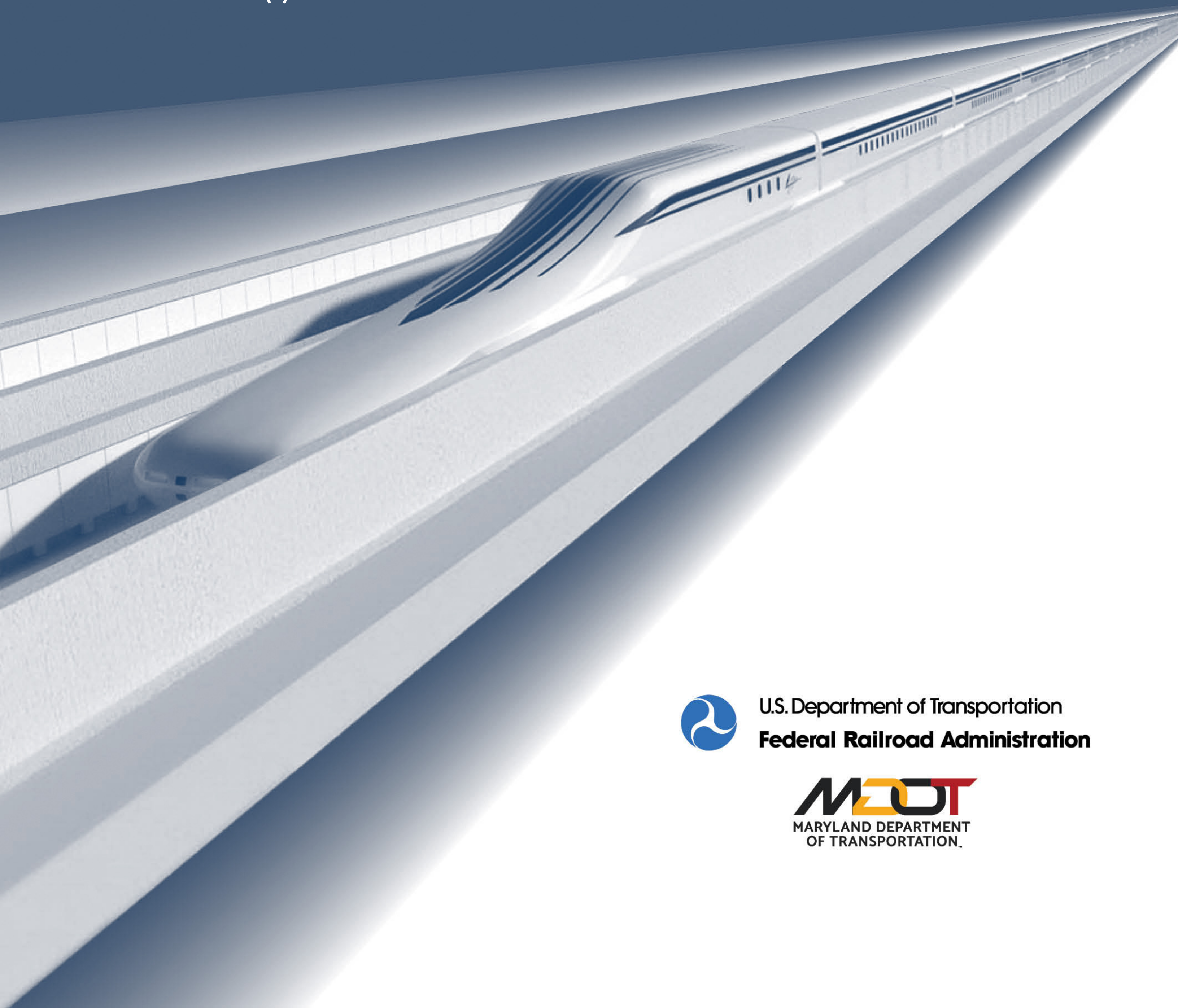
Section 4.17

Noise and Vibration

BALTIMORE-WASHINGTON SUPERCONDUCTING MAGLEV PROJECT

DRAFT ENVIRONMENTAL IMPACT STATEMENT AND SECTION 4(f) EVALUATION



U.S. Department of Transportation
Federal Railroad Administration

MARYLAND DEPARTMENT OF TRANSPORTATION

4.17 Noise and Vibration

4.17.1 Introduction

This section evaluates potential noise and vibration impacts from construction and operation of the Superconducting Magnetic Levitation (SCMAGLEV) Project. The Federal Railroad Administration (FRA) conducted a comprehensive noise and vibration study to assess the potential for impact from various sources of the SCMAGLEV Project. The assessment included a 24-hour noise monitoring program to establish baseline conditions, a modeling analysis to predict future levels from long-term operations of the system, a modeling analysis to predict noise levels from temporary construction activities and a mitigation assessment to evaluate various control measures. See Appendix D.10 for additional details on noise and vibration.

4.17.2 Regulatory Context and Methodology

4.17.2.1 Regulatory Context

In accordance with the National Environmental Policy Act (NEPA) [42 U.S.C. § 4321 et seq.], the Council on Environmental Quality (CEQ) regulations [40 C.F.R. Parts 1500 - 1508], and the FRA's Procedures for Considering Environmental Impacts [64 Fed. Reg. 28545, May 26, 1999], FRA assessed noise and vibration impacts from the SCMAGLEV Project with respect to applicable Federal, State, and local noise standards, including 49 CFR part 210 (FRA noise regulations) and 40 CFR part 201 (United States Environmental Protection Agency [USEPA] noise regulations).

Operational Criteria

Specifically, FRA evaluated train operations using FRA's *High-Speed Ground Transportation Noise and Vibration Impact Assessment*[1] guidelines while stations and ancillary facilities were evaluated using the Federal Transit Administration's (FTA) *Transit Noise and Vibration Impact Assessment*[2] guidelines. The FRA guidelines include methodologies and evaluation criteria for assessing potential impacts from very high-speed trains only. The FTA guidelines include methodologies for all other transit-related activities such as stationary sources and ancillary facilities. However, both guidelines share the same evaluation criteria and impact assessment methodologies.

As shown in **Table 4.17-1**, FRA assessed impacts based on land use categories and sensitivity to noise and vibration from transit sources. FRA used the average hourly equivalent noise level or Leq(h) to assess impacts at institutional land-uses such as laboratories and schools (Land Use Category 1 and 3). Similarly, FRA used the average day-night noise level (Ldn) to characterize noise at residences (Land Use Category 2).

[1] Federal Railroad Administration, "High-Speed Ground Transportation Noise and Vibration Impact Assessment," Office of Railroad Policy and Development, DOT/FRA/ORD-12/15, Final Report, September 2012, Washington, D.C.
[2] Federal Transit Administration, "Transit Noise and Vibration Impact Assessment,", May 2006, Washington, D.C.

The Ldn noise metric includes a 10-decibel "penalty" for all nighttime events that occur from 10 pm and 7 am to account for increased annoyance during those times.

Table 4.17-1: Corridor wide Impact Counts for Noise and Vibration

Land-Use Category	Noise Metric (dBA)	Description of Land-Use Category
1	Outdoor Leq(h)*	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, and national historic landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor Ldn	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 Leq(h)*	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches, where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. This category includes places for meditation or study associated with cemeteries, monuments, and museums. Certain historical sites, parks, campgrounds, and recreational facilities are also included.

