Crystal City / Potomac Yard Corridor Transit Improvements Project

Noise and Vibration Assessment Technical Memorandum

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Noise and Vibration Assessment

Crystal City / Potomac Yard Corridor
Transit Improvements Project

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1.0 INTRODUCTION

This report summarizes the results of the noise and vibration assessment for proposed BRT service along the Crystal City/Potomac Yard (CCPY) Corridor. This analysis was conducted according to the Federal Transit Administration's (FTA) *Transit Noise and Vibration Impact Assessment* guidelines.

1.1 Project Description

1.1.1 Project Purpose

The purpose of the CCPY Corridor Transit Improvements Project is to advance the proposed transit improvements for the CCPY Corridor into design and construction utilizing federal grants appropriated for these transit improvements. As required by the Federal Transit Administration (FTA), the potential effects on transportation conditions and social, cultural, and natural environments in the corridor will be evaluated and documented. This process will meet the requirements of the National Environmental Policy Act (NEPA) and other federal and state policies.

1.1.2 Background

The CCPY Corridor is a five-mile long corridor that extends from the Braddock Road Metrorail station in the City of Alexandria to the Pentagon in Arlington County. Metrorail Blue and Yellow lines and Jefferson Davis Highway, a segment of heavily-traveled U.S. Route 1, form the transportation backbone of the corridor. In 2003, the Virginia Department of Rail and Public Transportation (DRPT), Arlington County, and the City of Alexandria completed the CCPY Corridor Transit Alternatives Analysis (AA). In the AA, transit modes, which included bus rapid transit (BRT), light rail transit (LRT), and Metrorail, and alignment options were analyzed. The costs and benefits of each alternative were also assessed.

Following the completion of the AA, DRPT, in collaboration with Arlington County and the City of Alexandria, undertook the CCPY Corridor Interim Transit Improvements Study that formulated implementation strategies targeting the period from 2007 to 2014. As part of the study, an environmental scan and station area planning were conducted. At the conclusion of this study, a high-capacity, branded bus transit service using both mixed traffic operations and exclusive transitways was recommended. This service, while supporting growing transit demand from existing and new developments, would not preclude longer-term transit system improvement options that have been envisioned for the CCPY corridor, including BRT, LRT, and the addition of a Metrorail station.

1.1.4 Environmental Documentation

Both Alexandria and Arlington have secured considerable funding for the design and construction of the planned transit improvements, including several federal grants. In order to utilize the federal grants appropriated for transitways, the project sponsors must undertake environmental analyses to satisfy NEPA. Since the proposed transit improvements are planned largely in existing right-of-way and would require little or no construction, significant environmental effects are not anticipated. Based on consultation with FTA staff, the project sponsors will prepare a Documented Categorical Exclusion as the appropriate NEPA document. The studies will include an Air Quality analysis, a Noise and Vibration analysis, a Traffic analysis, a Historic and Archaeological Analysis, a water resources analysis, and a Phase I

ESA. The studies will document the level of potential impact associated with the project and identify any mitigation measures necessary to reduce or eliminate impacts.

There are a number of activities within this project corridor that are either currently being constructed by others or planned to be constructed by others. Figure 1-1 shows the CCPY planned alignment and areas where construction is underway or planned by others. Construction activities by others include new roadways, bridges, and intersection improvements. Current and proposed projects planned or constructed by others are not evaluated as part of this project, and any potential impacts to known or potential hazardous materials sites are not included in this current study. Evaluations of potential environmental impacts associated with those other improvements are assumed to be part of separate environmental documents being prepared by the agencies sponsoring those improvements.

2.0 SITE DESCRIPTION

2.1 Project Alignment and Planned Improvements

The planned alignment for the CCPY Corridor Transit Improvements Project begins at the Braddock Road Metrorail Station and ends near the Pentagon in Arlington County. The alignment passes through 38 intersections. The planned transit alignment, stops, and location of exclusive right-of-way are shown in Figure 1-1. The planned CCPY Corridor Alignment has been separated into six segments that are identified from south to north. The segments are described below:

Segment A - Alexandria Route 1 South

Segment A begins at the Braddock Road Metrorail Station and heads east on Madison Street to North Fayette Street. The planned alignment turns north on Fayette Street and then east on 1st Street before turning north again on North Henry Street and crossing the realigned Monroe Avenue Bridge. The planned alignment in Segment A runs entirely in mixed traffic on existing roadway.

Segment B - Alexandria Route 1

Segment B runs north along Route 1 from the realigned Monroe Avenue Bridge to East Glebe Road. The planned alignment in Segment B runs entirely in exclusive transit lanes either in a median busway or along the east and west curbsides of Route 1 to East Glebe Road, where it transitions to mixed traffic. [1]

