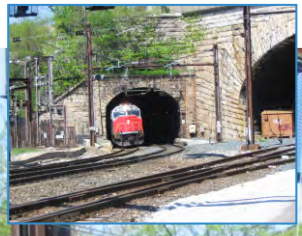
B&P TUNNEL PROJECT

B&P Tunnel Project
Baltimore, Maryland

NOISE TECHNICAL REPORT

June 2016



U.S. Department of Transportation
Federal Railroad Administration

Maryland Department of Transportation

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I. AFFECTED ENVIRONMENT

This Technical Report presents the background, methodology, and results of the noise analysis for the B&P Tunnel Project ("Project") Final Environmental Impact Statement (FEIS). The FEIS focuses on the assessment of the Preferred Alternative, identified as Alternative 3B. This report discusses noise due to train operations, Project construction, and ventilation systems.

This section provides background information on human perception of noise, the regulatory framework, and noise assessment methodology.

A. Human Perception of Noise

According to the Federal Transit Administration (FTA), noise is generally considered unwanted sound.[2] Three factors generally affect the level of sound as perceived by the human ear: amplitude (quiet or loud), frequency (low or high pitch), and time pattern (variability). First, the loudness of sound is measured in decibels (dB) that can range from 0 dB (the threshold of hearing) to about 120 dB. Second, the number of times sound waves occur in one second is frequency, expressed in Hertz (Hz). Humans can typically detect noises ranging from 20 Hz to 20,000 Hz. The frequency of a noise will impact how it sounds. For example, a low-frequency noise is a rumble, and a high-frequency noise is a whistle. Third, the time pattern of noise sources can be characterized as: continuous, such as with a ventilation fan; intermittent, such as for trains passing by; or impulsive, such as pile-driving activities during construction.

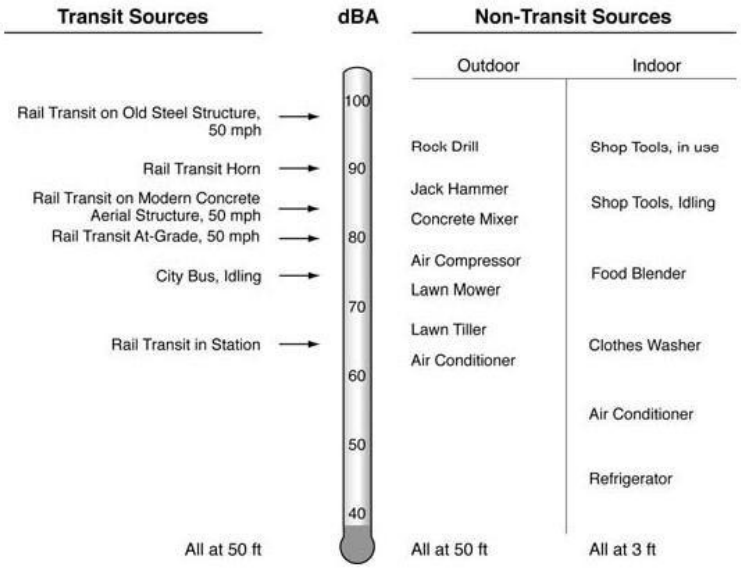
The amplitude and frequency of sound are affected by the distance between the source and receiver. That is, the observed sound level decreases as the distance between source and receiver increases. This reduction is due to several factors: divergence (spreading) of sound energy over a greater area; absorption of sound as it travels over sound-absorbing surfaces such as grass; and, shielding from building rows, noise barriers, or vegetation.

Various sound metrics are used to quantify noise from transit sources. The A-weighted decibel (abbreviated "dBA") is used to describe the overall noise level and closely matches the human ear's response to audible frequencies. Typical A-weighted sound levels from transit and other common sources are shown in **Figure 1**. The following A-weighted noise metrics are used to describe impacts from transit related sources:

- L_{max} – The maximum noise level that occurs during an event (such as a train passby);
- L_{eq} – The equivalent sound level, which is the level of constant noise with the same acoustical energy as the fluctuating noise levels observed during a given time interval (such as one hour); and
- L_{dn} – The 24-hour day-night average sound level, an average sound level which includes a 10-decibel penalty added between 10:00 pm and 7:00 am to account for greater nighttime sensitivity to noise.
- SEL – The sound exposure level that converts the cumulative noise energy of an event into one second.