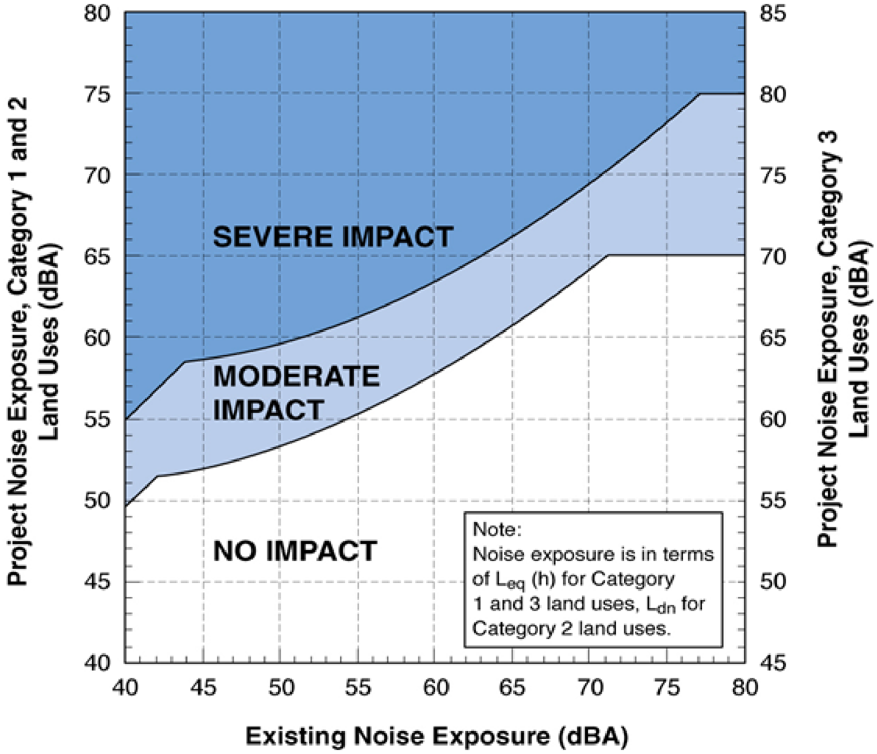
Source: FRA guidelines.

The noise criteria delineate two categories of impact: 'moderate' and 'severe'. The 'moderate' impact threshold defines areas where the change in noise is noticeable but may not cause a strong, adverse community reaction. The 'severe' impact threshold defines the noise limits above which new noise would highly annoy a significant percentage of the population. The noise criteria are shown graphically in **Figure 4.17-1**.

As shown in **Table 4.17-2**, FRA defines vibration criteria in terms of human annoyance for the same land use categories as for noise. The vibration threshold of human perceptibility is approximately 65 VdB. To reflect FRA's experience with community response to vibration, the most stringent criteria attributed to 'frequent' events was used to assess impacts. The 'frequent' event threshold reflects more than 70 events or train passbys per day. Along tunnel sections with no airborne noise, ground-borne noise may cause a rumble indoors due to the propagation of vibration through building structures. Along viaduct sections, ground-borne noise is less perceptible compared to airborne noise, so it is less of a concern.

Specific land-uses more sensitive than those represented by the FTA Category 1 criteria will be addressed during the FEIS pending close coordination with the affected property owners (e.g., United States Department of Agriculture [USDA], National Aeronautics and Space Administration [NASA], General Services Administration [GSA], Surface Transportation Board [STB], and Federal Aviation Administration [FAA]).

Figure 4.17-1: Noise Impact Criteria for High-Speed Rail Project



Source: FRA guidelines.

Table 4.17-2: FRA Ground-borne Vibration and Noise Criteria

Land Use Category	Vibration Criteria 'frequent'[1]	Noise Criteria 'frequent'[1]
Category 1: Buildings where Vibration would interfere with interior operations.	65 VdB[2]	N/A[3]
Category 2: Residences and buildings where people normally sleep.	72 VdB	35 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	40 dBA

1. Frequent Events are defined as more than 70 vibration events of the same kind per day.

2. This criterion limit levels 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.

3. Vibration-sensitive equipment is not sensitive to ground-borne noise.

Source: FRA guidelines.

Construction Criteria

FRA evaluated noise and vibration impacts due to temporary construction activities using the FRA guidelines. The FRA guidelines include methodologies and evaluation criteria for assessing potential impacts from various construction equipment. As shown in **Table 4.17-3**, the FRA used the one-hour average noise level or Leq(h) to assess preliminary impacts at residences, commercial and industrial uses. This general noise assessment uses the FRA noise criteria when detailed construction activities are unknown.

Table 4.17-3: General Assessment Construction Noise Criteria

Land Use	1-Hour Leq (dBA)	
	Day	Night
Residential	90	80
Commercial	100	100
Industrial	100	100

Source: FRA guidelines.

Similarly, FRA used the peak particle velocity vibration level (PPV) in inches per second (or in/sec) to assess the potential for damage at residences and other sensitive receptors using the criteria shown in **Table 4.17-4**. Unlike the VdB vibration level, the PPV vibration level represents the maximum peak level and is, therefore, typically used to assess stresses on buildings. FRA also used the vibration criteria shown in **Table 4.17-2** to assess the potential for annoyance or interference with vibration-sensitive activities because PPV is not a good indicator of human response.

Table 4.17-4: Construction Vibration Damage Criteria

Building Category	PPV in/sec	Approximate Lv [1]
I. Reinforced-concrete, steel or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Note 1: RMS velocity in decibels, VdB re 1 micro-in/sec

Source: FRA guidelines.