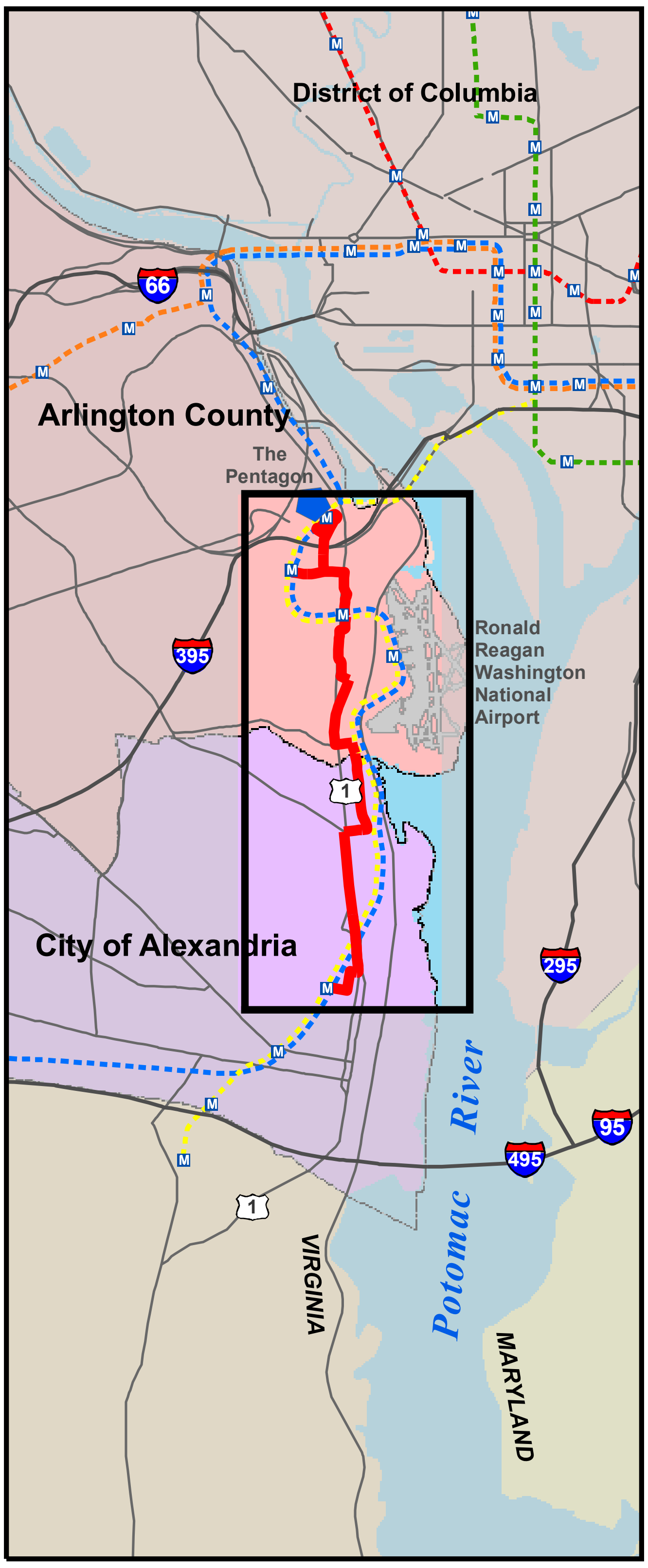
Segment C - Alexandria Potomac Yard

Segment C travels east on East Glebe Road from Route 1 through the planned Potomac Yard Town Center to Potomac Avenue. It then turns north along Potomac Avenue to the Alexandria/Arlington line. The planned alignment in Segment C runs entirely in mixed traffic.

Segment D - Arlington Potomac Yard

Segment D begins at the Alexandria/Arlington border running in mixed traffic north on Potomac Avenue. It transitions to exclusive lanes as it turns west on South Glebe Road, running on the northern side of the roadway in right-of-way donated as part of the planned development of Potomac Yard. The alignment turns north on Jefferson Davis Highway and merges with South Crystal Drive, running on the east side of the roadway to the intersection of South Crystal Drive and 26th Street South.

[1] The 2030 analysis is based upon a median alignment in Segment B as the proposed action. The City of Alexandria has not made a definitive decision about the alignment in Segment B; thus, the 2015 analysis examines the effects of both alignments.



