, the Preferred Alternative would not have the potential to result in any adverse noise impacts at receptors in New York.

12.7.3.2 VIBRATION AND GROUND-BORNE NOISE

As described above in Section 12.3.1.3, there are receptors located within the screening distance from the Preferred Alternative; therefore, FRA and NJ TRANSIT conducted a general vibration analysis for the Preferred Alternative and identified one residential receptor in Manhattan.

FRA and NJ TRANSIT calculated vibration levels resulting from rail activity with the Preferred Alternative for these receptors using the general vibration assessment methodology previously described in Section 12.2.3.2.2. At receptor 8a, which is proximate to the new tunnel included in the Preferred Alternative but not the existing rail alignment, the frequency of rail activity in Preferred Alternative would fall into the “frequent events” category as described above in **Table 12-5**. Consequently, the vibration impact threshold is 72 VdB and the ground-borne noise impact threshold is 35 dBA for category 2 use (i.e., residences). **Table 12-22** shows the results of the general vibration assessment for receptors in Manhattan.

Table 12-22
New York Operational Vibration and Ground-Borne Noise Analysis Results

Receptor	Alternative	Vibration Levels (VdB)			Ground-Borne Noise Levels (dBA)		
		Impact Threshold	Rail-Generated Level	Impact?	Impact Threshold	Rail-Generated Level	Impact?
8a	Existing	72	n/a	No Impact	35	n/a	No Impact
	No Action	72	n/a	No Impact	35	n/a	No Impact
	Preferred	72	67	No Impact	35	17	No Impact

As shown in **Table 12-20**, the calculated vibration and ground-borne noise levels resulting from rail activities associated with the Preferred Alternative would be less than the impact thresholds at the analyzed receptor. This receptor location represents the closest sensitive location in New York to the rail right-of-way. At other locations and other sensitive receptors, which would be located further from the railway, vibration and ground-borne noise levels would be lower and consequently would also not exceed the vibration impact threshold. Consequently, the Preferred Alternative would not result adverse vibration or ground-borne noise impacts at any receptors in New York.

12.8 CONCLUSIONS

The detailed construction noise analysis conducted according to FTA analysis guidance found that there would be the potential for adverse construction noise impacts at receptors both in New Jersey and New York:

- Pile driving and ventilation fan operation at the Tonnelle Avenue staging area and underpass construction work area would have the potential to result in adverse construction noise impacts at residential receptors along Grand Avenue between 19th Street and 23rd Street in New Jersey for up to approximately 2.5 years during new tunnel construction. Additionally, ventilation fan operation at the Tonnelle Avenue staging area during rehabilitation work for the North River Tunnel would have the potential to result in adverse construction noise impacts at residential receptors along Grand Avenue and Paterson Plank Road between 19th Street and 23rd Street in New Jersey for up to approximately 4 years.
- Trucks traveling to and from the Tonnelle Avenue staging area would have the potential to result in an adverse noise impact at the residences along Tonnelle Avenue between 10th Street and Secaucus Road for up to approximately 4 years during construction of the new tunnel and 4 additional years during rehabilitation of the North River Tunnel.
- Trucks traveling to and from the Hoboken staging area would have the potential to result in an adverse noise impact at the residences along the truck routes in Weehawken on Willow Avenue south of West 19th Street and on Park Avenue south of West 19th Street for 4 years.
- Pile driving operations at the Twelfth Avenue shaft site and as part of the West 30th Street cut-and-cover work would result in noise levels that exceed the impact threshold for approximately 12 months at the residential buildings at 606 West 30th Street and 601 West 29th Street (if they are completed when pile driving occurs), the 312 Eleventh Avenue residential building, the 450 West 33rd Street residential building, and the portion of the High Line that runs along West 30th Street. If the garage and potential EMS facility on West 29th Street (lot 12) are delayed and their construction occurs later, the total duration would increase to up to approximately 2 years.

The construction noise and vibration analyses found that at other receptors, noise and vibration resulting from construction of the Preferred Alternative may result in noticeable levels of noise and/or vibration, but the noise and/or vibration would occur over only a limited period of time or would not rise to the level of an adverse impact.

At receptors in Manhattan, noise levels resulting from pile driving activity would exceed the *CEQR Technical Manual* noise impact criteria; however, since pile driving activity associated with the Twelfth Avenue shaft and West 30th Street cut-and-cover work would occur for a period shorter than two years, these exceedances would not constitute adverse construction noise impacts according to *CEQR Technical Manual* noise impact criteria.

The general noise analysis conducted according to FTA analysis guidance found that there would be no potential for the permanent elements of the Preferred Alternative to result in noise impacts at the analyzed receptors, with the exception of one. At this one receptor, i.e., residences immediately adjacent to the proposed ventilation fan plant in Hoboken, the potential for a moderate noise impact was predicted to occur according to FTA impact criteria. However, based on the incremental change in noise levels, which would be imperceptible, this receptor was predicted not to experience an adverse noise impact according to FTA impact criteria. The general vibration and ground-borne noise analysis conducted according to FTA guidance found that there would be no potential for exceedances of the vibration or ground-borne noise impact criteria. Based on the conclusion that the Preferred Alternative would not have the potential to result in adverse impacts relating to airborne noise, vibration, or ground-borne noise at any of the analyzed receptor sites, and that these receptor sites represent the sites closest to the Project site and would thus have the greatest potential to experience noise and vibration impacts as a result of the Preferred Alternative, the Preferred Alternative would not result in any adverse impacts related to noise or vibration upon completion.

