TIER 3 – NOISE AND VIBRATION

TECHNICAL MEMORANDUM

Prepared for:

Southeastern Pennsylvania Transportation Authority (SEPTA)

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Executive Summary

ES-1 Purpose

The Federal Transit Administration (FTA), in cooperation with the Southeastern Pennsylvania Transportation Authority (SEPTA), is preparing a Draft Environmental Impact Statement (DEIS), under the National Environmental Policy Act of 1969 (NEPA), that examines and evaluates a proposed extension of the existing Norristown High Speed Line (NHSL) to the King of Prussia area, known herein as the King of Prussia (KOP) Rail Project. King of Prussia is a section of Upper Merion Township, Montgomery County, PA.

The purpose of this technical memorandum, which supports the DEIS, is to document potential impacts related to noise and vibration due to the operation and construction of the KOP Rail Project (Project), along with potential minimization and mitigation measures, as necessary.

ES-2 Methodology

A noise and vibration screening assessment was conducted in accordance with the National Environmental Policy Act (NEPA) and the Federal Transit Administration's (FTA) guidelines *Transit Noise and Vibration Impact Assessment* (May 2006). Specifically, FTA's "General Assessment" guidelines were used to enable a relative comparison of potential noise and vibration impacts among the Project alternatives at the current, conceptual level of design. The FTA's General Assessment noise and vibration guidelines (including the noise and ground-surface vibration curves) are a conservative or worst-case evaluation of the potential for impacts.

The assessment examined potential Project impacts in two study areas: the transportation study area in King of Prussia, Upper Merion Township, PA and the 69th Street Transportation Center study area in Upper Darby Township, PA. The assessment used a number of Project operating assumptions (such as power source, number of trains, operating speed), and study area characteristics (such as population density and proximity to transportation facilities) to estimate where noise and vibration impacts could potentially occur. The number of potentially impacted land uses was then counted.

ES-3 Environmental Consequences

ES-3.1 No Action Alternative

In the No Action Alternative, projected noise and vibration levels, which are primarily influenced by traffic on Project study area roadways, are anticipated to be essentially the same as in the existing condition.

ES-3.2 Action Alternatives

ES-3.2.1 Noise

The screening assessment identifies the potential for noise impacts by each Action Alternative in the Project study area. At this level of analysis and without consideration of noise control

measures, the number of potential noise impacts among the Action Alternatives is shown in Table ES-1. The potentially affected land uses are primarily residences as well as existing and proposed institutional uses that would be close to the proposed guideway.

Table ES-1: Potential Noise and Vibration Impacts by the Action Alternatives

Action Alternative	Number of Potentially Impacted Land Uses (a)	
	Noise	Vibration
PECO–1st Ave.	69	1
PECO/TP–1st Ave.	35	3
PECO/TP–N. Gulph	34	3
US 202–1st Ave.	32	0
US 202–N. Gulph	31	0

Source: AECOM 2016.
(a) Includes FTA category 2 and 3 land uses.

SEPTA would use its existing fleet of N5 vehicles that operate on the NHSL, plus six new vehicles. Along the existing NHSL, where existing train operations contribute to existing noise levels and characteristics, new Project trains would moderately increase noise levels compared to existing levels, according to a preliminary assessment. No noise impact is anticipated to occur as a result of accommodating the Project at 69th Street Transportation Center in Upper Darby Township as activities would occur away from noise-sensitive receptors.

ES-3.2.2 Vibration

The screening assessment identifies the potential for one vibration impact (Kingwood Road Park) by the PECO-1st Ave. Action Alternative in the Project study area, and potentially three vibration impacts (residential properties) by PECO/TP-1st Ave. and PECO-TP-N. Gulph. No vibration impacts are expected to occur as a result of the other Action Alternatives. At this level of analysis and without consideration of vibration control measures, the potential vibration impact is shown in Table ES-1.

ES-3.2.3 Construction-Related Impacts

Temporary noise and vibration impacts are anticipated to occur during Project construction in the Project study area. As no noise or vibration sensitive receptors are in the 69th Street Transportation Center study area, no construction-related noise or vibration impacts are anticipated to occur as a result of the Project.

ES-4 Minimization and Mitigation

The screening assessment of potential noise and vibration impacts in this technical memorandum indicates that such impacts could occur and that more detailed noise analysis and consideration of minimization and mitigation strategies is warranted. SEPTA will undertake this further analysis after selection of a Locally Preferred Alternative and additional design. Detailed analysis typically includes measurements and modeling to characterize existing and future noise and vibration conditions. Where impacts are indicated by detailed analysis, SEPTA

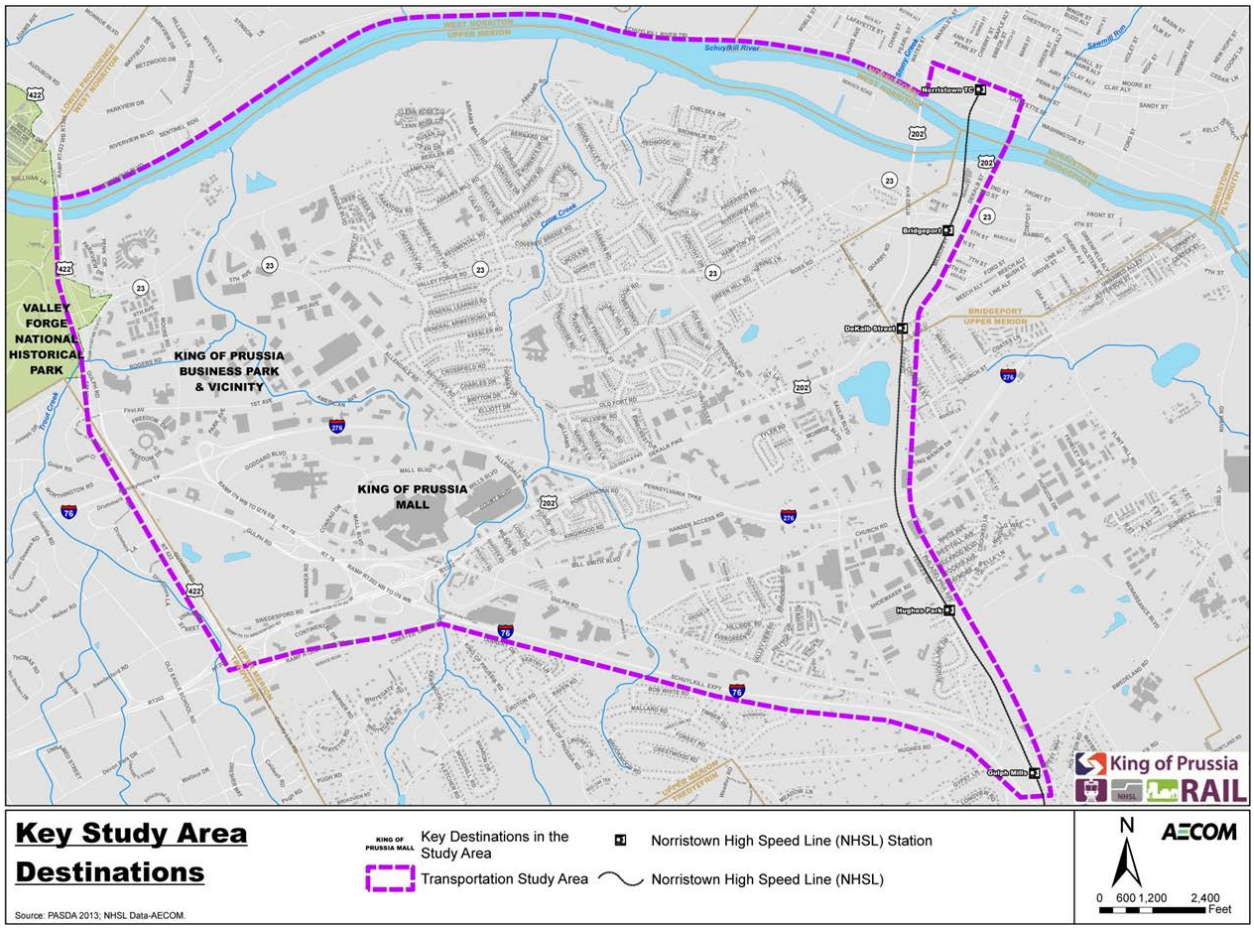
will consider the feasibility and reasonableness of the potential noise and vibration control measures. For noise control, measures may include barriers such as guideway walls, and wheel-rail friction modifiers to eliminate or reduce the severity of wheel noise. These noise mitigation strategies can substantially reduce and possibly eliminate noise impacts from vehicle operations that are predicted to be experienced by noise-sensitive receptors. Vibration control measures may include resilient track fasteners, ballast mats, or other measures that eliminate or reduce vibration transmission from the track to the guideway structure.