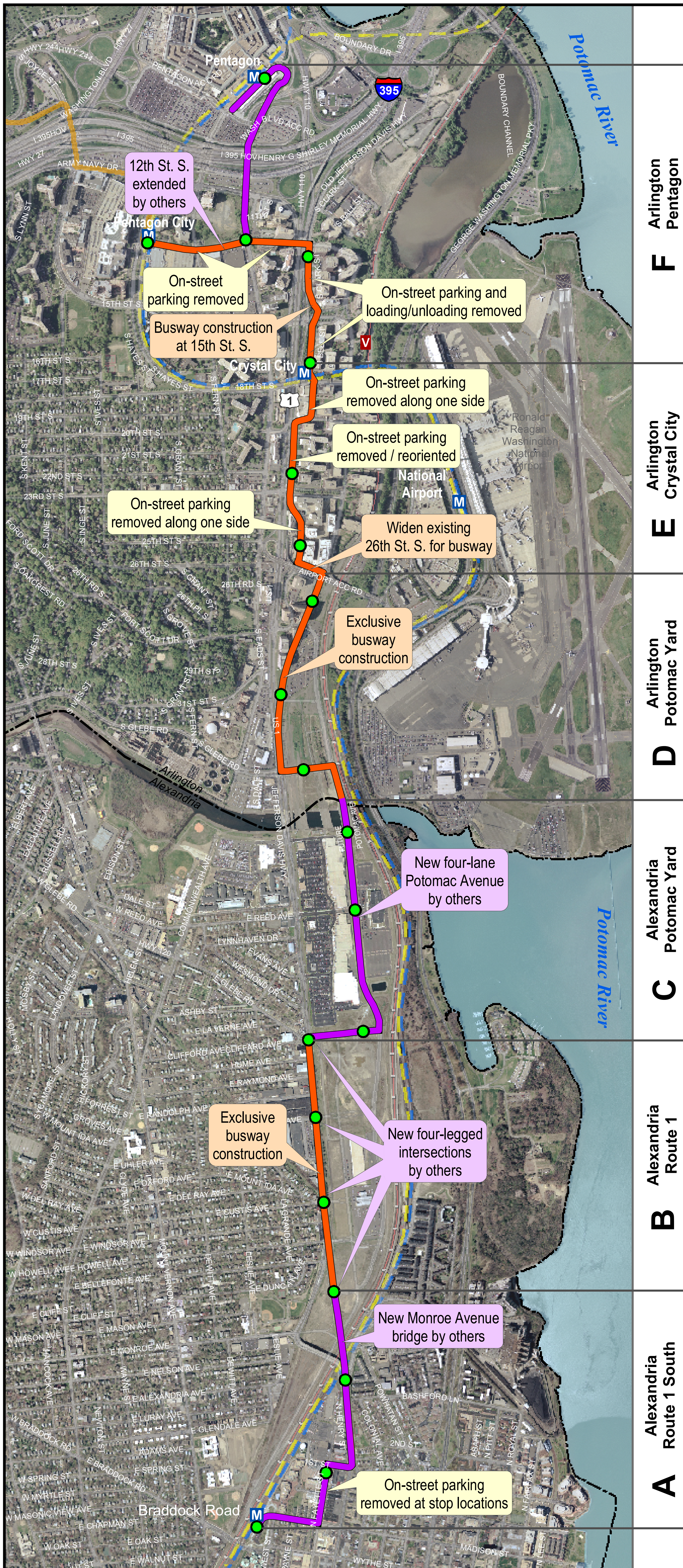


Figure 1-1
Planned Alignment

Legend

- VRE Station
- Metro Station
- Blue Metro Line
- Yellow Metro Line
- VRE Railroad
- Proposed Station Stop
- Columbia Pike Transit (Proposed)

Planned Alignment

- Mixed Traffic ROW
- Dedicated ROW
- Improvement Associated with CC/PY Project
- Improvement by Others
- Affected Parking

N

0 0.3 0.6 Miles

Crystal City/Potomac Yard Transit Improvements Project - Environmental Review

Segment E- Arlington Crystal City

Segment E begins at 26th Street South and South Crystal Drive running west before turning north on South Clark Street to 20th Street South. At 20th Street South, the planned alignment turns east and then north on South Bell Street to the Crystal City Metrorail Station at 18th Street South. This segment runs entirely in exclusive curbside lanes.

Segment F - Arlington Pentagon

Segment F begins at the Crystal City Metrorail Station and travels north on South Bell/South Clark Street before turning west on 12th Street. At South Eads Street, the alignment splits into two branches serving the Pentagon and Pentagon City. The first branch turns north on South Eads Street to the Pentagon Transit Center. The second branch continues west on 12th Street South to the Pentagon City Metrorail Station. The planned alignment in Segment F runs in exclusive curbside lanes until the intersection of 12th Street and South Eads Street, where it transitions to running in mixed traffic.

2.2 Study Area

The study area for the assessment of noise and vibration is defined as 250 feet from the planned CCPY alignment centerline. This study area was chosen according to the FTA screening guidelines to include potential sites within or immediately adjacent to the planned alignment due to the relatively limited construction foreseen for the project. For the purposes of this analysis, construction activities assumed to have invasive or subsurface work would include the installation/upgrading of station stops and the installation of new roadways. All other project work is assumed to be completed at grade. Therefore, as described in Section 5.3, construction impacts are not anticipated outside of the 250-feet study area at this time.

2.3 Current Use of Adjoining Properties

Conditions along the corridor are very urban with a mix of commercial and residential land uses. Most of the corridor has been disturbed over the years to make way for the various developments that exist. Very little natural environment exists with the exception of designated recreation areas, landscaped areas, and along Four Mile Run and the Potomac River.

The density and mix of uses varies within the corridor. The existing development in the southern half of the corridor is residential in character, with commercial uses along Route 1, Mount Vernon Avenue, and around the Braddock Road Metrorail station. There is also active redevelopment of several sites for residential and retail uses at the edge of Old Town Alexandria. The central portion of the corridor is occupied by Potomac Yard, a 368-acre former rail yard that is being redeveloped with a mix of office, residential, and retail uses. Build-out of Potomac Yard over the next 10 years will result in approximately 4.4 million square feet of new office space, 3,000 new residential units, 1,200 new hotel rooms, and 270,000 square feet of new retail space.

The Pentagon City and Crystal City areas in the northern part of the corridor are a mix of high-density residential and office uses. Development projects in the area include new residential buildings in Pentagon City and Crystal City, as well as a possible conference center and office building in Pentagon City just south of the Pentagon reservation. Northeast of the proposed alignment is the North Tract site, a former industrial-commercial area which includes the former Davis Scrap Yard and is being redeveloped by Arlington County for recreational use and open space.

3.0 METHODOLOGY

The modeling methodologies used for the noise and vibration assessments, including descriptions of the noise and vibration metrics, are described in the following section.

3.1 Human Perception of Noise and Vibration

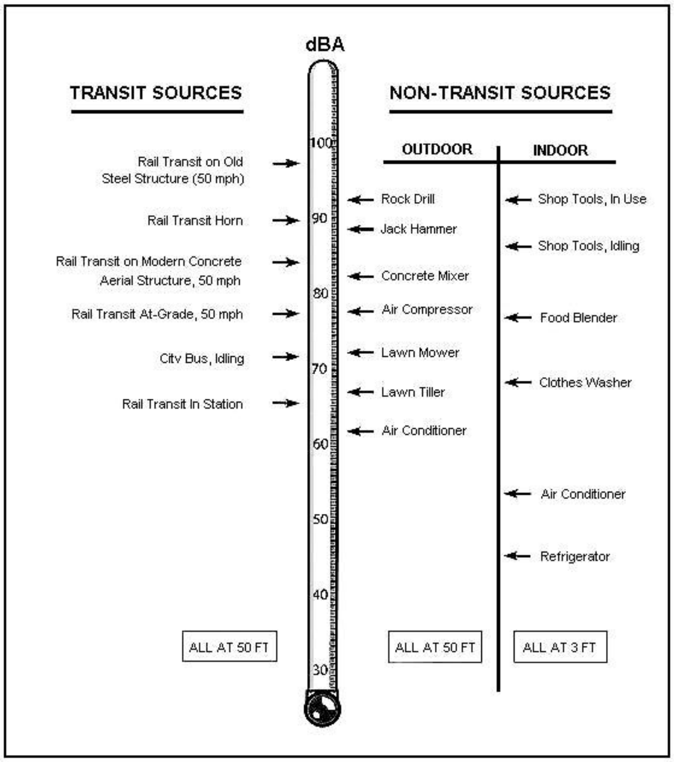
3.1.1 Noise

Noise is “unwanted sound” and, by this definition, the perception of noise is a subjective process. Several factors affect the actual level and quality of sound (or noise) as perceived by the human ear and can generally be described in terms of loudness, pitch (or frequency), and time variation. The loudness, or magnitude, of noise determines its intensity and is measured in decibels (dB) that may range from 40 decibels (the rustling of leaves) to over 100 decibels (a rock concert). Pitch describes the character and frequency content of noise such as the very low “rumbling” noise of stereo sub-woofers, or the very high-pitched whistle noise. Finally, the time variation of some noise sources can be characterized as continuous, such as a building ventilation fan; intermittent, such as for a train passby; or impulsive, like a car backfire.