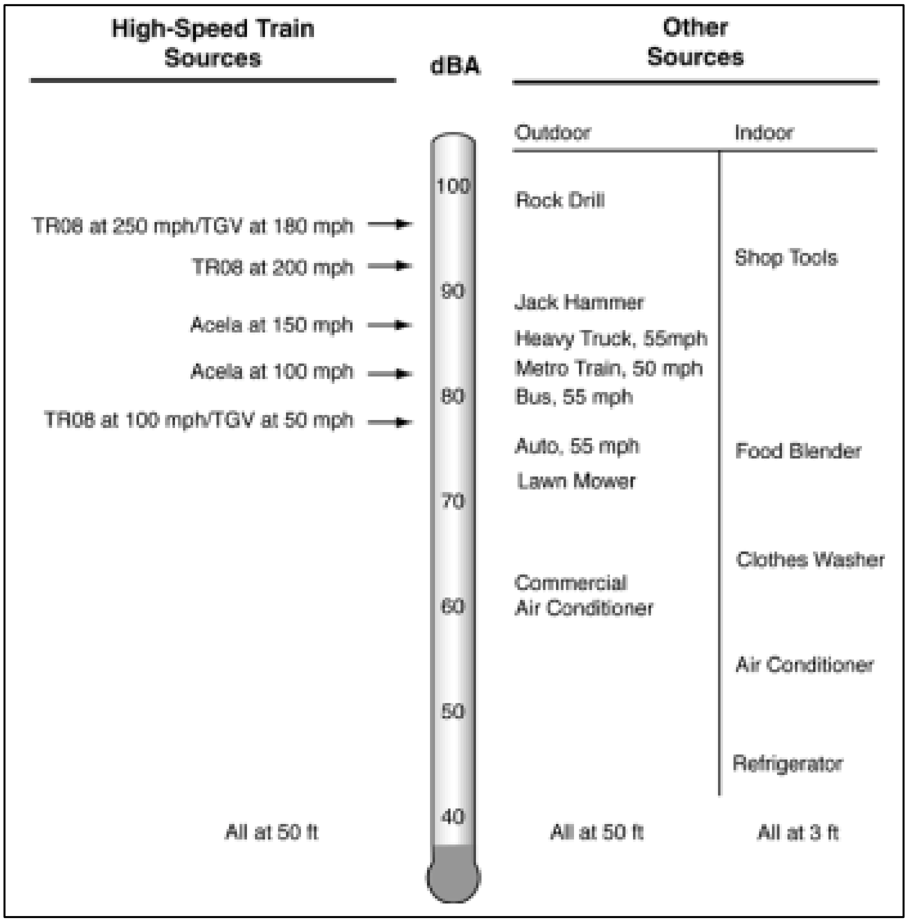
4.17.2.2 Methodology

Noise and Vibration Fundamentals

Noise is defined as unwanted or excessive sound, and can interfere with sleep, work, relaxation, and/or recreation. The adverse effects of noise depend on the duration, loudness, frequency, time of day, and personal preferences. To establish a noise measurement that reflects the likelihood of community annoyance, the A-weighted decibel measurement accounts for those frequencies most audible to the human ear. The A-weighted sound level (dBA) is the descriptor of noise levels most often used for community noise assessment. It is important to note that the dBA scale is logarithmic, meaning that each increase of 10 dBA describes a doubling of perceived loudness. For example, we perceive the background noise in an office at 50 dBA as twice as loud as in a library at 40 dBA. For most people, a 3-dBA change is barely perceptible, while a

5 dBA a change in noise level would be readily noticeable. FRA evaluated all noise levels in this analysis using the 24-hour day-night noise level (or Ldn) for residential receptors and the average peak hourly noise level (or Leq) for institutional and other non-residential receptors. **Figure 4.17-2** shows typical noise levels.

Figure 4.17-2: Typical A-Weighted Maximum Sound Levels

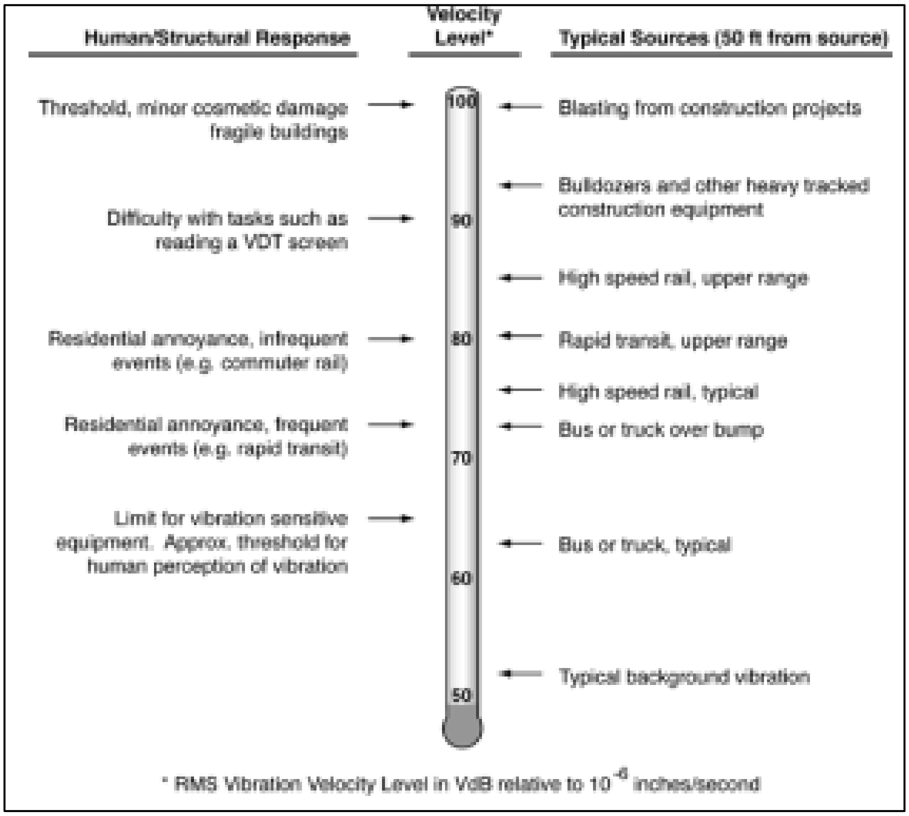


Source: FRA guidelines.

Ground-borne vibration typically travels along the ground and through building structures. Depending on the geological properties of the surrounding terrain and the type of building structure, vibration propagation can be more or less efficient. Buildings with a solid foundation set in bedrock are "coupled" more efficiently to the surrounding ground and experience relatively higher vibration levels than buildings in sandier soil. Heavier buildings (such as masonry structures) are less susceptible to vibration than wood-frame buildings because they absorb more vibrational energy.

The vibration velocity level is used to assess vibration impacts from all transportation and construction projects. More specifically, the human response to vibration used to assess nuisance impacts is the root mean square amplitude, expressed in inches per second (in/sec) or vibration velocity levels in decibels (VdB). The peak particle velocity level (or PPV) is used to assess potential damage during construction and indicates the stresses experienced by buildings rather than human annoyance. Vibration that radiates inside a building when a train passes can cause a low-frequency sound or rumble. This interior rumble is referred to as ground-borne noise and utilizes the same measurement as airborne noise (dBA). **Figure 4.17-3**. Shows typical vibration levels.

Figure 4.17-3: Typical Levels of Ground-borne Vibration



Source: FRA guidelines.

Noise and Vibration Sources Evaluated

FRA evaluated project noise and vibration impacts using the FRA guidelines for the following sources:

- high-speed train operations; and,
- construction activities.

Similarly, FRA evaluated all other project impacts using the FTA guidelines for the following sources:

- passenger stations
- fresh air and emergency egress facilities (FA/EE);
- trainset maintenance facilities (TMF);
- maintenance of way facilities (MOW); and,

- electrical substations.

As shown in **Table 4.17-5**, FRA conducted a detailed noise and vibration assessment of future operations for each of the 12 Build Alternatives, which include various combinations of passenger stations and ancillary facilities. All the Build Alternatives include Mount Vernon and BWI Marshall Airport Station. In addition to the two optional stations and three optional TMF sites, there are 12 different substation locations.

Table 4.17-5: Build Alternatives and Project Source Evaluation Matrix

Build Alternative	Station	TMF & MOW	Substation
J-01	Cherry Hill	MD 198	SS01
J-02	Cherry Hill	BARC Airstrip	SS02
J-03	Cherry Hill	BARC West	SS03
J-04	Camden Yards	MD 198	SS04
J-05	Camden Yards	BARC Airstrip	SS05
J-06	Camden Yards	BARC West	SS06
J1-01	Cherry Hill	MD 198	SS07
J1-02	Cherry Hill	BARC Airstrip	SS08
J1-03	Cherry Hill	BARC West	SS09
J1-04	Camden Yards	MD 198	SS10
J1-05	Camden Yards	BARC Airstrip	SS11
J1-06	Camden Yards	BARC West	SS12

Source: AECOM.