SEPTA will also consider means to control noise and vibration impacts during construction. Best management practices to be examined include using equipment that causes less noise and vibration, conducting a pre-construction survey of existing buildings potentially susceptible to construction vibration, restricting construction hours to times of day when noise sensitivity is less, and identifying staging areas and truck haul routes away from noise and vibration-sensitive areas.

1.0 Introduction

The Federal Transit Administration (FTA), in cooperation with the Southeastern Pennsylvania Transportation Authority (SEPTA), is preparing a Draft Environmental Impact Statement (DEIS), under the National Environmental Policy Act of 1969 (NEPA), that examines and evaluates a proposed extension of the existing Norristown High Speed Line (NHSL) to the King of Prussia area, known herein as the King of Prussia (KOP) Rail Project (Project). King of Prussia is a section of Upper Merion Township, Montgomery County, PA (Figure 1-1.1).

Figure 1-1.1: The Project's Transportation Study Area



A noise and vibration assessment was conducted in accordance with the FTA's *Transit Noise and Vibration Impact Assessment* guidelines [FTA, May 2006]. The noise and vibration assessment used conservative (worst case) modeling assumptions as a way to "screen" and compare the potential impacts of the Action Alternatives. The Project study area for this assessment consists of two parts. The King of Prussia (transportation) study area is the geographic area encompassing the King of Prussia area defined by the NHSL to the east, the Schuylkill River to the north, US Route 422 to the west, and the Schuylkill Expressway to the south. The second part of the Project study area is in Upper Darby Township; it is the geographic area around the proposed new track at SEPTA's 69th Street Transportation Center.

1.1 Purpose of Report

The purpose of the technical report is to describe potential noise and vibration impacts associated with the Project, including proposed mitigation measures, as necessary. The noise and vibration evaluation includes an assessment of the Project's potential impacts on sensitive receptors along each Action Alternative alignment and near associated facilities.

1.2 Project Overview

SEPTA's alternatives development and evaluation process is grounded in the Project purpose and need. The purpose of the proposed Project is to extend faster, more reliable public transit service to the KING OF PRUSSIA area that:

- Offers improved transit connections to the area from communities along the existing Norristown High Speed Line, Norristown, and Philadelphia;
- Improves connectivity between defined key destinations within the King of Prussia area; and
- Better serves existing transit riders and accommodates new transit patrons.

The need for expanded transit service in Montgomery County has been identified for more than 20 years in regional studies and local plans. The Project need stems from existing transit service deficiencies that are expressed by long travel times, delays due to roadway congestion, required transfers leading to two or more seat trips, and destinations that are underserved, or currently not served, by public transit. These needs are compounded by growing population and employment in the area, concentrations of major commercial development in King of Prussia, and substantial planned development for the area.

2.0 Project Description

The DEIS and this technical memorandum examine five Action Alternatives and the No Action Alternative described in the following subsections.

2.1 No Action Alternative

The No Action Alternative assumes no improvements to the transportation system in the King of Prussia area other than those contained in the financially constrained element of *Connections 2040 Plan for Greater Philadelphia*, the long-range transportation plan of the Delaware Valley Regional Planning Commission. Table 2-1.1 lists the committed No Action Alternative projects within the King of Prussia area.

Table 2-1.1: Committed No Action Alternative Projects in the King of Prussia Area

Project	Type	Description
New US Route 422 Bridge crossing over Schuylkill River	Highway	New 4-lane bridge westbound; replace bridge eastbound.
Widen US Route 422 from US Route 202 to PA 363	Highway	Widen this 2-mile segment from 4 lanes to 6.
Full interchange at US Route 422 and PA 363	Highway	Complete to a full interchange, with movements in both directions.
PA Turnpike widening from Morgantown exit to Valley Forge	Highway	Widen to 6 lanes throughout.
Lafayette Street extension and new Turnpike exit in Norristown	Highway	Construction on extension underway. Construction on Turnpike exit could start in 2018.
First Avenue Streetscape and Multi-use Trail (known also as the 1st Avenue Road Diet project)	Highway	Funded through statewide TAP program. Road Diet, streetscaping and multi-use trail along the length of 1st Avenue to enhance multi-modal access.
Relocate PA 23/Valley Forge Road and North Gulph Road	Highway	Move roadway 300 feet east of current entrance with Valley Forge National Historical Park to improve operations and reduce traffic impacts in the vicinity of the Park, and create a new Gateway entrance.
Widen Henderson Road and South Gulph Road	Highway	Widen South Gulph Road from Crooked Lane to I-76 intersection at Gulph Mills, and widen Henderson Road from South Gulph to Shoemaker Road.
Chester Valley Trail Extension	Multimodal	Extend the Chester Valley Trail to connect with the Schuylkill River Trail in Norristown, a 3.5 mile extension.

Source: DVRPC, *Connections 2040 Plan for Greater Philadelphia.*

The No Action Alternative projects consist primarily of planned capacity and operational improvements to regional and local area roadways, particularly US Route 422 and the Pennsylvania Turnpike. All but one roadway project operates at the periphery of the Project

study area; the 1st Avenue "road diet" project is within the Project study area. Montgomery County's Chester Valley Trail Extension is also within the Project study area. In addition to these planned and committed projects, the No Action Alternative consists of highway and transit networks, transit service levels, traffic volumes, and forecasted demographics for the horizon year 2040.

2.2 Action Alternatives

Figures 2-2.1 through 2-2.5 illustrate the Action Alternatives, described as follows:

- **PECO-1st Ave. Alternative**: The PECO-1st Ave. Action Alternative would use a portion of the PECO electric utility corridor as its trunk, passing in front of (to the south of) the King of Prussia Mall, turning north to use a portion of the Norfolk Southern Railroad (NS) Industrial Track before turning west along 1st Avenue as its branch and ending near the intersection of 1st Avenue and N. Gulph Road near the Valley Forge Casino Resort (VFCR).

- **PECO/TP-1st Ave. Alternative**: The PECO/TP-1st Ave. Action Alternative would use portions of the PECO electric utility corridor and PA Turnpike as its trunk, passing behind (to the north of) the King of Prussia Mall, turning north to use a portion of the NS Industrial Track before turning west along 1st Avenue as its branch and ending near the intersection of 1st Avenue and N. Gulph Road near the VFCR.

- **PECO/TP-N. Gulph Alternative**: The PECO/TP-N. Gulph Action Alternative would use portions of the PECO electric utility corridor and PA Turnpike as its trunk, passing behind (to the north of) the King of Prussia Mall, turning south to connect to N. Gulph Road before turning west along the N. Gulph Road as its branch and ending near the intersection of 1st Avenue and N. Gulph Road near the VFCR.

- **US 202-1st Ave. Alternative**: The US 202-1st Ave. Action Alternative would use portions of the US Route 202 corridor and the PA Turnpike right-of-way as its trunk, passing behind (to the north of) the King of Prussia Mall, turning north to use a portion of the NS Industrial Track before turning west along 1st Avenue as its branch and ending near the intersection of 1st Avenue and N. Gulph Road near the VFCR.

- **US 202-N. Gulph Alternative**: The US 202-N. Gulph Action Alternative would use portions of the US Route 202 corridor as its trunk, passing behind (to the north of) the King of Prussia Mall, turning south to connect to N. Gulph Road before turning west along the N. Gulph Road as its branch and ending near the intersection of 1st Avenue and N. Gulph Road near the VFCR.

As part of each Action Alternative, two, side-by-side rail tracks (a pair) would be provided on primarily elevated guideway. However, a short at-grade section would be provided in the turnoffs adjacent to the existing NHSL. In the PECO and PECO/TP Trunks, the tracks would also be at grade on a hilltop area within the PECO corridor a short distance west of Henderson Road.

The Action Alternatives include five to seven proposed station areas: Henderson Road, the Court, Mall Boulevard North, Plaza, 1st Avenue East, and the terminal stations at 1st & Moore or Convention Center. The Henderson Road and 1st & Moore stations would include park-and-ride facilities, currently configured as a surface lot at the Henderson Road station and a multi-story garage structure at 1st & Moore.

As the elevated guideway approaches the western terminal stations (1st & Moore or Convention Center), the two-track guideway structure would widen from approximately 34 feet to a three-track cross-section approximately 50 feet wide. In the widened area, the third track would provide SEPTA with the necessary track capacity for efficient train operations at the terminal station and along the alignment in those areas.

SEPTA would add trains to the NHSL to serve King of Prussia. Some trains that currently turn back at Hughes Park would continue to King of Prussia. In addition, new trains would provide service between Norristown Transportation Center and King of Prussia. SEPTA proposes to use the same vehicles that currently operate on the NHSL and the existing track and guideway. With the exception of providing a new wye junction with the NHSL to enable Project trains to connect to the NHSL, SEPTA proposes no physical changes to the NHSL guideway or its related infrastructure. In the PECO-1st Ave., PECO/TP-1st Ave. and PECO/TP-N. Gulph Alternatives, the wye would be in the vicinity of the PECO corridor crossing of the NHSL, north of I-276. In the US 202-1st Ave. and US 202-N. Gulph Alternatives, the wye would be just south of Old DeKalb Pike. The proposed wye junction would consist of connecting the new Project guideway and track to the existing NHSL guideway and track.