Various sound levels are used to quantify noise from transit sources, including a sound's loudness, duration, and tonal character. For example, the A weighted decibel (dBA) is commonly used to describe the overall noise level because it is an attempt to take into account the human ear's response to audible frequencies. Because the decibel is based on a logarithmic scale, a 10 decibel increase in noise level is generally perceived as a doubling of loudness, while a 3-decibel increase in noise is just barely perceptible to the human ear. Typical A-weighted sound levels from transit and other common sources are shown in Figure 3-1.

Several A-weighted noise descriptors were used to determine impacts from transit related sources including the Lmax, which represents the maximum noise level that occurs during an event or train passby; the Leq, which represents a level of constant noise with the same acoustical energy as the fluctuating noise levels observed during a given interval, such as one hour; and the Ldn, or the 24 hour day-night noise level that includes a 10-decibel penalty for all nighttime activity between 10 p.m. and 7 a.m.

Figure 3-1: Typical A-weighted Noise Levels



Source: *Transit Noise and Vibration Impact Assessment,* Final Report, Federal Transit Administration, Washington, DC, April 1995.

3.1.2 Vibration

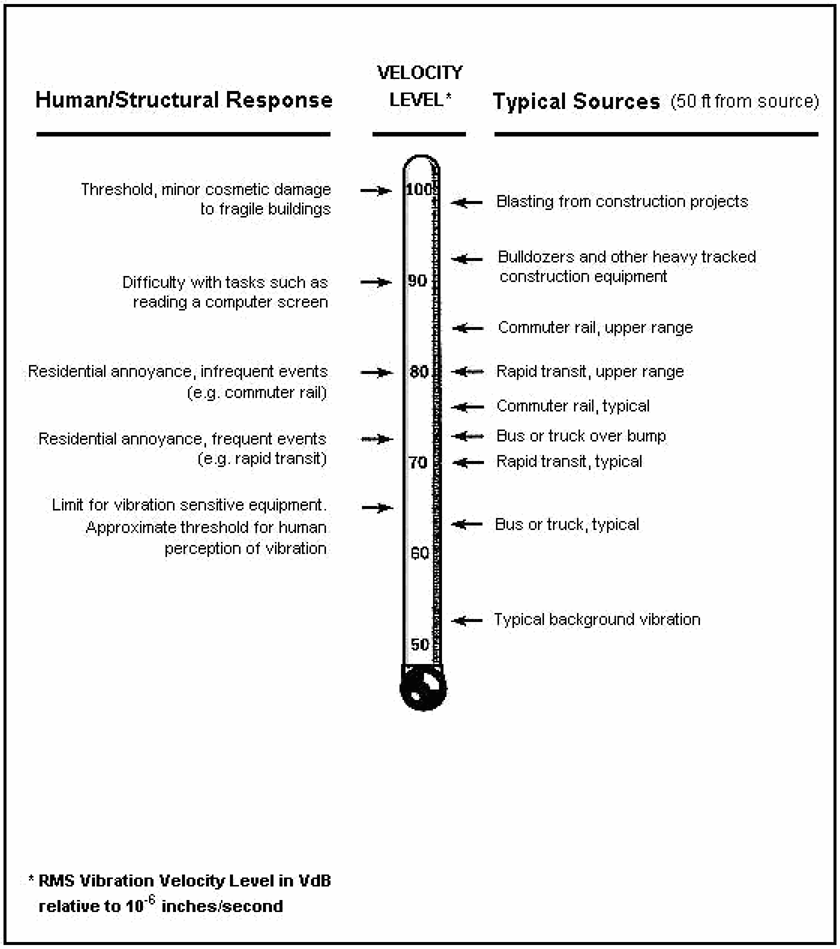
Ground-borne vibration associated with vehicle movements is usually the result of uneven interactions between the wheel and the road or rail surfaces. Examples of such interactions (and subsequent vibrations) include train wheels over a jointed rail, an untrue rail car wheel with "flats", and motor vehicle wheels hitting a pothole or even a manhole cover.

Unlike noise, which travels in air, transit vibration typically travels along the surface of the ground. Depending on the geological properties of the surrounding ground and the type of building structure exposed to transit vibration, vibration propagation may 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 those buildings located in sandier soil.

Vibration induced by vehicle passbys can generally be discussed in terms of displacement, velocity, or acceleration. However, human responses and responses by monitoring instruments and other objects are more accurately described with velocity. Therefore, the vibration velocity level is used to assess vibration impacts.

To describe the human response to vibration, the average vibration amplitude called the root mean square (RMS) amplitude, is used to assess impacts. The RMS velocity is expressed in inches per second (ips) or decibels (VdB). All VdB vibration levels are referenced to 1 μips. Typical ground-borne vibration levels from transit and other common sources are shown in Figure 3-2.

Figure 3-2: Typical Ground-Borne Vibration Levels



Source: *Transit Noise and Vibration Impact Assessment,* Final Report, Federal Transit Administration, Washington, DC, April 1995.

3.2 Modeling Methodology

The noise and vibration assessments were conducted in accordance with the FTA's *Transit Noise and Vibration Impact Assessment*[2] guidelines. Specifically, an expanded Detailed Assessment was conducted to compute project noise and vibration levels from the following Build Alternatives:

- Curbside Alternative — the curbside alignment is proposed along the edge of the existing roadways closest to the sidewalk or curb; and,
- Median Alternative — the median alignment is proposed along the middle or centerline of the existing roadways.