Methodology Summary

FRA utilized the FRA screening distance of 800' to select all eligible first- and second-row receptors closest to the project alignment. First-row receptors include those residences immediately adjacent to the alignment while second-row receptors include those residences behind and shielded by the first row. Following FRA's guidance, the analysis does not tabulate receptors beyond the first two rows. The intent was not to document project impacts at all receptors within the study area but identify locations with predicted impact. FRA selected almost 4,000 sites closest to the project Build Alternatives to evaluate noise and vibration impacts during operations and construction. One set of receptors was used for all Build Alternatives, due to the similar nature of the alignments.

FRA determined operational train impacts using headway times, train speed profiles, track and ground elevation profiles. Train speeds ranged from 0 mph at stations to 311 miles per hour along the guideway. Track elevations ranged from over 308' below grade near Mount Vernon Station to 142' above grade near the MD 198 TMF. Train consists include 16 cars for all operations during the operating period between 5 am and 11 pm. Unlike standard trains, which include propulsion and guideway/structural noise effects, high-speed SCMAGLEV trains also present significant aerodynamic noise from the train nose cone and the turbulence or disturbance around the train body (or turbulent boundary layer).

Since little information is available for the ancillary facilities (such as the activities proposed there), traditional activity levels were used as a surrogate. For example, the trainset maintenance facilities are expected to have most of their activities indoors including all maintenance, repair and inspection. Therefore, the FTA's railcar washing station was used to represent noise impacts from the TMF sites. Similarly, the FTA's rail yard was used to represent noise impacts from the MOW facilities. Any impacts related to the passenger stations or ancillary facilities predicted as part of this project are preliminary only and final design would address details on these activities.

In accordance with the guidelines, FRA evaluated project noise impacts using cumulative noise metrics (such as day-night noise level for residences). These statistical metrics capture the total noise exposure at residences along the corridor over a 24-hour period. These total noise levels are compared with the project impacts criteria to determine the likelihood of impact. The project impact criteria are based on the baseline noise measurements, which vary along the project corridor.

Vibration impacts were compared against the 'frequent' criteria using levels for single events. Ground-borne noise levels were determined from the vibration levels using a 'typical ground' attenuation factor.

Since the SCMAGLEV train operations would occur along a dedicated guideway, there are no grade crossings and no need for train horns unlike typical surface rail systems.

FRA determined vibration levels from train operations using the FRA 'maglev' general assessment curves. FRA utilized standard ground-attenuation effects with no adjustments for building foundations. Adjustments for individual building foundation effects will be applied during final design where impacts are predicted.

FRA also evaluated temporary construction impacts using the two loudest pieces of equipment as part of the FRA's general assessment guidelines for each of the following scenarios:

- Tunnel boring;
- Viaduct construction;
- Station excavation/construction;
- EE/FA excavation/construction;
- Trainset maintenance facility;

- Maintenance of way facility;
- Staging and laydown areas (at tunnel portals).

For this preliminary construction assessment, all the selected equipment is assumed to operate continuously over a one-hour period. As a conservative assumption, FRA did not apply ground attenuation effects.

Refer to Section 4.12 Ecological Resources for more information on impacts to wildlife.

4.17.3 SCMAGLEV Project Affected Environment

The SCMAGLEV Project Affected Environment contains a wide variety of land use types, ranging from wide open rural areas to open rural areas to dense urban communities. As such, the existing noise conditions within the SCMAGLEV Project Study Area also ranges from quiet conditions along forested/agricultural open spaces (Beltsville Agricultural Research Center (BARC) and Patuxent Research Refuge (PRR)) to louder conditions in the downtown areas (Washington, D.C. and Baltimore City, MD). Local noise conditions reflect the major land use types that they are in and their proximity to existing transportation corridors.

FRA conducted a noise-monitoring program at 20 representative locations within the project study area. As shown in **Table 4.17-6**, 24-hour continuous noise measurements were conducted at each of the selected monitoring locations between October 2018 and March 2019. The noise measurements document existing noise sources along the SCMAGLEV Project and establish the project impact criteria for similar nearby receptors. Overall, the measured noise levels provide an overview of current conditions in communities along the project alignment. As shown in **Table 4.17-6**, measured day-night noise levels range from 55 dBA in Laurel, MD to 75 dBA in Linthicum Heights, MD.

Table 4.17-6: Baseline Noise Monitoring Results

Receptor		Land-use	Noise Level (dBA)	
ID	Description	Category	Ldn	Leq(h)
N01	Anacostia River Trail	3	74	74
N02	M-NCPPC wooded property on Kenilworth Ave	3	65	63
N03	Norman A. Berg National Plant Materials Center	3	58	56
N04	MDOT property, Elmshorn Wy	2	63	61
N05	MDOT property, MD 195 Ramp	2	71	68
N06	Muirkirk Park (M-NCPPC)	2	64	60
N07	MDOT property, I-295 NB Ramp	2	67	63
N08	Maryland City Park	3	64	61
N09	Brock Bridge Elementary School	3	55	53
N10	8400 River Rd	3	62	60

Receptor		Land-use	Noise Level (dBA)	
ID	Description	Category	Ldn	Leq(h)
N11	NSA National Cryptologic Museum	3	66	62
N12	MDOT property, Telegraph Rd	2	74	73
N13	Lindale Middle School, Flighttime Dr	3	60	60
N14	MDOT property, I-895 SB	2	75	72
N15	Southwest Area Park	3	66	64
N16	Unger's Field	2	62	56
N17	Cherry Hill Park	2	67	66
N18	Middle Branch Trail	3	68	63
N19	Waterview Ave	2	68	65
N20	Woodland Job Corps Center	3	58	57

Source: AECOM

In lieu of existing vibration measurements, FRA estimates the existing background vibration to range from 50 VdB or lower in rural areas to 65 VdB near roadways. The background vibration velocity level of 50 VdB in residential areas or rural areas is well below the threshold of perception for humans of around 65 VdB. Within buildings, operation of mechanical equipment, movement of people, or slamming of doors causes most perceptible indoor vibration. Typical outdoor sources of perceptible vibration are construction equipment, steel-wheeled trains and traffic on rough roads.

4.17.4 Environmental Consequences

4.17.4.1 No Build Alternative

Noise

Future noise levels for the No Build Alternative would be similar to existing conditions. Noise from a mix of transportation sources including the NEC and other passenger and freight rail traffic lines, aircraft overflights and motor vehicle traffic along regional and local roadways affects communities along the SCMAGLEV Project. Additionally, other commercial and industrial activities associated with urban and suburban communities also contribute to the ambient noise levels. Implementation of other planned and funded transportation projects could also affect the ambient noise. However, unless the planned projects are in the immediate vicinity, existing noise is unlikely to change. As a result, the No Build Alternative would not contribute to new noise impacts.

Vibration

FRA expects the vibration levels under the No Build Alternative to be similar to those currently experienced under existing conditions. Traffic, including heavy trucks and buses, rarely create perceptible vibration unless vehicles are operating very close to buildings or there are irregularities in the road, such as potholes or expansion joints. Similarly, the dominant source of vibration at receptors adjacent to existing rail corridors is existing rail service. FRA does not expect this to change significantly from the existing conditions. As a result, the No Build Alternative would not contribute to new vibration impacts.