[2] Federal Transit Administration, *Transit Noise and Vibration Impact Assessment*, Washington, DC, May 2006

Figure 1: Typical A-Weighted Sound Levels



Source: *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration, Washington, DC, May 2006.

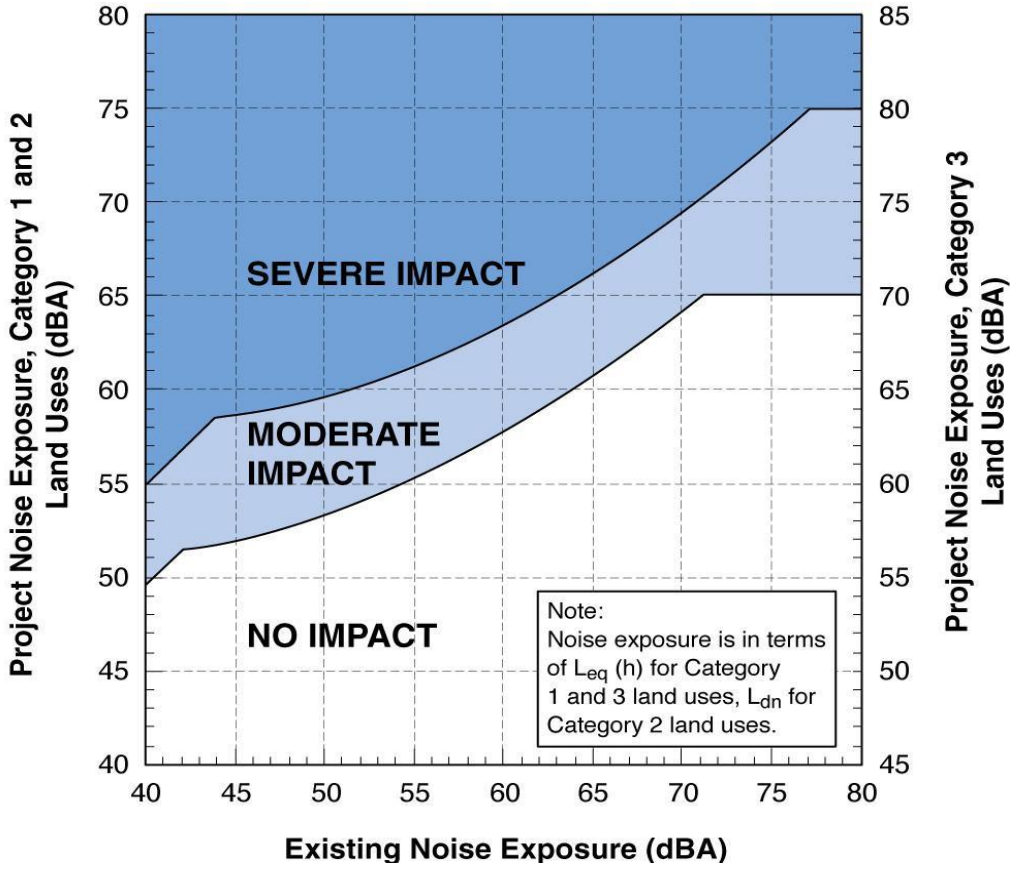
B. Regulatory Framework and Evaluation Criteria

1. Operational Noise Criteria

The FTA's guidance manual, *Transit Noise and Vibration Impact Assessment*, presents the basic concepts, methods and procedures for evaluating the extent and severity of noise impacts from transit projects. Transit noise impacts are assessed based on land use categories and sensitivity to noise from transit sources under the FTA guidelines. As shown in **Figure 2**, the FTA noise impact criteria are defined by two curves. The FTA land use categories and required noise metrics are shown in **Table 1**.