Figure 2-2.1: PECO – 1st Ave. Action Alternative

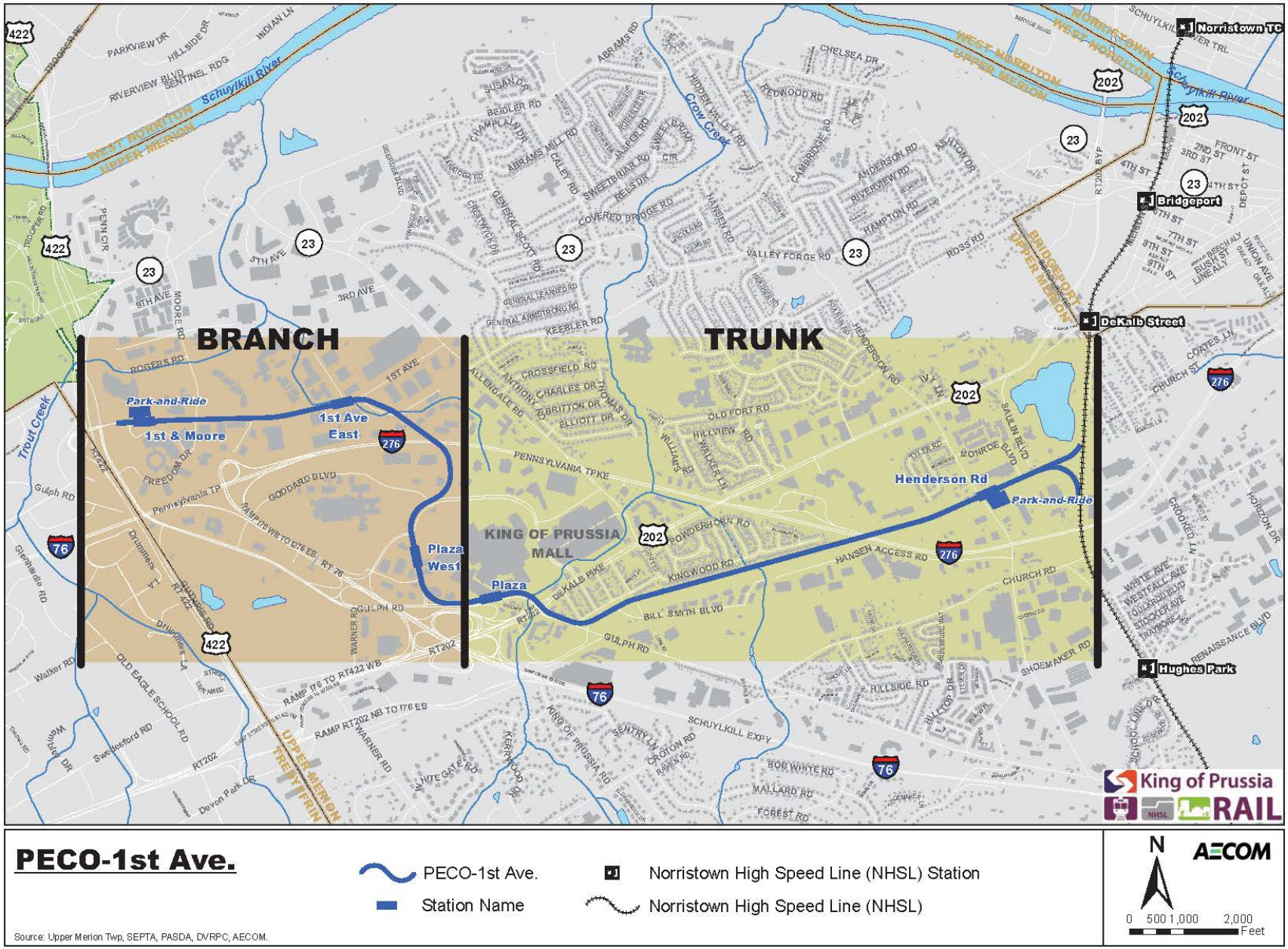


Figure 2-2.2: PECO/TP– 1st Ave. Action Alternative

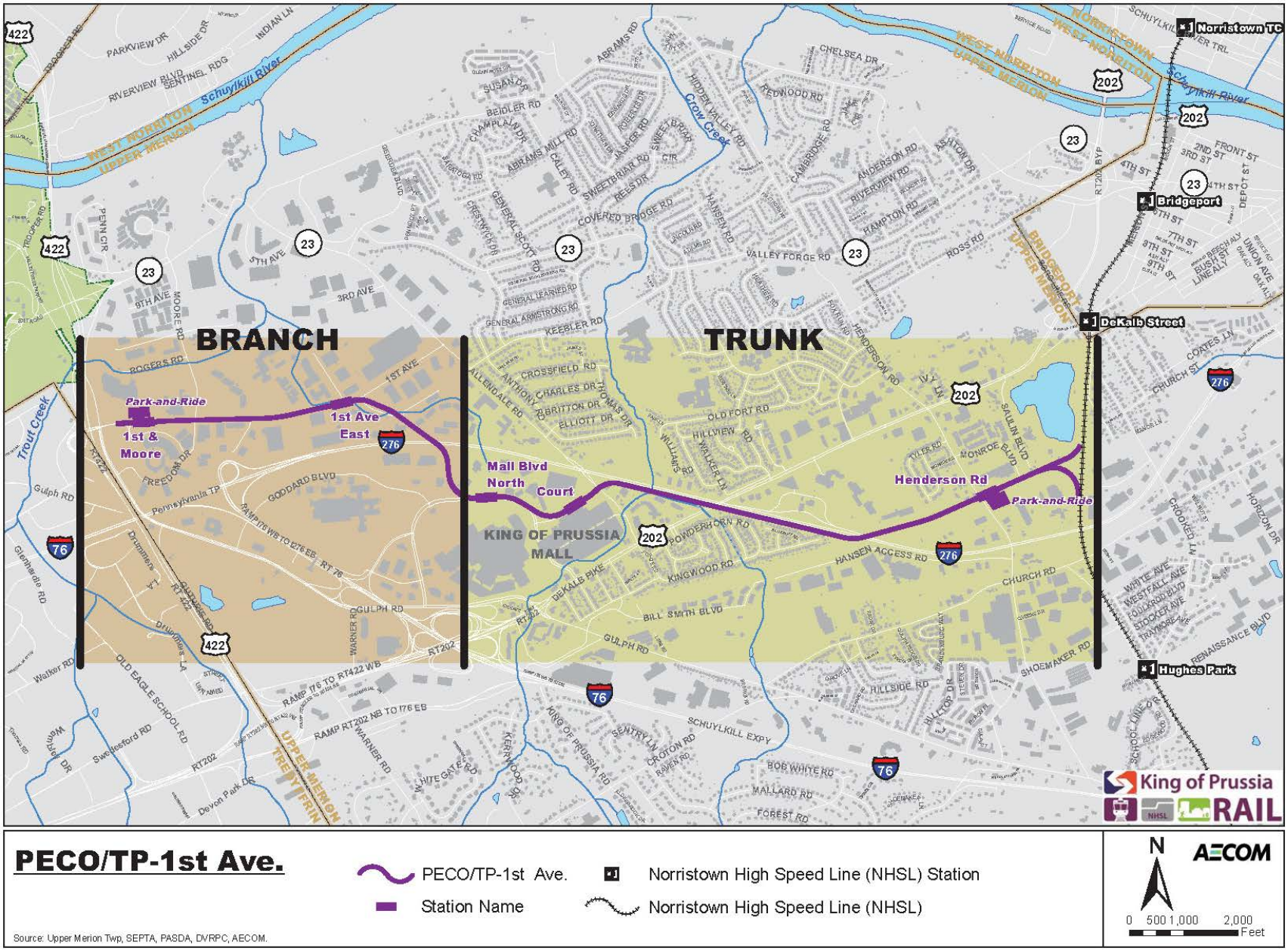