4.17.4.2 Build Alternatives

Principal Conclusions and Impacts

FRA conducted a detailed noise and vibration assessment of future operations for each of the 12 proposed Build Alternatives. As shown in **Table 4.17-7**, FRA predicted noise impacts at residences and institutional receptors along the proposed Build Alternatives. Along tunnel sections, FRA did not predict any airborne or community noise impacts since all train operations would be underground. Therefore, all predicted operational train noise impacts occur along the viaduct sections of the alignment due to the exposure of the train passbys along the elevated guideway. High train speeds generate operational impacts due to aerodynamic noise effects created by the air turbulence of a rapid train passby. Additionally, FRA also predicted noise impacts at residences adjacent to the proposed ancillary facilities, which include trainset maintenance facilities, fan plants, maintenance of way facilities and substations. FRA did not predict any noise impacts due to startle effects at tunnel portals since the portal design includes noise mitigation hoods to eliminate these effects. Overall, the FRA predicted fairly consistent corridor-wide noise impacts between the various Build Alternatives with only minor differences due to length of the viaduct section, the path of the guideway and the selection of the various ancillary facilities. The following subsections provide further details on the predicted noise impacts.

Similarly, FRA also predicted vibration impacts at residences and one institutional receptor (the National Cryptologic Museum adjacent to the National Security Agency in Fort Meade, MD). **Table 4.17-7** summarizes vibration impacts. Unlike noise, FRA predicted vibration impacts from train operations along both tunnel and viaduct sections of the guideway. FRA did not predict any vibration impacts from the ancillary facilities (including the trainset maintenance facilities) due to the low activity levels there.

Table 4.17-7: Corridor wide Impact Counts for Noise and Vibration[1]

Build Alternative	Noise					Vibration[4]	
	Category 2[2]	Category 3[2]	‘moderate’ Totals[3]	‘severe’ Totals	Total	Vibration	GB-Noise
J-01	187 / 377	17 / 14	205	392	597	359	485
J-02	186 / 378	17 / 14	204	393	597	359	485
J-03	190 / 377	17 / 14	208	392	600	359	485
J-04	162 / 373	16 / 14	179	388	567	359	485
J-05	161 / 374	16 / 14	178	389	567	359	485
J-06	165 / 373	16 / 14	182	388	570	359	485

Build Alternative	Noise					Vibration[4]	
	Category 2[2]	Category 3[2]	'moderate' Totals[3]	'severe' Totals	Total	Vibration	GB-Noise
J1-01	195 / 96	7 / 9	203	105	308	340	564
J1-02	194 / 97	7 / 9	202	106	308	340	564
J1-03	198 / 96	7 / 9	206	105	311	340	564
J1-04	170 / 92	6 / 9	177	101	278	340	564
J1-05	169 / 93	6 / 9	176	102	278	340	564
J1-06	173 / 92	6 / 9	180	101	281	340	564

Note 1: Impact counts were tabulated for high-sensitivity receptors (FRA Category 1 land-uses), residential receptors (FRA Category 2 land-uses) and institutional receptors (FRA Category 3 land-uses).

Note 2: Category 2 and 3 results include both 'moderate' / 'severe' noise impacts.

Note 3: FRA also predicted one 'moderate' noise impact and one 'severe' noise impact at Category 1 land uses (Goddard GGAO and NSA Headquarters, respectively) for all Build Alternatives J-01 to J-06. FRA also predicted one 'moderate' noise impact at the NSA Headquarters for Build Alternatives J1-01 to J1-06.

Note 4: FRA predicted one vibration impact at the National Cryptology Museum (Category 3) in Fort Meade for all Build Alternatives.

Source: AECOM December 2020

FRA also predicted ground-borne noise impacts along tunnels sections only. Ground-borne noise or the rumbling sound from vibrating building surfaces is an indoor effect that is much lower than airborne noise. It is more noticeable along tunnel sections where there is no airborne noise than along the viaduct sections where airborne noise is more prevalent. Overall, the FRA predicted similar vibration impacts between the various Build Alternatives with only minor differences due to the path of the guideway.

Viaduct / Tunnel Noise Effects

The primary noise source for the SCMAGLEV system at the maximum train speeds is the air turbulence effects (or turbulent boundary layer) caused by the air wash over the body of the train. At these maximum train speeds, the aerodynamic noise effects along the viaduct are orders of magnitude higher than the noise from the train propulsion system or the structural guideway (i.e., viaduct). This is due in part to the shielding effects of the proposed viaduct structure, which includes 7' side walls or parapets. The elevated parapets shield the propulsion and nose cone noise but not the structural noise or the turbulent boundary layer, which is 10' above the track. Due to the effects of the aerodynamic noise effects, FRA predicted no noise impacts at speeds below 150 mph.

For example, along the viaduct sections of the guideway utilizing proposed maximum train speeds, FRA predicted airborne noise impacts up to 2,100' from the guideway. This impact distance is due to a combination of the aerodynamic effects of high-speed train operations, the elevated guideway and the low background noise level.[3] To highlight the difference in noise impacts between viaduct and tunnel sections, **Figure 4.17-4** shows a comparison between Build Alternative J-01 and J1-01 in

[3] The FRA impact criteria are based on a sliding scale whereby low background noise level result in more stringent thresholds.

Maryland City near a tunnel portal. One set of receptors was used for all Build Alternatives, due to the similar nature of the alignments. FRA predicted 'severe' noise impacts at residences in Maryland City from the viaduct under Build Alternative J-01 but no impacts from the tunnel under Build Alternative J1-01. The severity of impact changes between each of the Build Alternatives depending on proximity to the guideway. At the Brock Bridge Elementary School, for example, the predicted level increases from 'moderate' noise impact under Build Alternative J-01 to 'severe' noise impact under Build Alternative J1-01 because it would be closer.

A unique phenomenon occurs at the tunnel portals when the high-speed trains exit the tunnel onto the viaduct. The rapid release of air pressure is associated with a sudden onset of sound that can cause residents startle or surprise especially when they are not expecting it. Current project designs include flared tunnel openings and noise mitigation hoods to minimize these effects. Therefore, these noise effects are minimized compared to the aerodynamic noise effects of the train passby. For Build Alternatives with the J alignment, the tunnel portal would be located near residential communities (initiative housing) on Fort Meade. Project noise would range from 83 dBA (50 feet from tunnel portals) to 77 dBA (200 feet from tunnel portals) at the maximum train speed of 311 mph.

As shown in **Table 4.17-7**, noise impacts were categorized into 'moderate' and 'severe' impact levels. Although both impact categories require mitigation consideration, it is the 'severe' category that has the greatest adverse impact in the community and would warrant incorporation of mitigation. The number of 'severe' noise impacts predicted for each Build Alternative generally follows the viaduct section due to the preponderance of the aerodynamic noise effects. In other words, the longer the viaduct section is for each Build Alternative, the higher the number of predicted 'severe' noise impacts.

For example, FRA predicted 597 noise impacts for Build Alternative J-01 but only 567 noise impacts for Build Alternative J-04. This reduction of 5 percent is due primarily to the 8 percent reduction in the viaduct's length between these Build Alternatives. Similarly, FRA predicted 308 noise impacts for Build Alternative J1-01 or 48 percent less than Build Alternative J-01. This reduction is due primarily to the 40 percent reduction in the viaduct's length between these Build Alternatives. This trend applies to the other Build Alternatives as well.