The FTA noise criteria are delineated into two categories: *moderate* and *severe* impact. The *moderate* impact threshold defines areas where the change in noise is noticeable but may not be sufficient to cause a strong, adverse community reaction. The *severe* impact threshold defines the noise limits above which a significant percentage of the population would be highly annoyed by new noise. The level of impact at any specific site is established by comparing the predicted future Project noise level at the site to the existing noise level at the site. The FTA noise impact criteria for all three land use categories are shown in **Figure 2**.

Figure 2: Noise Impact Criteria for Transit Projects



Source: *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration, Washington, DC, May 2006.

Table 1: FTA Land Use Categories and Noise Metrics

Land-Use Category	Noise Metric	Description
1	L_{eq}(h)	Tracts of land set aside for serenity and quiet, such as outdoor amphitheaters, concert pavilions, and historic landmarks.
2	L_{dn}	Buildings used for sleeping such as residences, hospitals, hotels, and other areas where nighttime sensitivity to noise is of utmost importance.
3	L_{eq}(h)	Institutional land uses with primarily daytime and evening uses including schools, libraries, churches, museums, cemeteries, historic sites, and parks, and certain recreational facilities used for study or meditation.

Source: *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration, Washington, DC, May 2006.

The L_{dn} is used to characterize noise exposure for residential areas (FTA Category 2). The L_{dn} metric describes a receiver's cumulative noise exposure from all events over 24 hours. For other noise sensitive land uses, such as schools and libraries (FTA Category 3) and outdoor amphitheaters (FTA Category 1), the average hourly equivalent sound level $L_{eq}(h)$ is used to represent the peak operating hour.

2. Construction Criteria

During the EIS development phase of a project, construction details are limited. Therefore, the FTA guidelines suggest evaluating prototypical construction scenarios against local ordinances (if applicable criteria are available). The FTA design guidelines, for example, are evaluated against noise levels from the two loudest pieces of equipment that, under worst case conditions, are assumed to operate continuously for one hour during both the daytime (7 am to 10 pm) and nighttime (10 pm to 7 am) periods.

In Baltimore City, the local noise ordinance identified for the project study corridor exempts construction activities.[3] Since the local noise ordinance does not provide quantitative noise limits on construction activities, the noise policy from the Maryland Department of the Environment (MDE) was reviewed to assess temporary construction activities.

The MDE has established the following noise guidelines for construction activities (MDE 26.02.03, Control of Noise Pollution). These maximum allowable sound pressure levels, although not specified as such, are assumed to be L_{max} levels:

- 90 dBA – daytime (7 am to 10 pm) – residences,
- 55 dBA – nighttime (10 pm to 7 am) – residences,
- Blasting during construction is exempt during the daytime (7 am to 10 pm),
- Pile driving during construction is exempt from 8 am to 5 pm, and
- Construction activities on public property are exempt.

3. Ventilation Systems and Stationary Sources

Stationary sources of noise, such as ventilation facilities, would be subject to the operational noise level standards included in the Noise Regulation of the Health Code of Baltimore City.[4] This regulation provides the noise limits for manufacturing, commercial, and residential zones in Baltimore City – depending on the source of noise and the types of adjacent land uses. For noise generated within residential zones, there is a limit of 55 dBA at any point on the property line of the use (the noise limit is described as a measured maximum sound level; although not specifically stated, it is assumed to be in terms of L_{max}). Between 9:00pm and 7:00am, the limit is 5 dBA lower for any uses within a residential zone (that is, 50 dBA). Although the Health Code allows for different noise limits for “short, durational deviations”, for the purposes of this Project, it is assumed that the noise limit for the ventilation facilities is L_{max} 50 dBA at the property boundary of each ventilation facility.

[3] Health Code of Baltimore City, § 9-103.b Noise Regulation, 2015.

[4] Health Code of Baltimore City, § 9-206 Noise Regulation, 2015.