Figure 2-2.3: PECO/TP - N. Gulph Action Alternative

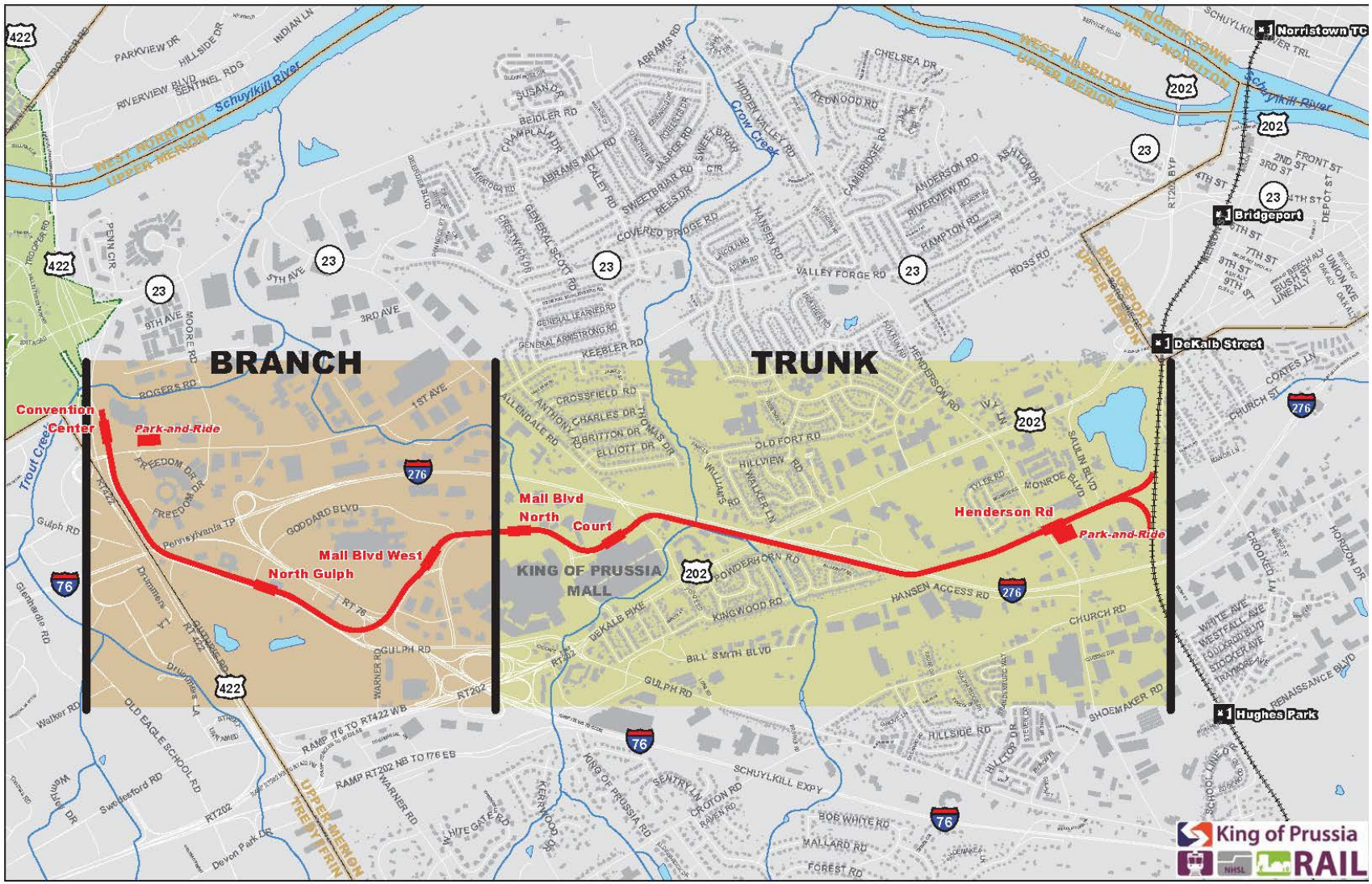


Figure 2-2.4: US 202 – 1st Ave. Action Alternative

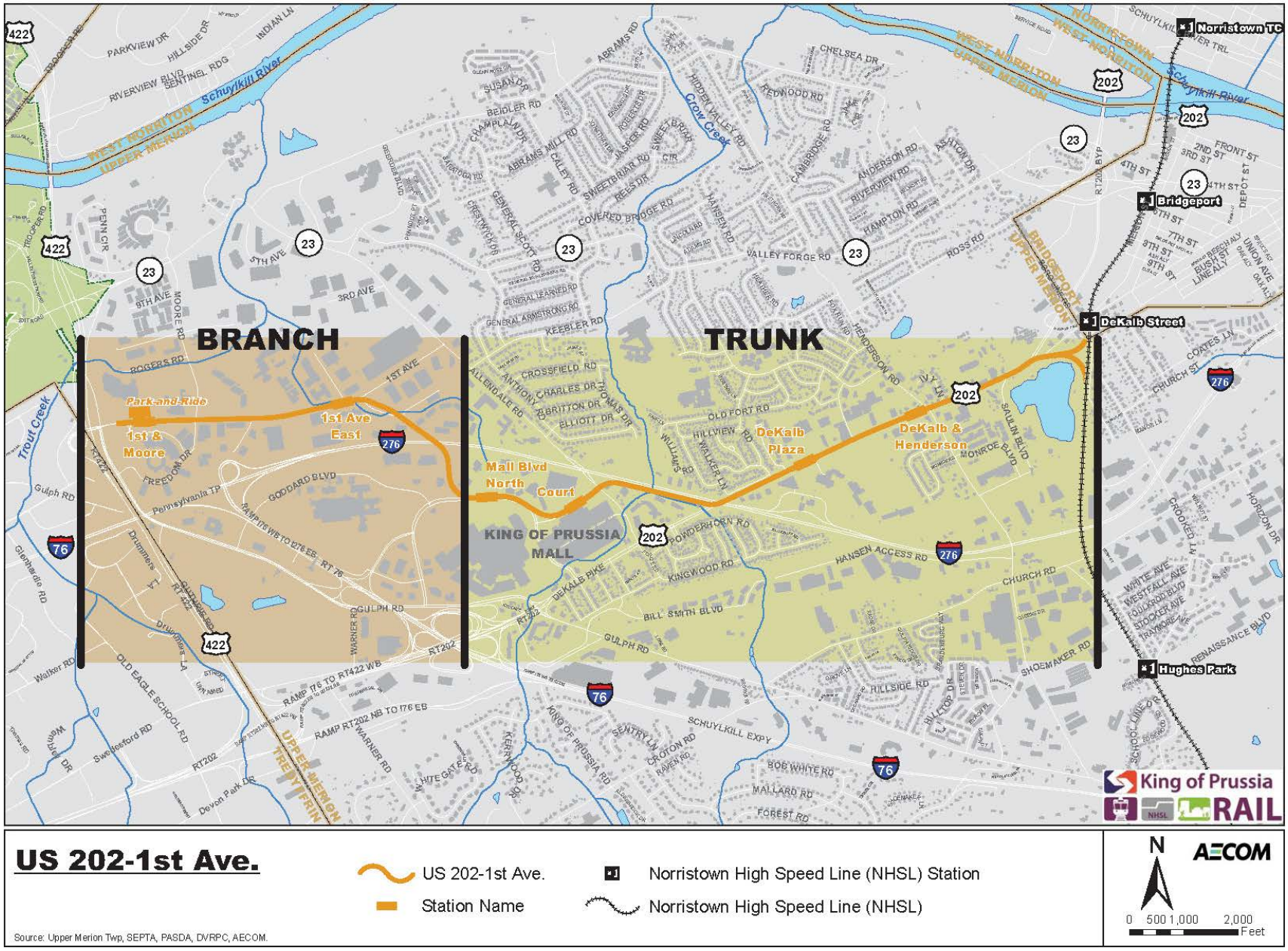
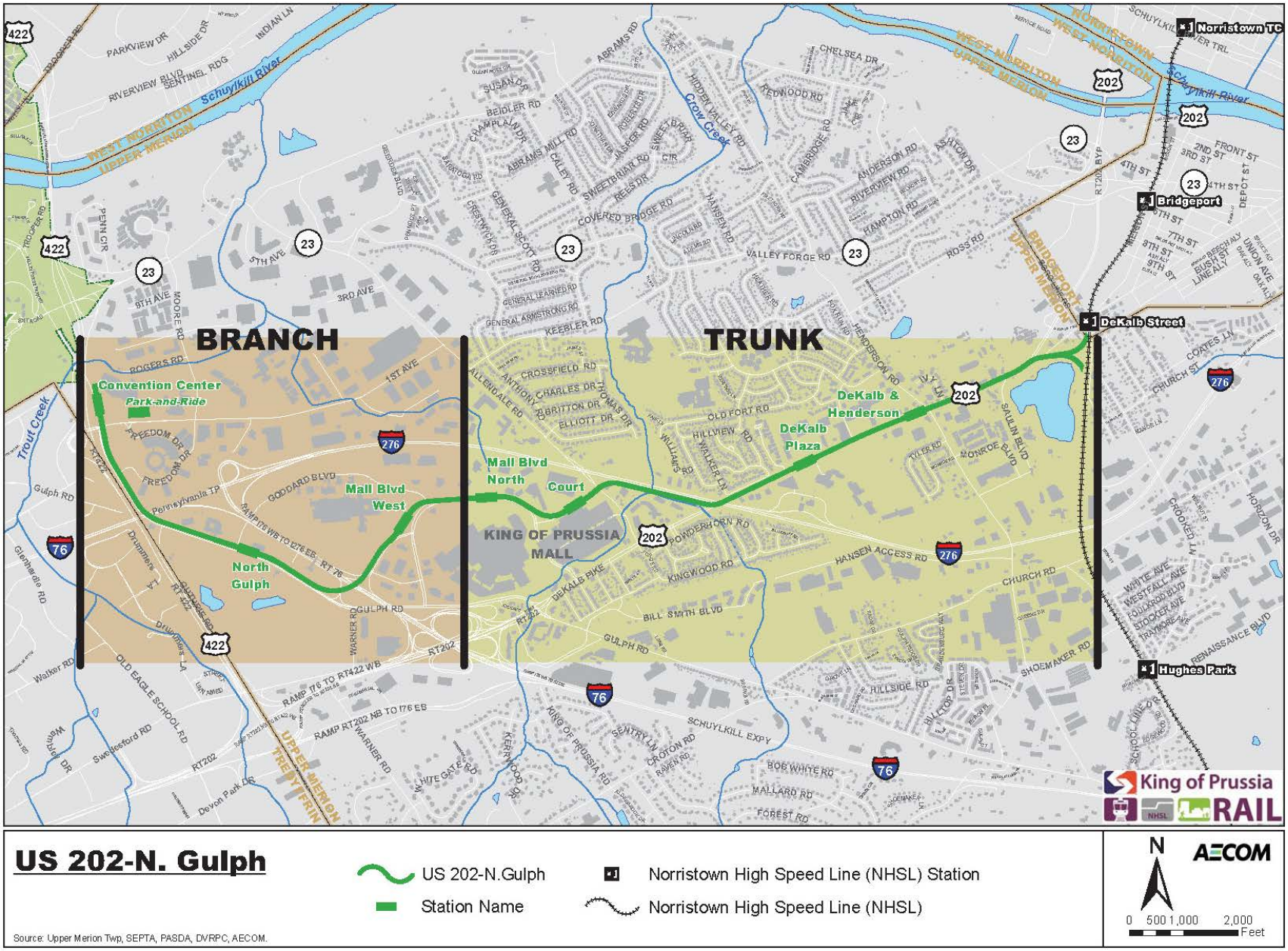