Ground-borne Vibration and Ground-borne Noise Effects

Most ground-borne vibration impacts are along tunnels sections of the alignment; with minor exceptions where receptors are within 150' of the viaduct. Overall, FRA predicted vibration impacts up to 225' from the guideway. Similarly, FRA predicted ground-borne noise impacts up to 250' from the guideway. Additionally, all ground-borne vibration and noise impacts occur at maximum train speeds of 311 mph. No predicted impacts occur at speeds below 311 mph. Due to the unique nature of the SCMAGLEV technology, slow-moving trains utilize auxiliary wheels while entering stations and within the trainset maintenance facility. As a result, all vibration impacts are due to train operations along the guideway with no impacts due to ancillary facilities.

As shown in **Table 4.17-7**, FRA predicted 359 vibration impacts for Build Alternatives J-01 to J-06 but only 340 impacts for Build Alternatives J1-01 to J1-06. This reduction of 5 percent does not match the 15 percent increase in tunnel sections between these alternatives. However, as shown in **Figure 4.17-5**, FRA predicted lower vibration due to deeper tunneling under Build Alternatives J1-01 to J1-06 (particularly in New Carrolton south of the Capital Beltway) compared to Build Alternatives J-01 to J-06. As a reminder, one set of receptors was used for all Build Alternatives, due to the similar nature of the alignments

Similarly, FRA predicted 485 ground-borne noise impacts along tunnel sections for Build Alternatives J-01 to J-06 and 564 impacts for Build Alternatives J1-01 to J1-06. This increase of 16 percent reflects a 15 percent increase in tunnel sections and a 17 percent increase in the number of residences within 250’ of Build Alternatives J1-01 to J1-06. **Figure 4.17-6** shows this change graphically.

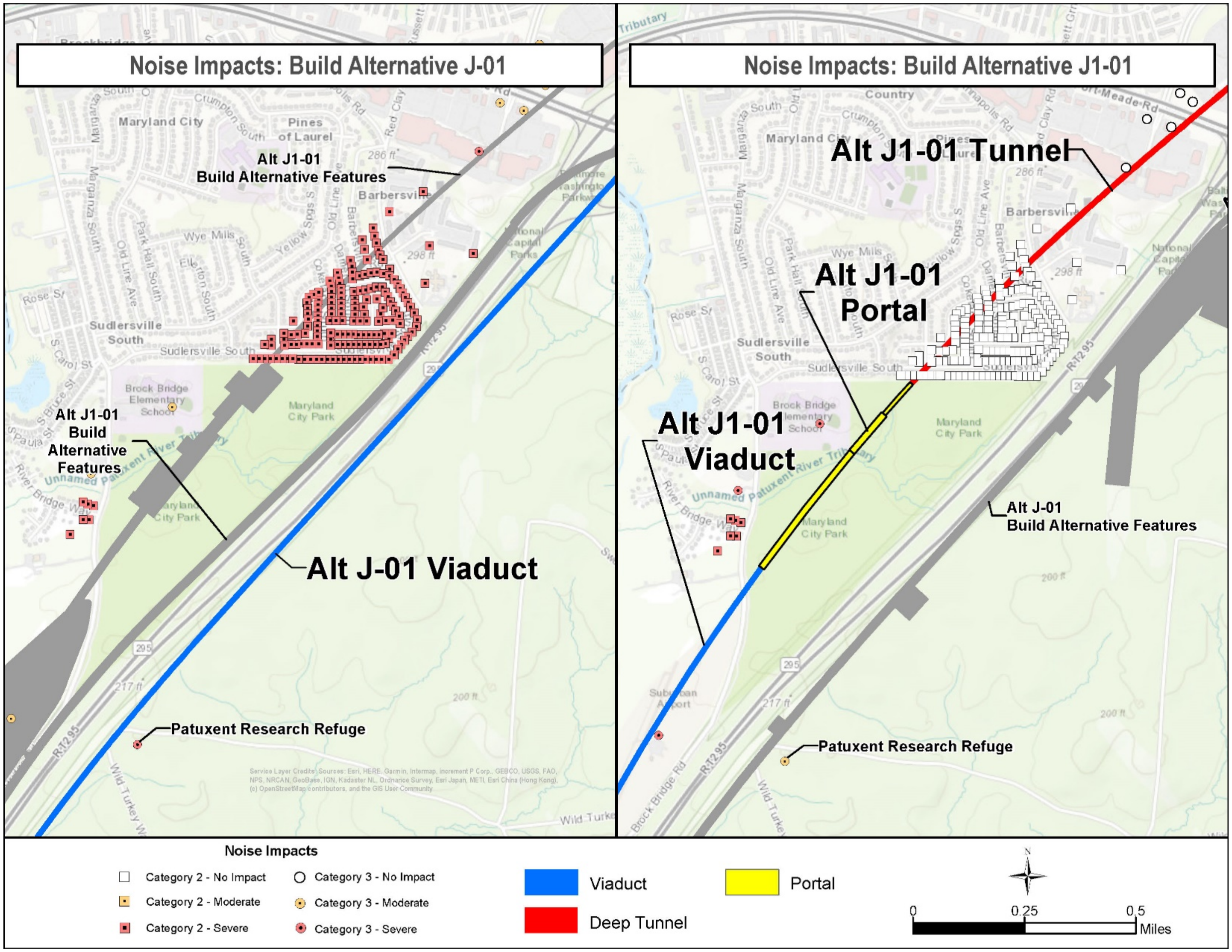
4.17.5 Short-term Construction Effects

4.17.5.1 Noise

Due to the size of the project and the facilities proposed for construction, temporary noise impacts are expected. To maintain the balance between constructing such a large project and quality of life for nearby communities, contractors utilize construction techniques and incorporate control measures to eliminate or minimize noise impacts. Project federal, State and local guidelines determine the appropriate control measures. The following is a preliminary estimation of the types of noise effects expected during the construction phase of the project.