C. Area of Potential Effect

In accordance with the FTA *Transit Noise and Vibration Impact Assessment* guidelines, a screening assessment was conducted to identify locations where the Project may cause noise impact. The FTA screening distances for operations are based on typical commuter rail systems. A screening distance of 750 feet was computed and used to determine if noise-sensitive land uses are present within a defined area of Project noise influence. This distance represents the unobstructed distance from a commuter rail line to where the Project noise reaches an L_{dn} of 50 dBA. The screening distance was applied from the centerline of the proposed Project to determine the area of potential effect (APE). Since noise-sensitive land uses were within the screening distance, further analysis was needed.

The APE for construction activities varies, depending on factors such as types and numbers of construction equipment operating in an area at the same time, and the specific location and distance between the construction activity and the sensitive receptor. The specific types and locations of equipment in any one location are difficult to predict at this early stage of project development. Therefore, the same APE used to assess operational impacts was also used to assess the potential for construction impacts.

D. Analysis Methodology and Assumptions

The reference noise levels for each of the proposed noise sources are summarized in **Table 2**. This data is based on default FTA data.

Table 2: Summary of Noise Source Reference Data

Source Type	Specific Source	Reference Conditions	Reference SEL (dBA)
Fixed Guideway	Locomotive	Diesel-electric, 3000 hp, throttle 5	92
	Rail Cars	Ballast, welded rail	82

Note: SEL noise levels are reported in decibels at a reference distance of 50 feet and a reference speed of 50 mph.
Source: *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration, Washington, DC, May 2006.

The tunnel operations data are summarized in **Table 3** for the build year. Existing average train operating speeds at the portals are approximately 30 miles per hour (mph). For the proposed Project, train operating speeds at the north portals are also 30 mph. The average speed at the south portals is projected to be 70 mph.[5]

[5] Weighted average speeds based upon projected speeds of Amtrak and MARC trains. Of note, MARC trains stop at the West Baltimore Station located approximately 1/2-mile south of the proposed south portal.

Table 3: Tunnel Operating Characteristics in the Build Year (2040)

Train Service	Locomotive Type	Total Bi-directional Frequencies		Consist Data		Speed N/S* (mph)
		Daily	Peak Hour	# of Locos	# of Cars	
MARC (Regional)	Diesel	164	15	1	8	30/70
Acela (Intercity Express)	Electric	82	8	N/A	14	30/70
NE Regional (Intercity Corridor)	Electric	48	4	1	8	30/70
Metropolitan	Electric	92	8	N/A	14	30/70
Freight	Diesel	2	0	1	30	30/70
Total	**All**	**388**	**35**			

*Note: Average train speed entering and exiting the north portal (N) and south portal (S).
Source: Federal Railroad Administration, NEC FUTURE Project, February 2015 (NEC Future Data Responses).

II. EXISTING CONDITIONS

To establish existing noise levels in vicinity of the Project, a noise monitoring program was conducted to document existing conditions at sensitive receptors within the Study Area. Due to the higher density of noise sensitive receptors in the vicinity of the south portals, existing noise levels were based on a noise-monitoring program conducted on May 14th and May 28th, 2015. The existing noise levels are shown in **Table 4**.

The noise monitoring was conducted at three sites in vicinity of the south portals including North Mount Street, West Lanvale Street, and at the Mary Ann Winterling Elementary School. The measured noise levels at these sites were used to estimate noise levels at other nearby sites because of similar proximity to the rail line, similar proximity to motor vehicle noise, and similar land use and housing density.

The noise measurements documented existing noise sources within the Study Area, such as existing rail traffic and motor vehicle traffic along surface streets. The L_{dn} is used to describe existing noise at residences and other FTA Category 2 land uses. Similarly, $L_{eq}(h)$ is reported for non-residential or institutional receptors such as schools, libraries, or churches. All noise levels are reported in dBA for comparison with the FTA criteria.

As summarized in **Table 4**, measured peak-hour noise levels in vicinity of the south portals range from 64.3 dBA to 70.3 dBA, and the measured day-night noise levels range from 63.2 dBA to 64.7 dBA.

Table 4: Existing Noise Levels

Receptor Location	FTA Land Use Category	FTA Description	Peak Hour Leq(h) (dB)	24-Hour L_{dn} (dB)
N. Mount Street	2	Residential	N/A	64.7
W. Lanvale Street	2	Residential	N/A	63.4
Mary Ann Winterling Elementary School	3	Institutional	64.3	N/A

Source: Noise measurements conducted on May 14th and May 28th, RK&K 2015.