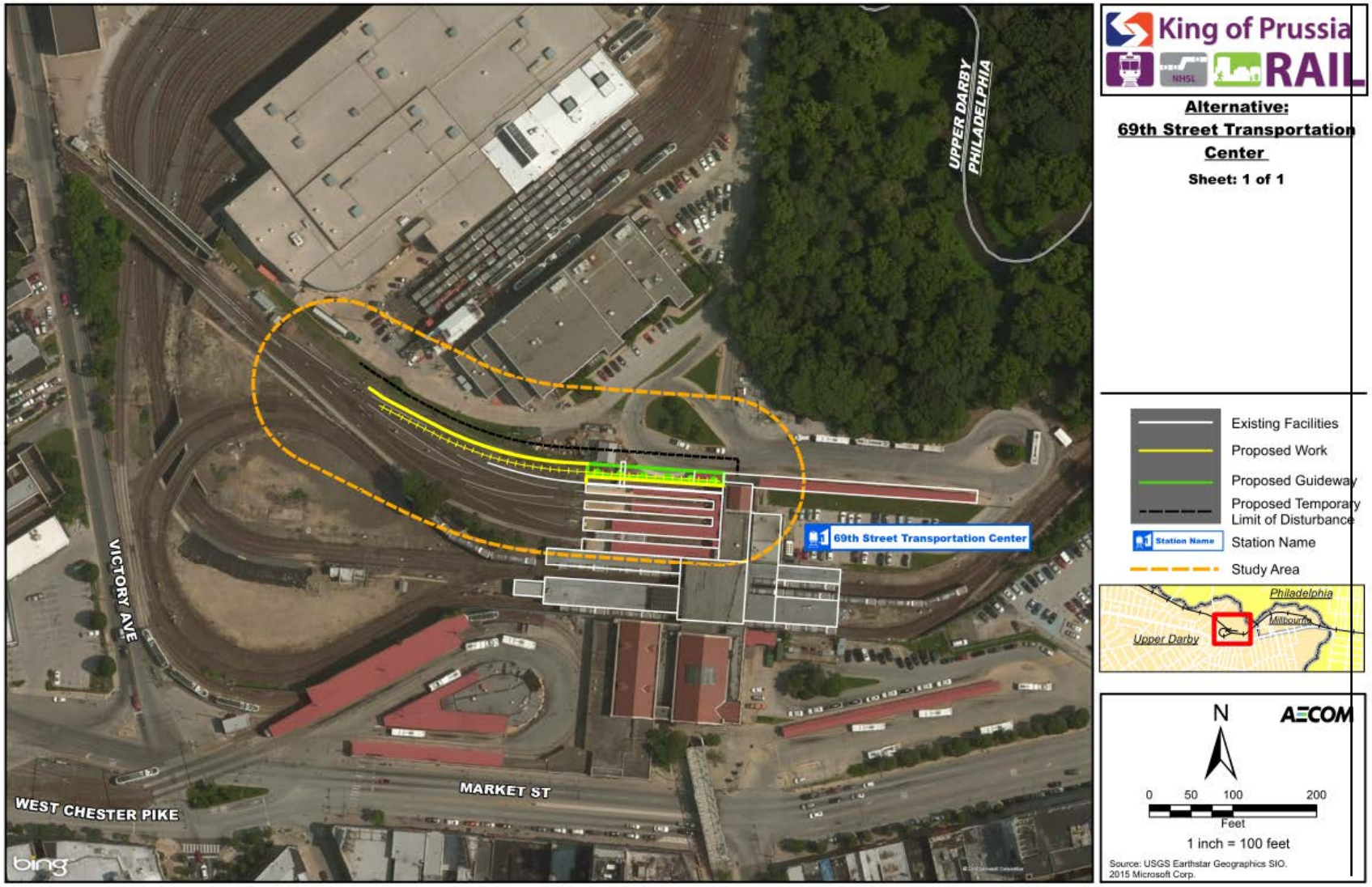
Figure 2-2.5: US 202 – N. Gulph Action Alternative



Extending NHSL service into King of Prussia would require SEPTA to add one new station track at SEPTA's 69th Street Transportation Center in Upper Darby Township, Delaware County (Figure 2-2.6). The new track would be aligned along the north side of the existing NHSL tracks, stopping at the existing building along the north side of the existing northern platform. The ballast embankment supporting the existing NHSL tracks would be widened to the north to accommodate the new track. Adjacent to the northern platform, the new track would be supported on an elevated guideway structure. The purpose of using structure rather than continuing the embankment up to the building is to avoid impacting the existing bus stop and turnaround area underneath and adjacent to the new track.

The existing, northern platform would be widened to serve the new track. As with the existing NHSL service, the new track and widened platform would be designed to enable level passenger boarding. The existing windbreak wall along the northern edge of the existing platform would be removed and rebuilt along the northern edge of the proposed guideway structure. Elements to be removed include a short section of existing turnout track along the proposed alignment as well as an existing stairway used by passengers exiting from the north platform and by SEPTA personnel. The existing track embankment retaining wall would be relocated to the north edge of the new embankment and the existing track turnout would be replaced. Other portions of the 69th Street Transportation Center would not be affected or changed by the proposed Project.

Figure 2-2.6: 69th Street Transportation Center



3.0 Regulatory Setting

The operational impacts of the Project were evaluated using the guidelines set forth by the FTA's guidance manual on *Transit Noise and Vibration Impact Assessment* (May 2006).