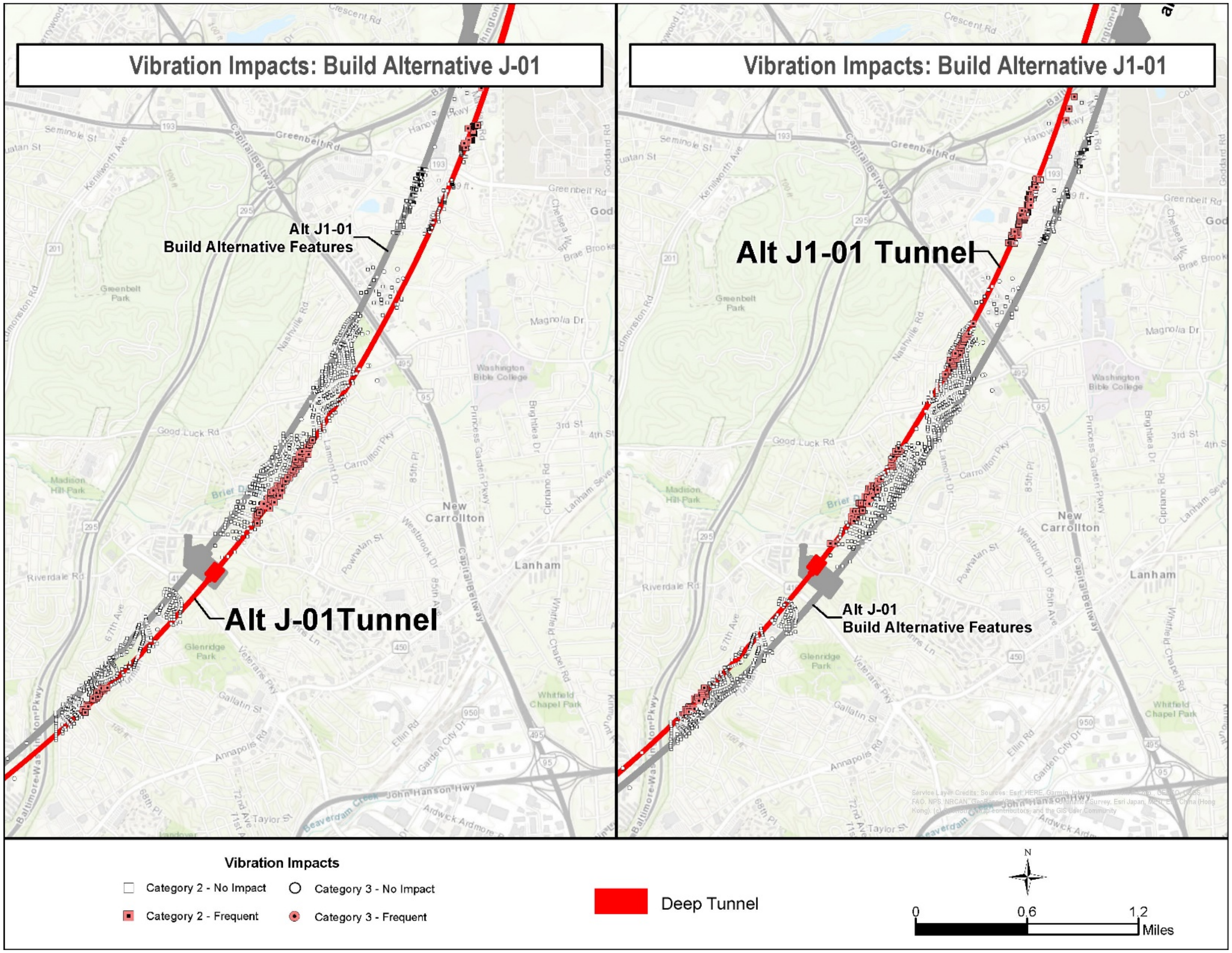
FRA predicts that maximum one-hour construction noise levels would range from below the ambient background (less than 45 dBA) to 85 dBA for FA/EE facilities to 91 dBA for the staging/laydown area at tunnel portals to 94 dBA for the viaduct construction to 96 dBA for the station excavation activities. Since construction could occur day or night depending on the activity and urgency to complete, FRA predicts that several of these levels would exceed the daytime limit of 90 dBA and the nighttime limit of 80 dBA. Construction noise levels vary by activity type and location for each of the Build Alternatives. For example, for Build Alternatives J-01, J-02, J-03, J1-01, J1-02, and J1-03, FRA predicted four daytime noise impacts and 21 nighttime noise impacts. For Build Alternatives J-04, J-05, J-06, J1-04, J1-05, and J1-06, FRA predicted four daytime noise impacts and 20 nighttime noise impacts.

Figure 4.17-4: Viaduct vs. Tunnel Noise Impacts



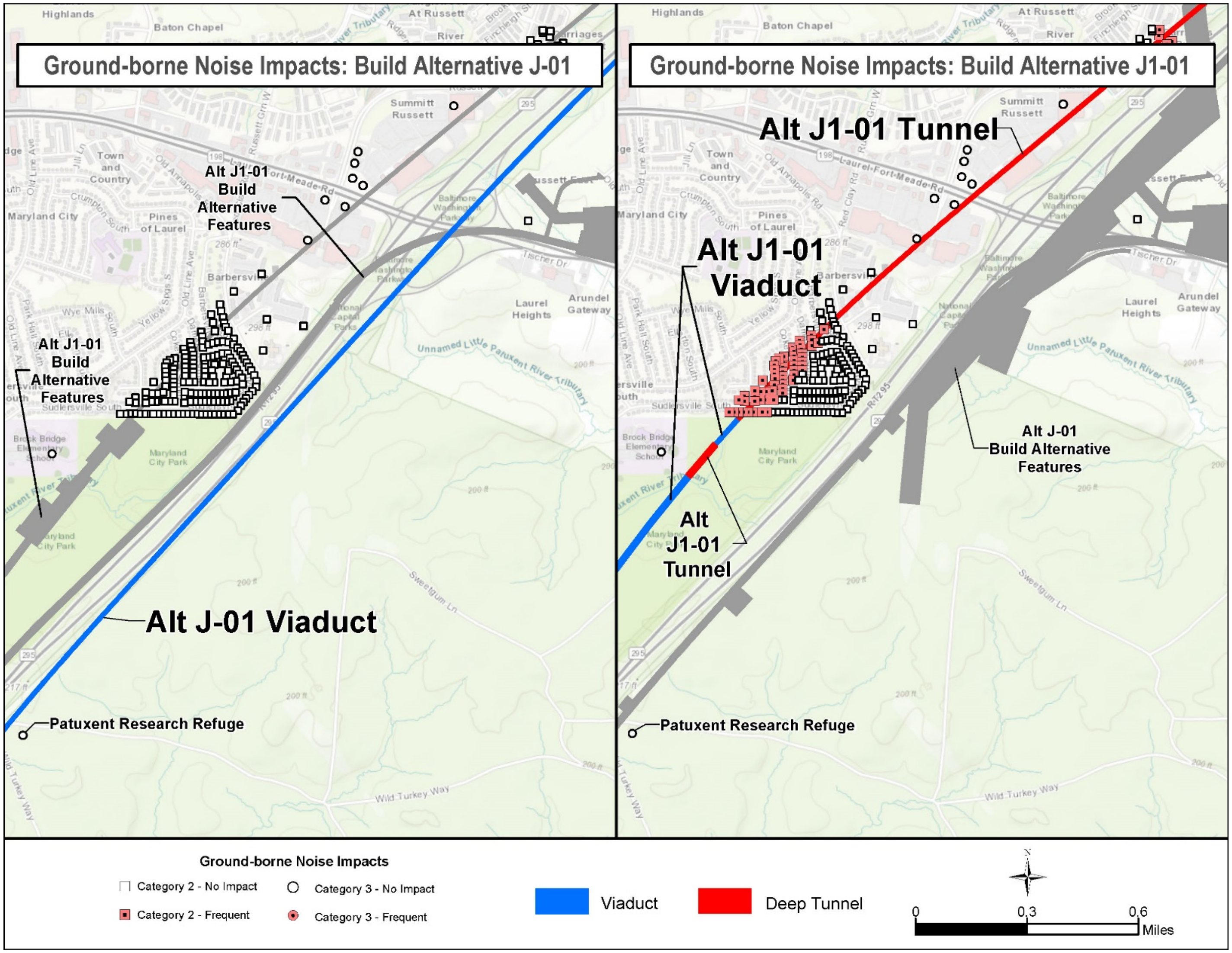
Note: Area shown is in Maryland City, MD.

Figure 4.17-5: Comparison of Vibration Impacts



Source: AECOM.

Figure 4.17-6: Comparison of Ground-borne Noise Impacts



Source: AECOM.