III. FUTURE NO BUILD CONDITIONS

Future ambient noise levels under the No-Build condition are anticipated to be similar to those under existing conditions. The Study Area is characterized by urban communities that include major highways (such as I-83) and arterials (such as N. Fulton Avenue and W. North Avenue). Irrespective of other projects in the Long Range Transportation Plan, ambient noise under the No-Build condition is anticipated to be similar to under existing condition.

IV. FUTURE BUILD CONDITIONS

A. Operational Noise

1. Detailed Assessment of the Proposed Project

Noise impact was assessed for the Preferred Alternative (Alternative 3B) using the FTA Detailed Assessment methodology. Based on the results of the prior DEIS analysis (i.e., FTA General Assessment), noise impacts were predicted to occur only in vicinity of the south portal. Therefore, a detailed noise analysis was carried out for noise sensitive receptors in this area.

Project noise levels were calculated at discrete receptor locations along the railroad including any noise reduction from shielding due to building rows or where the alignment was in a cut (i.e., trench). The results were then compared to the FTA impact criteria to identify moderate and severe impacts. Based on current U.S. Census data, a total of 437 persons were predicted to be impacted, of which 141 were predicted to be severely impacted. The severe impacts were predicted at residential areas nearest the railroad between the West Baltimore station and the south portal. One school, the Mary Ann Winterling Elementary School, was predicted to be moderately impacted. **Table 5** summarizes the results of the impact assessment, and **Figure 3** shows the locations of the noise impacts.