3.1 Metrics

3.1.1 Noise

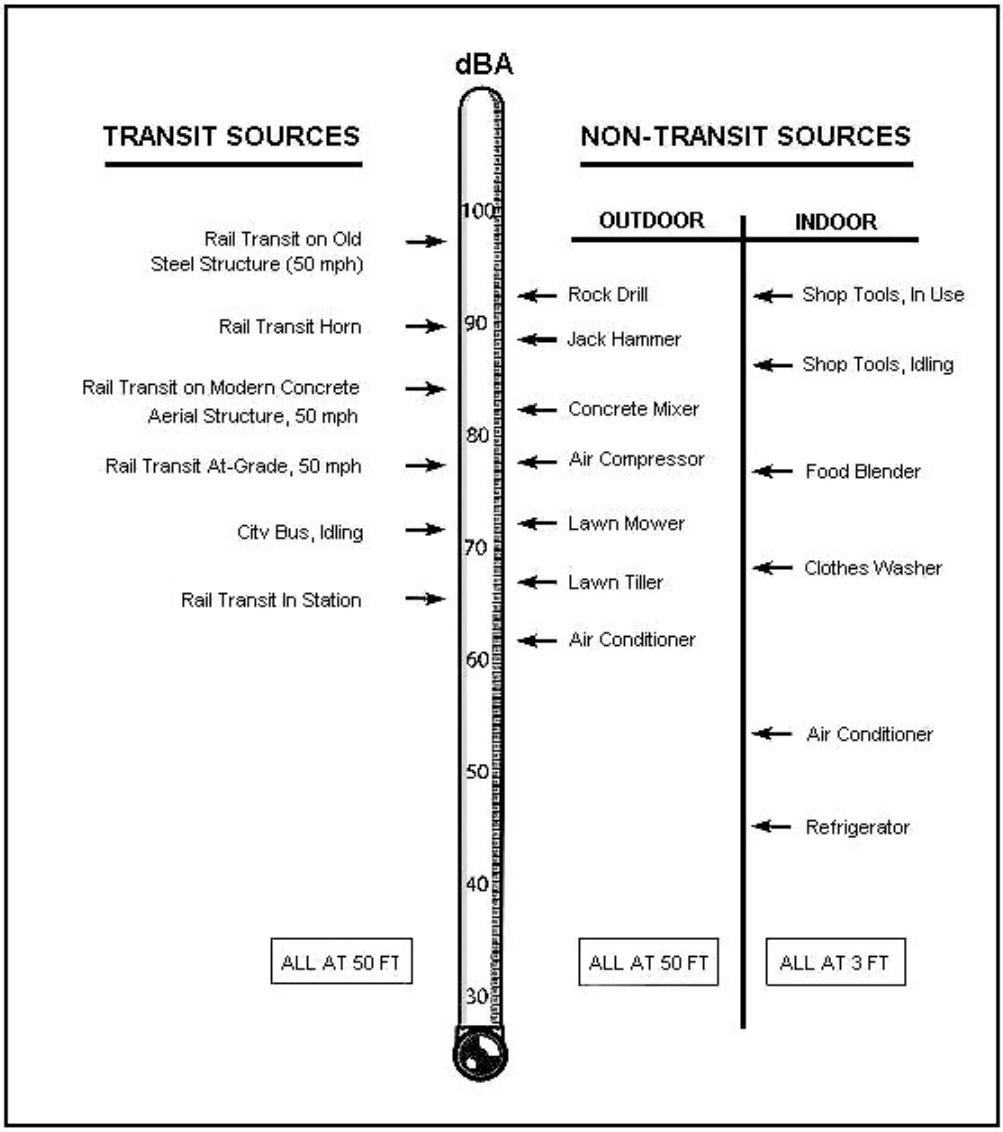
Noise is "unwanted sound" and by this definition, the perception of noise is subjective. Several factors affect the actual level and quality of sound (or noise) as perceived by the human ear and can generally be described in terms of loudness, pitch (or frequency), and time variation. The loudness, or magnitude, of noise determines its intensity and is measured in decibels (dB) that can range from below 40 dB (e.g., the rustling of leaves) to over 100 dB (e.g., a rock concert). Pitch describes the character and frequency content of noise, such as the very low "rumbling" noise of stereo subwoofers or the very high-pitched noise of a piercing whistle. Finally, the time variation of noise sources can be characterized as continuous, such as with a building ventilation fan; intermittent, such as for trains passing by; or impulsive, such as pile-driving activities during construction.

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 more closely matches the human ear's response to audible frequencies. Since the A-weighted decibel scale is logarithmic, a 10 dBA increase in a noise level is generally perceived as a doubling of loudness, while a 3 dBA increase in a noise level is just barely perceptible to the human ear. Typical A-weighted sound levels from transit and other common sources are documented in FTA's guidance manual on *Transit Noise and Vibration Impact Assessment* (2006), as shown on Figure 3-1.1 (Typical A-Weighted Noise Levels).

Several A-weighted noise descriptors are used to assess impacts from stationary and transit-related sources, including:

- **Maximum Noise Levels (Lmax):** represents the maximum noise level that occurs during an event such as a bus or train pass-by;
- **Average Hourly Equivalent Noise Level (Leq):** 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 (Leq(h)); and
- **Average 24-hour day-night noise level (Ldn):** includes a 10-decibel penalty for all nighttime activity between 10:00 p.m. and 7:00 a.m.

Figure 3-1.1: Typical A-Weighted Noise Levels

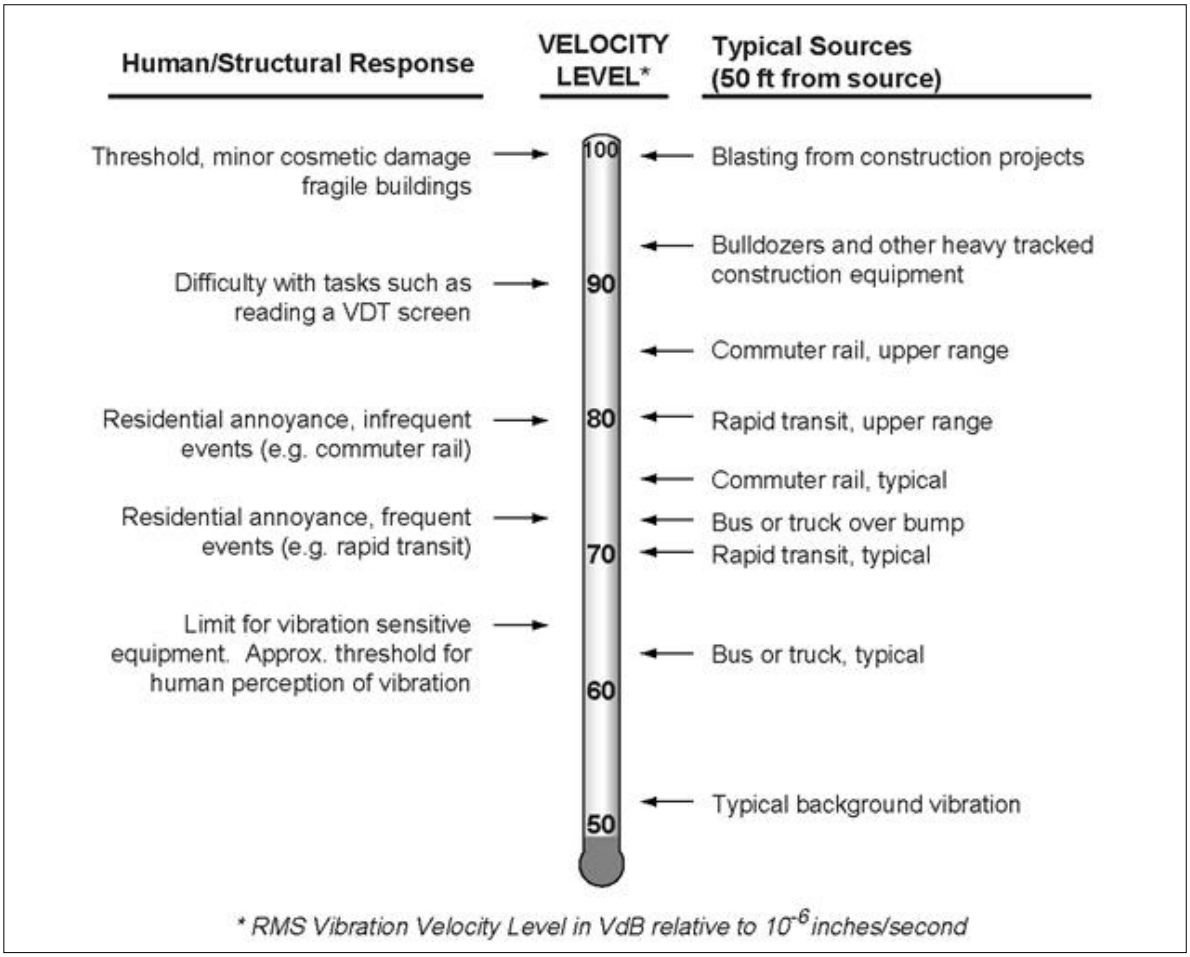


Source: *Transit Noise and Vibration Impact Assessment*. FTA. Washington, DC. May 2006.

3.1.2 Vibration

Ground-borne vibration associated with vehicle movements is usually the result of uneven interactions between wheels 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 a motor vehicle wheel hitting a pothole, a manhole cover, or any other uneven surface. Typical ground-borne vibration levels from transit and other common sources are shown on Figure 3-1.2 (Typical Ground-Borne Vibration Levels).

Figure 3-1.2: Typical Ground-Borne Vibration Levels



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

Unlike noise, which travels in air, transit vibration typically travels along the surface of the ground. Depending on the geological properties of the surrounding terrain and the type of building structure exposed to transit vibration, 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 located in sandier soil. Heavier buildings (such as masonry structures) are less susceptible to vibration than wood-frame buildings because they absorb more vibration energy.