Following the FTA guidelines, a screening assessment was conducted to select applicable receptors that are located within the FTA screening distance of 250 feet of the alignment for a busway with intervening buildings. From this population, four discrete receptors were selected to be representative of the other similar land use types identified along the corridor. The background noise-monitoring program was conducted at the four discrete receptors, which are

[2] "Transit Noise and Vibration Impacts Assessment: Final Report", Federal Transit Administration, Washington, DC, April 1995.

listed in Table 4-1. The results of the noise-monitoring program are described separately under the Existing Conditions Section 4.

The reference noise levels used for the modeling assessment are based on the tests conducted by the Pennsylvania State University Bus Testing and Research Center in Altoona, PA.[3] The following reference levels were measured by the Altoona Test Facility for the Orion VII bus, a bus similar to the compressed natural gas (CNG) BRT vehicle proposed for this project:

- 77 dBA maximum passby noise level at measured at 15 meters and 30 mph (accelerating at full throttle from standstill);
- 64 dBA maximum stationary noise level while at low idle measured at 15 meters; and,
- 75 dBA maximum stationary noise level while at high idle measured at 15 meters.

The vibration impacts from rubber-tired vehicles such as buses adjacent to the corridor are typically not a problem due to slower speeds and lighter vehicle weights. Nevertheless, a vibration impact assessment is included as part of this analysis using the FTA ground surface vibration curves for rubber-tired vehicles.

3.3 Evaluation Criteria

3.3.1 Noise

FTA's guidance manual 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 A-1 in Appendix A, the FTA noise impact criteria are defined by two curves that allow increasing project noise levels as existing noise increases up to a point, beyond which impact is determined based on project noise alone. The FTA land use categories and required noise metrics are described in Table 3-1.

The FTA noise criteria are delineated into two categories: *impact* and *severe impact*. The *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 can be established by comparing the predicted 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 A-1 in Appendix A**.** The WMATA noise criteria, which are intended to be applied to rapid transit operations rather than buses along city streets, were not used to evaluate noise impacts from BRT operations.

[3] "STURAA Test, 12-Year 500,000-Mile Bus from Orion Bus Industries, Inc., Model Orion VII" (PTI-BT-R0113), The Pennsylvania Transportation Institute, Pennsylvania State University, Bus Testing and Research Center, Altoona, PA, January 2002.

Table 3-1: FTA Land Use Categories and Noise Metrics

Land Use Category	Noise Metric	Description
1	Leq(h)	Tracts of land set aside for serenity and quiet, such as outdoor amphitheaters, concert pavilions, and historic landmarks.
2	Ldn	Buildings used for sleeping such as residences, hospitals, hotels, and other areas where nighttime sensitivity to noise is of utmost importance.
3	Leq(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,* Final Report, Federal Transit Administration, Washington, DC, April 1995.

3.3.2 Vibration

Although ground-borne vibration impacts are highly unlikely for slower-moving surface vehicles with rubber tires such as the proposed CNG BRT vehicle, the FTA vibration criteria were reviewed for completeness.

The FTA vibration criteria for evaluating ground-borne vibration impacts from train and bus passbys at nearby sensitive receptors are shown in Table 3-2. These vibration criteria are related to ground-borne vibration levels that are expected to result in human annoyance, and are based on RMS velocity levels expressed in VdB. The FTA's experience with community response to ground-borne vibration indicates that when there are only a few train or bus events per day, it would take higher vibration levels to evoke the same community response that would be expected from more frequent events. This is taken into account in the FTA criteria by distinguishing between projects with *frequent* and *infrequent* events, where the *frequent* events category is defined as more than 70 events per day. The vibration criteria levels shown in Table 3-2 are defined in terms of human annoyance for different land use categories such as high sensitivity (Category 1), residential (Category 2), and institutional (Category 3). In general, the vibration threshold of human perceptibility is approximately 65 VdB.

Table 3-2: FTA Ground-Borne RMS Vibration Impact Criteria for Annoyance (VdB)

Receptor Land Use		RMS Vibration Levels (VdB)	
Category	Description	Frequent Events	Infrequent Events
1	Buildings where low vibration is essential for interior operations	65	65
2	Residences and buildings where people normally sleep	72	80
3	Daytime institutional and office use	75	83
Specific Buildings	TV/Recording Studios/Concert Halls	65	65
	Auditoriums	72	80
	Theaters	72	80

Source: *Transit Noise and Vibration Impact Assessment,* Final Report, Federal Transit Administration, Washington, DC, April 1995.

4.0 EXISTING CONDITIONS

To determine the existing background noise levels at sensitive receptors along the CCPY Corridor, a noise-monitoring program was conducted in the community along the project corridor May 24 – 25, 2006, at four representative locations shown in Figure 4-1 and described in Table 4-1. Hourly equivalent noise levels (or Leq) were measured during each of three different periods of the day (daytime peak, daytime off-peak and late night) according to the FTA methodology to develop a 24-hour day-night noise level (or Ldn) at residential receptors. The noise measurements document existing background noise sources in the area including traffic along US 1 and South Clarke Street, existing Amtrak and Virginia Rail Express (VRE) train passbys along the mainline, as well as jet aircraft takeoffs at the Ronald Reagan National Airport. The background noise levels are also used to establish the project impact criteria against which future project noise levels are compared. All noise levels are reported in A-weighted decibels, which approximate best the sensitivity of human hearing.

As shown in Table 4-1, the day-night noise levels (Ldn) range from 62 dBA at Receptor R1 (a multi-family apartment building along South Eads Street in Crystal City) to 67 dBA at Receptor R2 (a mixed-use residential building along Crystal Drive). Similarly, peak-hour equivalent noise levels range from 66 dBA at Receptor R4 (town home at 802 North Fayette Street in Alexandria City) to 71 dBA at Receptor R2. These levels are typical of the types of dense urban land uses found along the project corridor, particularly the variety and frequency of transportation sources that range from traffic along arterials to passenger trains to jet aircraft over flights.