12.9 MEASURES TO AVOID, MINIMIZE, AND MITIGATE IMPACTS

The following measures will be implemented to avoid, minimize, and mitigate noise impacts during construction:

- During construction, the Project Sponsor will coordinate construction activities with affected municipalities in New Jersey, New York City, and nearby property owners to schedule construction to avoid or minimize adverse impacts where practicable.
- Noise from construction equipment will comply with FTA, the New Jersey Department of Environmental Preservation (NJDEP), and New York City noise emission standards where feasible and practicable. These Federal, state, and city requirements mandate that certain classifications of construction equipment and motor vehicles meet specified noise emission standards, and construction material be handled and transported in such a manner to not create unnecessary noise.
- A noise and vibration complaint procedure will be established to promptly address community concerns and implement additional control methods where necessary.
- To the extent practicable given space constraints at the work sites, construction will use acoustical noise tent and/or enclosures surrounding jackhammers or pavement breakers that can provide up to 15 dBA of noise reduction during any demolition activities. For additional noise reduction, jackhammer noise mufflers that can provide up to an additional 10 dBA of noise reduction can also be used.
- To minimize the noise from the backup warning alarms on trucks, vehicles will be routed through the construction sites to minimize the use of alarms. In addition, vehicles will also be

equipped with Occupational Safety and Health Administration (OSHA)-approved quieter backup alarms.

- At residential receptors along Paterson Plank Road and along Grand Avenue between 19th Street and 23rd Street and on Tonnelle Avenue at 10th Street in North Bergen, New Jersey, and residences on the Park Avenue service road, Willow Avenue, and the Willow Avenue service road between the HBLR and 19th Street in Weehawken, New Jersey, the Project Sponsor will offer to provide façade improvements in the form of storm windows and air conditioning units to allow for the maintenance of a closed-window condition. Such measures would result in lower levels of construction-generated noise inside these residential buildings, although they would not completely eliminate the predicted construction noise impacts.
- Blasting for the construction of the hard rock tunnel in the Palisades will occur during daytime hours and will not be performed after 7 PM in residential areas unless permission from the appropriate local regulatory agency (i.e., North Hudson Regional Fire and Rescue) is provided. Residences of Paterson Plank Road and Grand Avenue dwelling units will be provided a blasting schedule.
- At the Tonnelle Avenue construction staging area adjacent to the new Hudson River Tunnel portal, during final design, the Project Sponsor will examine the feasibility of including a noise barrier along the southern boundary of the staging site to shield the Hindu temple on Tonnelle Avenue from construction noise. If the analysis demonstrates that such a wall would be effective based on more refined design information about tunnel construction methods, the Project Sponsor will include a construction barrier at this location in the Project's design.
- At the Hoboken shaft and construction staging area, the Preferred Alternative will include a noise barrier (e.g., ¾-inch thick plywood) up to 25 feet high to provide noise mitigation for the residences nearest the site in Weehawken. This wall will be most effective at a height of 25 feet; if a lower wall is provided, noise levels due to construction would continue to exceed the FTA impact criteria for construction noise.
- Underpinning of the Willow Avenue viaduct will be accomplished using drilled piles rather than driven piles to reduce resulting noise levels.
- For construction sites in New York, site enclosures or temporary noise barriers (e.g., ¾-inch thick plywood) 15 feet high will be used. At cut-and-cover construction sites, barriers will be constructed along the curbline while the street nearest the curb will remain open to accept equipment to complete the excavation across the street.
- Blasting in Manhattan tunnel will not occur after 10 PM, except with special permission from the appropriate regulatory agency (i.e., the Fire Department of New York). A blasting schedule will be provided to neighboring building owners and occupants.
- A pre-construction inspection and vibration monitoring will be conducted for historic and non-historic buildings adjacent to construction sites to avoid minor structural damage during construction. To ensure that construction levels for vibration remain below FTA threshold criteria, the following specifications would be included in the construction contracts for the Project:
  - Mitigation for blasting and pile driving-related vibration will include controlled blasting techniques, timed multiple charges and blast mats, use of pre-auguring, where possible, and requiring that loose vibrating noise-producing fittings be appropriately secured prior to pile driving. Procedures specific to timed multiple charges will include the design of the number, location, and spacing of shot holes, delay times, pounds-per-delay, and firing sequences.

- Pre- and post-construction surveys and field vibration level monitoring during blasting and pile driving activities will be implemented to verify that actual vibration levels would be acceptable, and to require modification of the contractor's means and methods.
- Community outreach relative to times of blasting.
- Blasting in areas overseen by Amtrak will follow that agency's blasting requirements.
- Adjustments in blast design parameters, pre-auguring, and appropriate cuts in the pavement for pavement breaking to protect sensitive receptors. Where practical, saw cuts extending completely through the pavement would be implemented, and concrete cutters will be used on pavement surfaces instead of pavement breakers.
- Field vibration monitoring gauges will be installed during blasting, drilling, pile driving, and pavement breaking activities at sensitive receptors (including identified historic structures) and at or below buildings within which vibration-sensitive activities occur, to verify that actual vibration levels would remain below the U.S. Bureau of Mines building damage criteria damage threshold of 2.0 inches/second for buildings and 0.5 inch/second for historic buildings, and to require modification of the contractor's means and methods.

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