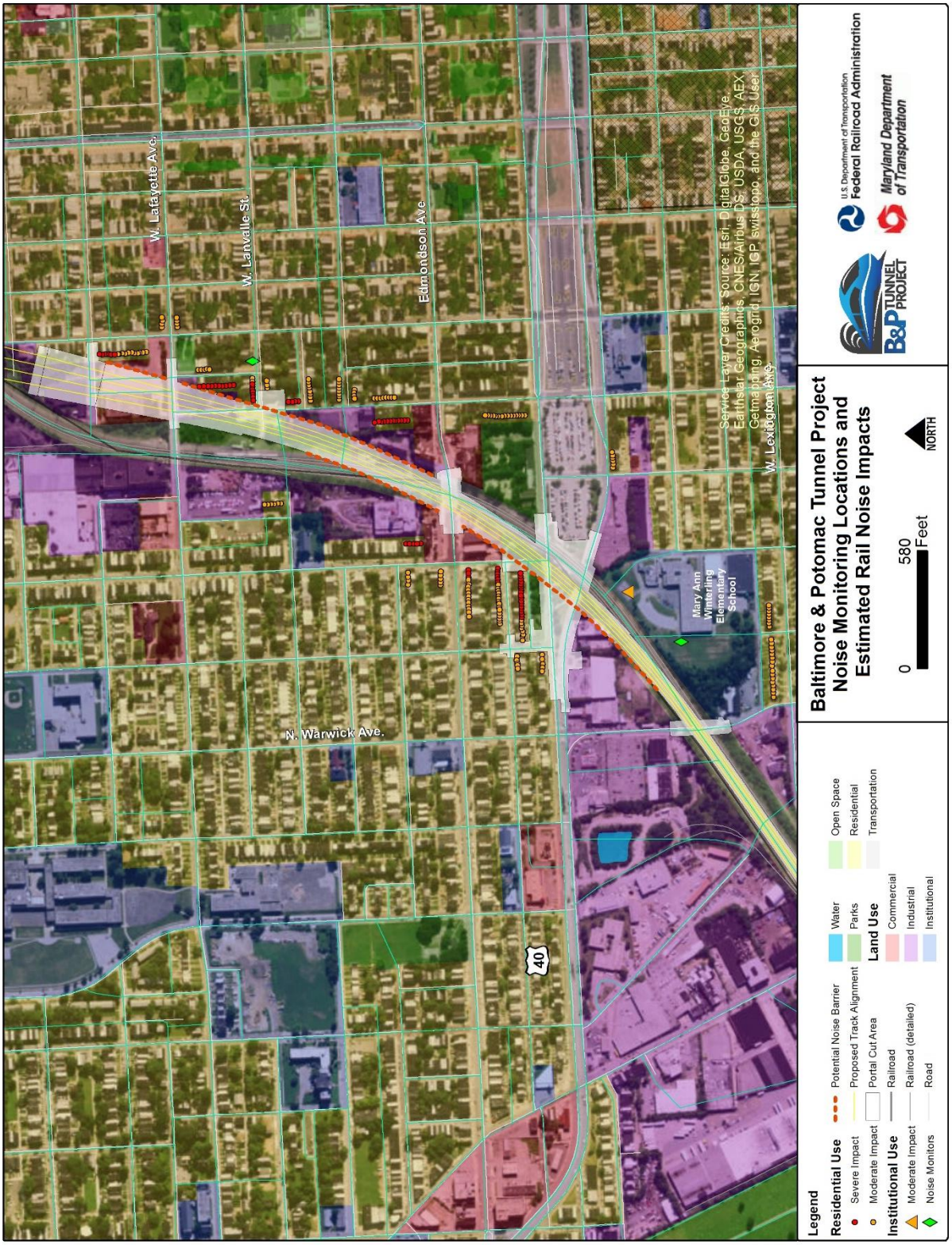
Table 5: Operational Noise Impacts

Receptor Area Description	Side of Tracks	Land Use Category	Noise Metric	Existing Noise Level	Noise Impact Criteria		Project Noise Levels	Impact Type
					Moderate	Severe		
Residences South of the West Baltimore Station	EB	2	L_{dn}	63	60	66	60-63	Moderate
Mary Ann Winterling Elementary School	EB	3	L_{eq}	64	66	71	68	Moderate
Residences between the West Baltimore Station and the South Portal	EB	2	L_{dn}	63	60	66	60-68	Moderate to Severe
Residences between the West Baltimore Station and the South Portal	WB	2	L_{dn}	63	60	66	60-72	Moderate to Severe

Count of Impacts	Moderate	Severe	Total
Residential (Number of Persons)	296	141	437
Institutional (Number of Schools)	1	0	1

Source: KB Environmental Sciences, June 2016.

Figure 3. Operational Noise Impact Locations and Approximate Barrier Locations



Source: KB Environmental Sciences, June 2016.

2. Operational Noise Mitigation Measures

FTA's guidance states that noise mitigation should be considered for areas of severe impact, unless the project's location or alignment can be modified to eliminate the impact. Noise impacts designated as moderate also require consideration for mitigation, but additional project factors should first be considered when assessing mitigation (such as the cost of the mitigation relative to the amount of noise reduction, the number of affected receptors, etc.).

Since noise impacts were predicted for the proposed Project, a range of mitigation measures were investigated for addressing train operations. The following are examples of the types of mitigation measures that could reduce noise impacts:

- Operational restrictions based on time of day;
- Utilizing approved control measures (such as spring frogs) to eliminate rail gaps at crossovers;
- Noise barriers or parapets to shield noise from train passbys;
- Acquisition of buffer zones; and
- Building noise insulation.

Table 6 shows a list of the noise mitigation measures and their approximate attenuation values and cost as summarized in the FTA *Transit Noise and Vibration Impact Assessment* and the Transit Cooperative Research Program (TCRP) report *Wheel/Rail Noise Control Manual*.

Table 6: Operational Noise Mitigation Measures

Mitigation Measure	Approximate Noise Attenuation	Cost
Vehicle Skirts	6-10 dB	$5,000-$10,000/vehicle
Undercar Absorption	5 dB	$3,500/vehicle
Spring Frogs	5 dB	$6,000/frog
Noise Barriers Close to Vehicles	6-15 dB	$25-$35/ft^2
Noise Barriers at Right-of-Way Line	3-10 dB	$25-$35/ft^2
Acquisition of Buffer Zone	Varied	Varied
Building Noise Insulation	5-20 dB	$25,000-$50,000/home

Source: *Transit Noise and Vibration Impact Assessment*, Federal Transit Administration, Washington, DC, May 2006; *TCRP Report 23: Wheel/Rail Noise Control Manual*, Transit Cooperative Research Program, Washington, DC, 1997.