The sound level meters that were used on this project meet or exceed the ANSI Standards for Type I accuracy and quality. Specifically, Brüel & Kjær Models 2236 were used and calibrated using a Brüel & Kjær Model 4231 before and after each measurement.

Table 4-1: Results of the Ambient Noise-Monitoring Program (in dBA)

Discrete Receptor		FTA	Leq Noise Levels (dBA)[1]			Ldn
No.	**Description**	**Cat.**	**Peak**	**Off-Peak**	**Late Night**	**(dBA)**
R1	1201 S. Eads Street, The Bennington (Arlington – Segment F)	2	67	64	52	62
R2	Two Potomac Yard, Crystal Drive (Arlington – Segment E)	2	71	70	53	67
R3	516 E. Bellefonte Avenue (Alexandria – Segment B)	2	67	68	59	66
R4	802 N. Fayette Street (Alexandria – Segment A)	2	66	66	53	63

1 Peak 1-hour Leq noise levels occurred between 6-9AM and 4-7 PM; Off-Peak noise levels occurred between 9AM-4PM; and late night noise levels occurred between 12-4AM.

Source: DMJM Harris, July 2006.

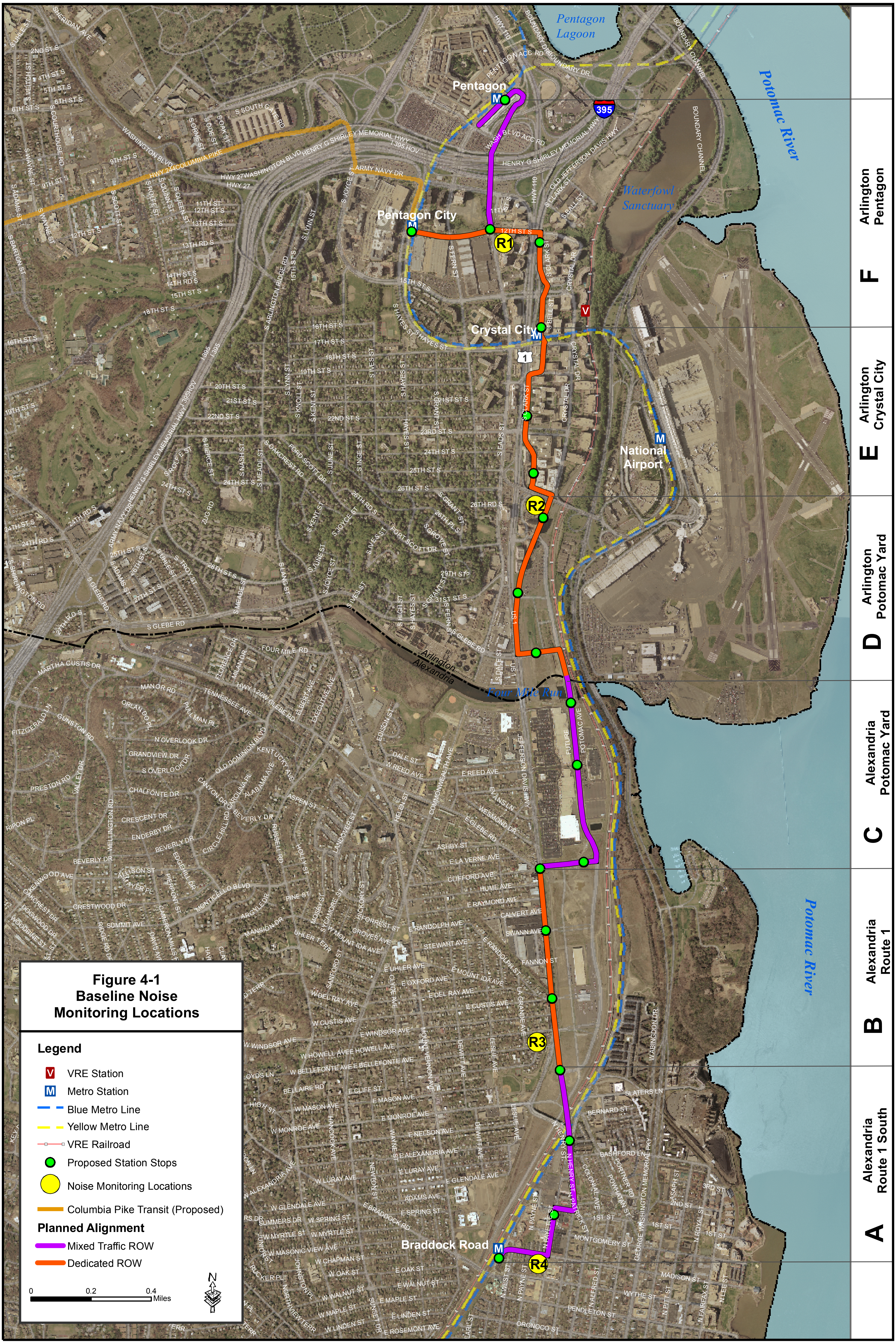


Figure 4-1
Baseline Noise Monitoring Locations

5.0 IMPACT ASSESSMENT

Maximum noise and vibration levels from BRT passbys along the corridor were evaluated at noise- and vibration-sensitive receptors along the project corridor. This impact assessment is described for both Build Alternatives including the Curbside and the Median Alternatives. As expected, the predicted levels for the median alignment are slightly lower than the levels predicted for the curbside alignment.

Typical maximum noise levels from the proposed BRT vehicle passby is predicted to range from 75 dBA at Receptor R3 (residences along Bellefonte Avenue in Alexandria) to 78 dBA at R2 and R4 (respectively a mixed use residential building along Crystal Drive in Arlington and town homes along North Fayette Street in Arlington). These maximum noise levels are slightly lower than the Metro city buses that currently operate along the Project Corridor.