In summary, there are no predicted noise impacts from the tunnel boring machine as all activities would be underground. However, the removal of spoils from the TBM launch areas (which typically occur continuously 24/7 during this phase) could cause impacts at residences in the Maryland City and Fort Meade communities. Localized noise impacts are also expected from station and FA/EE excavation as these will require deep boring, pile driving and possibly blasting.

4.17.5.2 Vibration

FRA predicted maximum construction vibration levels that range from 0.012 in/sec PPV for FA/EE facilities excavation up to 0.121 in/sec for viaduct construction. Based on this preliminary assessment of potential vibration damage, FRA predicted no exceedances of FRA Category I damage threshold (0.5 in/sec for typical timber structures) or the Category II damage threshold (0.5 in/sec for masonry buildings) for any of the Build Alternatives.

Similar to the noise, there are no predicted vibration impacts from the tunnel boring machine along the proposed alignment due to the deep depth of the tunnels. However, the removal of spoils from the TBM launch areas (which typically occur continuously 24/7 during this phase) could cause impacts at residences in the Maryland City and Fort Meade communities. Localized vibration impacts are also expected from station and FA/EE excavation as these will require deep boring, pile driving and possibly blasting.

4.17.6 Potential Mitigation Strategies

Noise and vibration impacts from both temporary construction activities and long-term operations exceed FRA criteria at several receptors in the SCMAGLEV Project Study Area. As a result, FRA has identified several noise and vibration control measures that could reduce potential impacts.

4.17.6.1 Long-term Operations

Mitigation strategies include the application of design features to minimize or eliminate potential noise and vibration impacts at residential communities within the SCMAGLEV Project Affected Environment. Features such as taller parapet walls could minimize noise impacts along viaduct sections but would not eliminate them. Similarly, concrete-lined tunnels and concrete viaducts would reduce vibration transmission but not eliminate them. Additional mitigation measures would be required to reduce noise and vibration impacts. The following proposed noise and vibration-reducing design features would minimize and potentially eliminate all noise and vibration impacts.

- Track design features
  - Sound attenuation hood or shroud to eliminate noise impacts predicted along elevated or at-grade sections of track by extending the hoods near portals to cover longer sections of track along residential communities. (See Appendix G.2 for design details).

  - Similar to underground tunnel sections, noise hoods or shrouds would enclose the noise from SCMAGLEV operations, thereby eliminating any escaping noise to the nearby communities.
- Tunnel portal design features
  - Aerodynamic design of the nose of the SCMAGLEV trainset to minimize portal startle effects.
  - Eliminating all gaps between railcars.
  - Flared tunnel portals similar to trumpets.
  - Elongated portals.
  - Perforated portal hoods to reduce aerodynamic effects there.
  - Constructing air shafts along the tunnel to relieve the micro-pressure waves.
  - Adopting larger tunnel cross-sections.
  - Installing specially designed noise mitigation hoods.
  - Creating elevated “tunnels” with enclosed track to eliminate portals all together.
- Augmented Parapet Walls (Refer to Appendix G.2 for design details)
  - Increasing the parapet height from seven to over 15 feet would eliminate ‘severe’ impacts predicted at residences along the SCMAGLEV Project.
- Sound Attenuation Walls
  - Noise barriers (like those constructed by the Maryland Department of Transportation State Highway Administration (MDOT SHA)) are an effective method to eliminate or reduce noise impacts along residential communities with large clusters of homes.
  - Ground-level noise barriers at the property lines are most effective when there are no openings or gaps that allow sound to pass through.
  - The Final Design phase of the SCMAGLEV Project would determine proper sizing and location.
- Vibration control measures for the SCMAGLEV Project would require further research and investigation to find a suitable solution. Based on the limited information available on the use of maglev or SCMAGLEV train service around the world, experience with source-specific vibration control measures is very limited. Applying first-order principles and experience gained from using successful control measures for other concrete-constructed systems has resulted

in sucessful mitigation of vibration impacts. Typical vibration mitigation would include resilient control such as:

  - Resilient track beds and resiliently supported viaducts would de-couple the track structure from the surrounding support system and thereby 'break' the vibration path between the track and the nearby vibration-sensitive receptors. These resilient materials and devices (typically used for buildings in earthquake zones) are those that can recoil or "spring-back" into shape after being compressed. These can come in many forms, including support pads, springs or other resilient material suitable for the structures proposed on this SCMAGLEV Project.
  - Similar to floating slabs for conventional track systems, a resiliently supported track bed that accommodates the SCMAGLEV electrical and magnetic propulsion and guidance systems would reduce the impact energy caused by the high-speed SCMAGLEV train passing by.

- At FA/EE Facilities, silencers and acoustical louvers are standard control measures typically used to eliminate noise impacts related to tunnel ventilation fans. Attenuator design would reduce low-frequency fan noise traveling along ventilation ducts. Attenuators include perforated metals with sound absorbing materials inside. FA/EE silencers are used in either supply or exhaust capacities.
- Acoustical louvers, which are architectural elements that allow air intake and exhaust flows to buildings, are also used to provide supplemental noise reduction. They include perforated metal panels with sound absorbing materials inside the louver panels. Final Design phase of the SCMAGLEV Project would determine proper sizing and location.
- Due to the sheer size and location of substations, investigation and design of equipment enclosures and acoustical louvers would eliminate noise impacts by isolating the noise inside the building or enclosure. Final Design phase of the SCMAGLEV Project would determine proper sizing of louvers and enclosure wall heights.
- At TMF and MOW facilities, equipment enclosures, perimeter noise barriers and relocating loud maintenance activities indoors are all typical measures used to eliminate noise impacts related to guideway maintenance facilities. Final Design of the SCMAGLEV Project would determine proper sizing and design of enclosure wall heights.

4.17.6.2 Short-term Construction

Unlike long-term operations, temporary construction mitigation would minimize nuisance, disruptions and potential damage during peak activity periods. For example, to minimize potential noise and vibration impacts at residences near staging, laydown and tunnel boring machine (TBM) launch sites, close coordination is required between the selected contractor and the affected properties. The Project Sponsor would require its contractors to implement appropriate noise and vibration control measures that would minimize impacts and extended disruption of normal activities.

In addition, the following may be implemented:

- At staging and laydown sites such as the TBM launch sites, consider installing acoustical curtains or other temporary noise shields to perimeter fencing to act as a temporary noise barrier.
- Strategic placement of containers or other barriers along the perimeter of staging areas would shield nearby residences from construction activities within the laydown area.
- Substituting impulsive equipment such as pile drivers and hoe rams with augers and vibratory pile drivers whenever possible.
- For continuous stationary equipment such as cranes, generators or pumps, enclose or shroud this equipment with temporary or semi-permanent barriers or acoustical enclosures.
- Acoustical curtains or other limp mass barriers hung so as to shield nearby noise-sensitive receivers from the loudest equipment or activities.
- In general, utilize equipment enclosures or shrouds for all exposed stationary equipment while other solutions (such as portable acoustical curtains hung from cranes) may be more practical for mobile sources.
- All equipment should include properly tuned exhaust mufflers or attenuators that comply with the local and municipal noise ordinances.
- Vibration impacts minimized by substituting impact devices with less vibratory equipment such as augers versus pile drivers.
- Additionally, utilize regional roadways rather than local streets for excavation of spoils and new deliveries to further minimize the construction impacts (i.e., noise, vibration, air quality, visual, traffic, etc.) on the nearby community.