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

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 level is expressed in inches per second (ips) or vibration velocity levels in decibels (VdB). All VdB vibration levels

are referenced to one micro-inch per second (μips). Similar to noise decibels, vibration decibels are dimensionless because they are referenced to (i.e., divided by) a standard level (such as $1x10^{-6}$ ips in the United States). This convention allows compression of the scale over which vibration occurs, such as 40 to 100 VdB rather than 0.0001 ips to 0.1 ips.

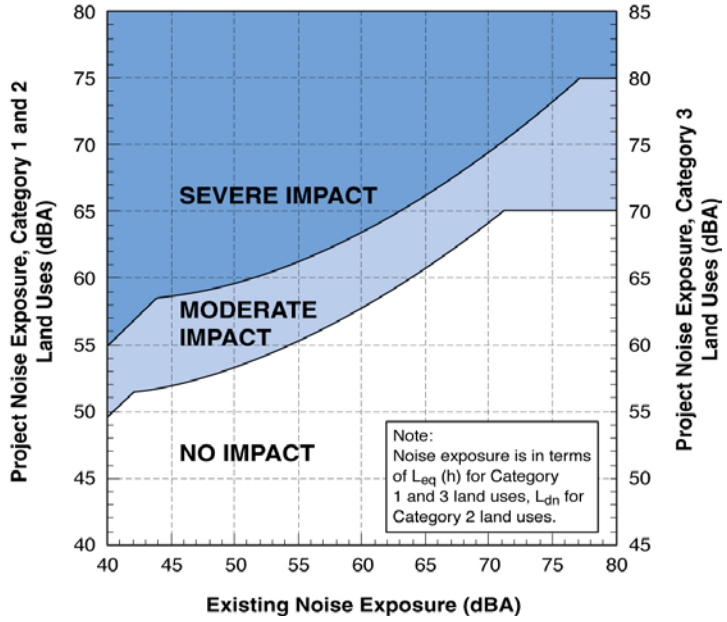
3.2 Evaluation Criteria

3.2.1 Operational Noise Criteria

The FTA's guidance manual on *Transit Noise and Vibration Impact Assessment* (May 2006) 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 noise impact criteria, land use categories and sensitivity to noise from transit sources under the FTA guidelines. Each is discussed below.

Noise impact criteria. As shown in Figure 3-2.1 (FTA Project Noise Impact Criteria), the FTA noise impact criteria are defined by two curves: a "moderate impact" curve and a "severe impact" curve. FTA developed each curve to represent the points at which a given baseline noise level plus a new noise level, a proposed project, would cause an impact. These curves reflect the logarithmic manner by which two sound levels are perceived by the human ear when added together as described in Section 3.1.1. FTA defines a moderate noise impact as occurring when the combination of the two noise levels would be noticeable but may not be sufficient to cause a strong, adverse community reaction. At the severe impact level, FTA defines the combination of noise levels as highly annoying to a substantial percentage of the affected population. Below the moderate noise impact curve, the combination of noise levels would not cause an impact.

Figure 3-2.1: FTA Project Noise Impact Criteria



SOURCE: *Transit Noise and Vibration Impact Assessment.* FTA. Washington, DC. May 2006.

Land use categories. Noise impacts are measured differently at land uses depending upon the type of land use. FTA identifies three land use categories (sometimes referred to as sensitive receptors) and assigns noise metrics (units of measure, such as $L_{eq}(h)$) to each as shown in Table 3-2.1. Land use categories 2 and 3 are most common. Category 2 land uses are locations where nighttime sensitivity to noise is of primary importance: residences, hotels and hospitals, for example. Category 3 land uses are primarily daytime uses: parks, schools and other institutional uses. The Project study area includes Category 2 and 3 land uses; none are located in the 69th Street Transportation Center study area. Category 1 land uses are, by definition, uses where quiet is an essential part of their purpose, such as outdoor theaters. The Project and 69th Street Transportation Center study areas do not contain land use category 1 uses.

Table 3-2.1: 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*. FTA. Washington, DC. May 2006.

Sensitivity to noise. As shown in Table 3-2.1, the average day-night noise level over a 24-hour period (or L_{dn}) is used to characterize noise exposure for residential areas (FTA land use category 2). The L_{dn} descriptor describes a receiver's cumulative noise exposure from all events over a full 24 hours, with events between 10:00 p.m. and 7:00 a.m. increased by 10 decibels to account for greater nighttime sensitivity to noise. For other noise sensitive land uses, such as schools and libraries (FTA land use category 3) and outdoor amphitheaters (FTA land use category 1), the average hourly equivalent noise level (or $L_{eq}(h)$) is used to represent the peak operating period.

3.2.2 Operational Vibration Criteria

The FTA vibration criteria for evaluating ground-borne vibration impacts from train pass-bys at nearby sensitive receptors are shown in Table 3-2.2 (Ground-Borne RMS Vibration Impact Criteria for Annoyance during Operations and Construction [VdB]). 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 referenced to 1 μips. The FTA's experience with community response to ground-borne vibration indicates that when there are only a few train 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*, *occasional*, and

infrequent events, where the *frequent* events category is defined as more than 70 events per day. Similarly, the *occasional* events category is defined as between 30 and 70 events per day while the *infrequent* events category is defined as less than 30 events per day. To be conservative, the worst case FTA *frequent* criteria were used to assess ground-borne vibration impacts in the Project study area.

The vibration criteria levels shown in Table 3-2.2 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 3-2.2: Ground-Borne RMS Vibration Impact Criteria for Annoyance during Operations and Construction (VdB)

Receptor Land Use		RMS Vibration Levels (VdB)		
Category	Description	Frequent Events	Occasional Events	Infrequent Events
1	Buildings where low vibration is essential for interior operations	65	65	65
2	Residences and buildings where people normally sleep	72	75	80
3	Daytime institutional and office use	75	78	83
Specific Buildings	TV/Recording Studios/Concert Halls	65	65	65
	Auditoriums	72	80	80
	Theaters	72	80	80

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

For at-grade (i.e., at ground level) or above-grade (i.e., elevated above ground) transit systems, the ground-borne noise is typically not evaluated, except for buildings that have sensitive interior spaces and that are well insulated from exterior noise. In general, airborne noise masks ground-borne noise for above ground transit systems.

4.0 Methodology

The methodologies used to assess the potential noise and vibration impacts of the Action Alternatives are described in the following subsections. Two geographic areas were investigated in this general assessment: the transportation study area in Upper Merion Township where SEPTA is considering the five Action Alternatives described in Section 2.2, and the 69th Street Transportation Center study area.

4.1 Screening Assessment

The FTA default screening distances for rail rapid transit of 350 feet for intervening buildings and 700 feet without intervening buildings were used to identify noise-sensitive receptors in the Project study area. Over 800 noise- and vibration-sensitive receptors, including over 570 residences, were identified using this approach. As part of the evaluation, the FTA's "General Assessment" guidelines were used to enable a relative comparison of potential noise and vibration impacts among the Action Alternatives at the current, conceptual level of design. The FTA's General Assessment noise and vibration guidelines (including the noise and ground-surface vibration curves) represent a conservative or worst-case evaluation of the potential for impacts.

4.2 Baseline Noise Estimation

To determine the existing background noise levels at sensitive receptors near the Action Alternative alignments in the Project study area, baseline noise levels were estimated using the FTA methodology based on land-use densities and proximity to transportation corridors.

4.3 Noise Screening Assumptions

The various noise screening assumptions, noise levels for each of the proposed noise sources (including train pass-bys, wheel squeal, etc.), and other operating characteristics (such as average duration times, source heights, etc.) used in the assessment for the Project study area are described below. These data are based on default FTA data, as well as operational information developed for the Project.

- Noise impacts from self-propelled, electrically-powered rail vehicles were evaluated along the Action Alternative alignments.

- Proposed rail vehicles were modeled using an average 2-car consist with up to 134 trains during the daytime (7:00 AM to 10:00 PM) and 41 trains during the nighttime (10:00 PM to 7:00 AM) originating from or ending at 69th Street Transportation Center; six trains would operate during the peak-hour period (10-minute headways) in the Project study area. An additional three trains originating from or ending at Norristown Transportation Center would operate during the peak-hour period in the Project study area (20-minute headways). All rail vehicle volumes were applied on a bi-directional basis.

- Potential noise impacts due to rail vehicles were evaluated using the default FTA reference noise level of 80 dBA L_{max} (or 82 dBA SEL) at 50 feet, a source height of two

feet and a reference speed of 50 miles per hour. The height of two feet represents the acoustical center of the aerodynamic noise and the wheel-rail noise, the source of noise from third rail electrically powered vehicles. The default FTA reference noise levels are well-established and represent a conservative (worst case) estimate of the type of vehicle to be used by SEPTA for the Project. Actual noise levels at receptors could be lower if the noise level at the source and actual travel speeds are lower.