5.1 Curbside Alternative

The results of the noise and vibration assessments for the Curbside Alternative are described in the following subsection.

5.1.1 Noise

Under the Curbside Alternative, predicted Ldn noise levels due to BRT operations are predicted to range from 55 dBA at Receptor R3 (residences along E. Bellefonte Avenue in Alexandria) to 62 dBA at Receptor R2 (mixed-use residential building along Crystal Drive in Arlington). As shown in Table 5-1, except for Receptor R2, none of these Ldn noise levels are predicted to exceed the FTA *impact* or *severe impact* criteria under the Curbside Alternative. Due to the close proximity of the planned station stop near Receptor R2, BRT idling noise of 62 dBA while at the station is predicted to be equal to the FTA *impact* criterion at the exterior façade for Category 2 receptors. However, at this urban location, there are no exterior land-uses (such as yards) thereby minimizing the potential for impact. Additionally, the outdoor-to-indoor noise reduction of the newly constructed building is expected to provide greater than 20 dBA thereby further reducing the potential for impact.

Table 5-1: Results of the Noise Assessment

Discrete Receptor		FTA		Noise Levels (dBA)[1]			Impact Criteria	
No.	Description	Cat.	Metric	Existing	Curbside	Median	"IMP"	"SEV"
R1	1201 S. Eads Street, The Bennington (Arlington – Segment F)	2	Ldn	62	58	57	59	65
R2	Two Potomac Yard, Crystal Drive (Arlington – Segment E)	2	Ldn	67	62	62	62	68
R3	516 E. Bellefonte Avenue (Alexandria – Segment B)	2	Ldn	66	55	54	62	67
R4	802 N. Fayette Street (Alexandria – Segment A)	2	Ldn	63	57	56	60	65

[1]Day night noise levels (Ldn) are reported for all residential receptors (FTA Category 2) along the project corridor under each of the two Build Alternatives: Curbside and Median alignments.

Source: DMJM Harris, October 2006.

5.1.2 Vibration

Vibration from the proposed rubber-tired transit buses is not expected to contribute to an annoyance at receptors along the corridor. Ground-borne vibration can be a serious concern for nearby neighbors of a transit system causing buildings to shake and rumbling sounds to be heard indoors. However, in contrast to airborne noise, ground-borne vibration is not a common environmental problem particularly for rubber-tired vehicles such as buses and trucks. Even in locations close to major roads, ground-borne vibration from transit vehicles along smooth asphalt streets, such as is proposed along the Crystal City/Potomac Yard Corridor, is barely perceptible even in locations close to the corridor. Some other common sources of ground-borne vibration are trains with wheel flats, tracks with rail joins or switches and construction activities that involve impulse activities such as blasting, pile driving and operating heavy earth-moving equipment.

Vibration levels from BRT passbys along the Project Corridor are predicted to range from 56 VdB at Receptor R3 (a residence along E. Bellefonte Avenue in Alexandria) to 61 VdB at Receptor R1 (an apartment building along S. Eads Street in Arlington) to 65 VdB at Receptor R4 (multifamily town homes along N. Fayette Street in Alexandria). None of the predicted vibration levels are predicted to exceed the FTA impact criterion of 72 VdB (for "frequent events") at Category 2 receptors such as residences under the Curbside Alternative.

5.2 Median Alternative

Compared to the noise and vibration levels predicted for the curbside alignment, BRT operations along the median alignment are expected to result in slightly lower noise and vibration levels because the median lanes are farther from the receptors.

5.2.1 Noise

Noise levels from BRT operations under the Median Alternative are expected to be slightly lower than the levels predicted for the curbside alignment. For example, predicted Ldn noise levels due to BRT operations are predicted to range from 54 dBA at Receptor R3 (residences along E. Bellefonte Avenue in Alexandria) to 58 dBA at Receptor R2 (mixed-use residential building along Crystal Drive in Arlington). As shown in Table 5-1, none of these Ldn noise levels are predicted to exceed the FTA *impact* or *severe impact* criteria under the Median Alternative. Due to the close proximity of the planned station stop near Receptor R2, BRT idling noise of 62 dBA while at the station is predicted to be equal to the FTA *impact* criterion at the exterior façade for Category 2 receptors. However, at this urban location, there are no exterior land-uses (such as yards) thereby minimizing the potential for impact. Additionally, the outdoor-to-indoor noise reduction of the newly constructed building is expected to provide greater than 20 dBA thereby further reducing the potential for impact.

5.2.2 Vibration

Compared to the Curbside Alternative, vibration levels from BRT passbys under the Median Alternative are predicted to be slightly lower ranging from 55 VdB at Receptor R3 (a residence along E. Bellefonte Avenue in Alexandria) to 60 VdB at Receptor R1 (an apartment building along S. Eads Street in Arlington) to 64 VdB at Receptor R4 (multifamily town homes along N. Fayette Street in Alexandria). None of the predicted vibration levels are predicted to exceed the FTA impact criterion of 72 VdB (for "frequent events") at Category 2 receptors such as residences under the Median Alternative.

5.3 Construction

Noise and vibration levels from construction activities along the Project Corridor, although temporary, could create a nuisance condition at nearby sensitive receptors. Exposure to excessive noise and vibration levels varies depending on the types of construction activity and the types of equipment used for each stage of work. Project construction activities may include roadway realignment, pavement removal, station stop construction, and other miscellaneous activities. Although details of the actual construction activities are not known at this preliminary phase of the project, particular attention should be paid during final design when details of the actual construction equipment required become clearer. However, several "good housekeeping" practices are recommended in Section 5.4 (Mitigation) to eliminate or reduce the annoyance associated with these activities.