Table 7 shows the amount of noise reduction that a mitigation measure or combination of mitigation measures would need to provide to mitigate all predicted noise impacts (i.e., severe and moderate), and the amount needed to mitigate only the severe impacts. A noise mitigation measure that can provide at least 4 dB of noise reduction could mitigate impacts to the residences south of the West Baltimore station and to the impacted school; there were no severe impacts within these areas. Noise impacts between the West Baltimore station and the south portal exceeded the FTA noise impact criteria by as much as 13 dB. These impacted areas could require multiple noise mitigation measures, such as a combination of noise

barriers and building insulation. Eliminating severe impacts within these areas would be more achievable as the maximum reduction required is 7 dB.

Table 7: Required Noise Reduction to Mitigate Noise Impacts

Receptor Area Description	Mitigate All Impacts	Mitigate Only Severe Impacts
Residences South of the West Baltimore MARC Station, EB	1-4 dB	n/a
Mary Ann Winterling Elementary School, EB	3 dB	n/a
Residences between West Baltimore MARC Station and South Portal, EB	1-9 dB	1-3 dB
Residences between West Baltimore MARC Station and South Portal, WB	1-13 dB	1-7 dB

Source: KB Environmental Sciences, June 2016.

The implementation of noise barriers along the railroad right-of-way would be effective in reducing outdoor noise levels, within practical limits of cost and feasibility. The approximate locations of proposed noise barriers are shown in **Figure 3** and the results of the noise barrier analysis are provided in **Table 8**. The approximate height of 6-7 feet was based on reducing the severe noise impacts to levels below the FTA impact criteria. Of note, some of the projected moderate noise impacts would also be reduced somewhat by the proposed barriers. The total barrier length for the Project would be approximately 3,700 feet (0.7 miles) at a total cost of about $700,000.

A more detailed noise barrier design will be conducted during the final design phase of the Project. Factors that could affect the final barrier design include: barrier installation on rail bridges and at the West Baltimore MARC station; gaps in the barriers that would be necessary to accommodate roadway overpasses at Edmondson Avenue and West Lafayette Avenue; and the varying depth of the portal cut area from at-grade near Edmondson Avenue to tunnel elevation at the south portal (which could vary the barrier height along this section).

At locations where noise barriers may not be feasible (such as buildings very close to the right-of-way or roadway overpasses), building noise insulation would be another potential mitigation measure. Building noise insulation typically involves caulking and sealing gaps in the building envelope and installation of specially-designed acoustic windows and solid-core doors. Depending on the existing condition of a building, especially windows and doors, noise insulation treatments can reduce interior noise levels by 5 to 20 dBA.

Table 8: Preliminary Noise Barrier Design

Location of Barrier	Height (feet)	Length (feet)	Cost (Dollars)*	Noise Reduction (dB)
Eastbound Side				
Edmondson Avenue to W. Lafayette Avenue	6	1,370	$246,600	9
W. Lafayette Avenue to W. Mosher Street	6	320	$57,600	9
Westbound Side				
N. Warwick Avenue to Edmondson Avenue	7	1,290	$270,900	13
Edmondson Avenue to W. Lanvale Street	6	720	$129,600	7
Total		**3,700**	**$704,700**	7 to 13

*Based on $30 per square foot.
Source: KB Environmental Sciences, June 2016.

B. Construction Noise

Temporary noise impacts may occur during construction of the B&P Tunnel at residences and other sensitive receptors along the proposed Project. To reduce any construction noise impacts that may occur, the following noise control measures could be incorporated into the construction process:

- Where practical, erect temporary noise barriers between noisy activities and noise-sensitive receptors.
- Locate construction equipment and material staging areas away from sensitive receptors. Route construction traffic and haul routes along roads in non-noise-sensitive areas where possible.
- Whenever possible, conduct all construction activities during the daytime and during weekdays in accordance with the MDE noise policy.
- Require contractors to use best available control technologies to limit excessive noise and vibration when working near residences.
- Adequately notify the public of construction operations and schedules. Methods such as construction-alert publications or a Noise Complaint Hotline could be used to handle complaints.
- Where possible, consideration should be given to early construction of permanent noise barriers to shield receptors from construction noise.