5.4 Mitigation

Except for a mixed-use residential building along Crystal Drive in Arlington, none of the project noise or vibration levels are predicted to exceed the FTA impact criteria anywhere along the project corridor. As described previously, the noise level of 62 dBA is predicted at the exterior building façade of Receptor R2 where there are no exterior land-uses. Although the FTA does not specify interior noise criteria, the interior levels are expected to be well below an impact condition due to the greater than 20-dBA noise reduction benefit of the new double-glazed windows. Therefore, no mitigation measures are currently recommended at this location. However, to avoid potential impacts from the project, especially during construction, the following mitigation measures are recommended to eliminate or minimize short-term annoyances due to construction activities:

Elevated noise levels that are predicted at several locations along the project corridor are primarily due to BRT vehicle activities while idle at the proposed station stops. To eliminate the predicted impacts from stationary activities, several noise control measures are available, such as relocating station stops away from residences. Other measures may include engine shrouds to better insulate the engine noise from the community and multiple-baffle mufflers to reduce impacts from the roof-top exhaust.

To minimize temporary construction impacts, several "good housekeeping" practices are available. For example, noise and vibration control measures that could be incorporated into the construction process include: (1) conducting all construction activities during the daytime between 7 AM and 7 PM; (2) erecting temporary noise barriers between noisy activities and noise-sensitive receptors; (3) establishing equipment and material staging areas away from sensitive receptors; and, (4) re-routing construction traffic along roadways that minimize impacts at nearby sensitive receptors.

6.0 CONCLUSION

The results of the noise and vibration impact assessment are summarized by segment of the project corridor in Table 6-1. As shown in Table 6-1, none of the project noise or vibration levels are predicted to exceed the FTA impact criteria anywhere along the project corridor.

Table 6-1: Summary of Noise and Vibration Impacts by Project Corridor Segment

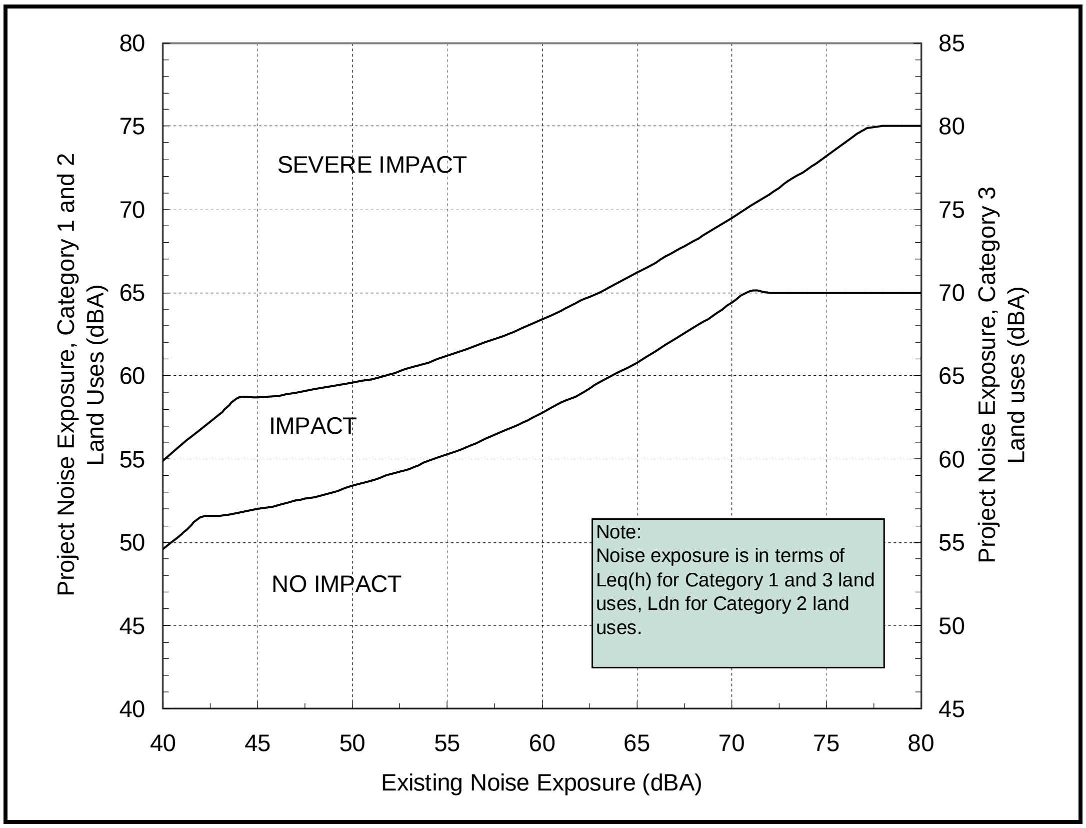
Corridor Segment		Impacts	
No.	**Description**	**Noise**	**Vibration**
A	Alexandria Route 1 South	0	0
B	Alexandria Route 1	0	0
C	Alexandria Potomac Yard	0	0
D	Arlington Potomac Yard	0	0
E	Arlington Crystal City	0	0
F	Arlington Pentagon	0	0

Source: DMJM Harris, October 2006

APPENDICES

APPENDIX A
FTA Noise Impact Criteria Curve

Figure A-1: FTA Noise Impact Criteria for Transit Projects



Source: *Transit Noise and Vibration Impact Assessment,* Final Report, Federal Transit Administration, Washington, DC, April 1995.

APPENDIX B

CNG BRT Vehicle

Figure B-1: A CNG BRT Vehicle Showing the Roof-top Exhaust and Rear-Engine Compartment

APPENDIX C
BRT Operations Data

Table C-1: Estimated Headway Times for BRT Service along the Project Corridor under the Future Build Alternatives

BRT	Headway Times (in min/hr)			
Route	**AM Pk-Hr**	**MID 1-Hr**	**PM Pk-Hr**	**Late**
9A	30	30	30	60
BLUE (9E)	5	7	5	60
RED (9S)	5	0	5	60
ORANGE (9S)	10	15	10	60
DASH AT14	15	30	15	60

Source: DMJM Harris, October 2006.