All mitigation measures would be confirmed and refined during the final design and permitting phase of the Project.

C. Ventilation System Noise

Noise levels in the immediate vicinity of the ventilation facilities would be caused by the operation of the ventilation fans within each facility. The fans would operate periodically and would generate sound that would propagate through the louvers on the top of the ventilation facilities. Fans would operate when emissions levels in the tunnel exceed a set threshold or in emergencies when smoke is present in the tunnel. Emissions levels are likely to be highest when the level of diesel locomotive operations are highest, or when congestion causes trains to operate slowly or to idle in the tunnel.

The ventilation facilities would be designed to meet the L_{max} 50 dBA noise limit. The design standard for the ventilation facilities would limit the outdoor noise level when the fans are in operation to L_{max} 50 dBA at the facility property lines.

To achieve the required reduction in noise level, cylindrical or rectangular sound attenuators would be mounted directly to each fan or to the ductwork within the system. In addition, the building itself would partially shield noise generated within the interior of the ventilation facility, which would further reduce noise levels outside of the building. The proposed ventilation facilities, with attenuators installed, will emit noise at approximately 45 dBA.[6] This would meet the design standard of L_{max} 50 dBA at the facility property lines (i.e., the noise level generated would be less than the design standard). By comparison, the measured L_{max} at a nearby site ranged from 47 dBA to 92 dBA, and the average of all measured L_{max} values was 72 dBA.[7]

V. CONCLUSION

Projected train operations on the above-ground portion of the proposed Project would cause adverse noise impacts, but only within the vicinity of the south portal. A total of 437 persons were predicted to be impacted, of which 141 were predicted to be severely impacted. Therefore, noise mitigation is necessary to minimize the severe impacts. A noise barrier analysis showed that noise levels at severely-impacted receptors could be reduced below the FTA impact criteria with barrier heights of 6-7 feet and a total barrier length of approximately 3,700 feet (0.7 miles).

Temporary noise impacts may occur during construction of the B&P Tunnel at residences and other sensitive receptors along the proposed Project. To reduce any construction noise impacts that may occur, noise control measures should be incorporated into the construction process. Mitigation measures would be confirmed and refined during the final design and permitting phase of the Project.

Noise exposure due to the ventilation of the proposed Project was assessed in terms of the operation of the ventilation facilities. The applicable noise ordinances and guidelines were assessed relative to the land uses surrounding each portal and the intermediate ventilation facility location. The ventilation facilities would be designed in order to meet the Baltimore Health Code noise regulations. This would ensure that,

[6] Via email from RK&K, October 10, 2015.

[7] Measruements were conducted near the originally-proposed site along Whitelock Street and Brookfield Avenue. The noise measurements were conducted for 24 consecutive hours on October 8-9, 2015 along Whitelock Street. L_{max} was calculated once every five minutes during the 24-hour measurement period.

during operation of the ventilation facilities, the resulting noise levels in the adjacent communities would meet the applicable standards.

VI. REFERENCES

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RK&K, Noise measurements conducted on October 8-9, 2015 along Whitelock Street.

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VII. ACRONYMS

APE	Area of Potential Effect
B&P	Baltimore & Potomac
dB	Decibel
dBA	A-weighted Decibel
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
Hz	Hertz
L_{eq}	Equivalent Sound Level
$L_{eq}(h)$	Average Hourly Equivalent Sound Level
L_{dn}	24-Hour Day-Night Average Sound Level
L_{max}	Maximum Sound Level
MARC	Maryland Area Regional Commuter
MDE	Maryland Department of the Environment
mph	Miles per Hour
NEC	Northeast Corridor
NEPA	National Environmental Policy Act
SEL	Sound Exposure Level