- A maximum speed of 35 miles per hour was used everywhere as a conservative assumption. In reality, however, average rail vehicle operating speeds are expected to vary by location and would range from 15 miles per hour near stations to a maximum speed of 35 miles per hour between stations.

- Rail vehicle reference noise levels were adjusted to account for speed, distances to sensitive receptors, and acoustically "soft" ground to reflect yards and lawns, where present.

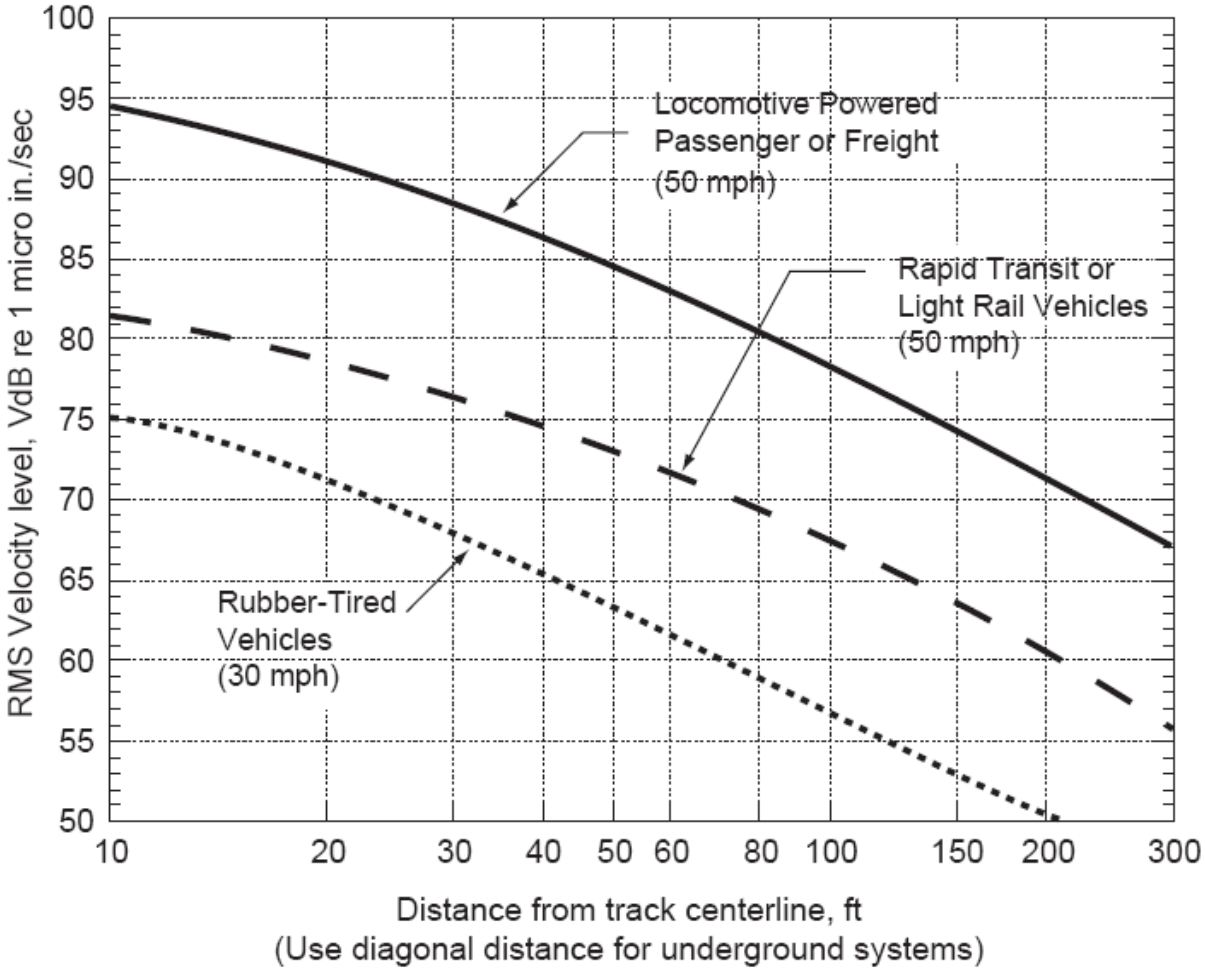
- None of the following noise sources was evaluated during the screening evaluation. These potential noise sources, if present, would be assessed in a more detailed noise analysis after a Locally Preferred Alternative is selected.

    - Warning Horns
    - Crossing Bells
    - Bell Ringing at Stations
    - Wheel Squeal at Curves
    - Turnout Switches
    - Park-and-Ride Facilities
    - Traction Power Substations

4.4 Vibration Screening Assumptions

Potential ground-borne vibration levels from rail vehicle pass-bys in the Project study area were predicted using the default ground surface vibration curves in FTA's guidance manual on *Transit Noise and Vibration Impact Assessment* (May 2006). These ground-borne vibration levels are shown on Figure 4-4.1 (FTA Generalized Ground Surface Vibration Curves). The proposed low speed of the rail vehicles limits the potential for vibration impacts to nearby receptors. As a conservative modeling assumption, the surface vibration curves in Figure 4-4.1 were adjusted to reflect local conditions (receptor distances) and changes in train speed. No adjustments for geologic ground conditions or building effects were applied. Additionally, no adjustments were applied for corrugated rail, wheel flats or other unmaintained rolling stock. Vibration can be minimized by a rigorous rail-grinding and wheel-trueing program. Finally, no adjustments were applied to account for various receptor building construction types (i.e., masonry versus timber).

Figure 4-4.1: FTA Generalized Ground Surface Vibration Curves



Source: Transit Noise and Vibration Impact Assessment. FTA. Washington, DC. May 2006.

5.0 Affected Environment

The existing condition is described in the following subsections.

5.1 Baseline Noise Levels

Using FTA's typical estimates for noise exposure shown in Table 5-1.1 (Estimating Existing Noise Exposure for General Assessment), the baseline noise levels in the Project study area were estimated using population density and proximity to transportation corridors.

- Population density: Based on an estimated population density of 1,656-2,359 people per square mile[1], Table 5-1.1 indicates an L_{dn} of 50 dBA would be appropriate.

- Proximity to transportation facilities: In this assessment, proximity to arterial roadways was used as a factor since most residents that could be impacted by the Project are a distance of 200-500 feet from arterial roadways.[2] These residents are also at least 200 feet from active railroad corridors. Examining these factors in Table 5-1.1 indicates a baseline day-night noise level range of 50 to 60 dBA depending on location. This range is a reasonable estimate of baseline noise because it accounts for traffic and other sources that contribute to the noise levels residents and other people in the developed Project study area experience. Population proximity to interstate highways was not considered because sound barriers along the PA Turnpike reduce noise exposure; the factors in Table 5-1.1 would not be appropriate for the Project screening assessment.

In this assessment, proximity to arterial roadways and railroads results in the highest noise exposure, 60 dBA. Thus, 60 dBA was utilized as a conservative estimate for all residences as well as category 2 and 3 land uses in the Project study area. Although this estimate is a simplification of the actual background noise levels in the Project study area, it is conservative (worst case) and results in a higher count of impacts.

[1] Population densities for Montgomery County and King of Prussia are based on information from Census.gov and Pennsylvania.HomeTownLocator.com, respectively.

[2] In this assessment, proximity to arterial roadways was used as a factor since most residents that could be impacted by the Project are 200 feet or more from busy roadways. These residents are also at least 200 feet from active railroad corridors.

Table 5-1.1: Estimating Existing Noise Exposure for General Assessment

Distance from Major Noise Source[1] (feet)			Population Density (people per sq. mile)	Noise Exposure Estimates			
Interstate Highways[2]	Other Roadways[3]	Railroad Lines[4]		Leq Day	Leq Evening	Leq Night	Ldn
10-50				75	70	65	75
50 - 100				70	65	60	70
100 - 200				65	60	55	65
200 - 400				60	55	50	60
400 - 800				55	50	45	55
800 and up				50	45	40	50
	10-50			70	65	60	70
	50 - 100			65	60	55	65
	100 - 200			60	55	50	60
	200 - 400			55	50	45	55
	400 and up			50	45	40	50
		10-30		--	--	--	75
		30 - 60		--	--	--	70
		60 - 120		--	--	--	65
		120 - 240		--	--	--	60
		240 - 500		--	--	--	55
		500 - 800		--	--	--	50
		800 and up		--	--	--	45
			1 - 100	35	30	25	35
			100 - 300	40	35	30	40
			300 - 1000	45	40	35	45
			1000 - 3000	50	45	40	50
			3000 - 10000	55	50	45	55
			10000 - 30000	60	55	50	60
			30000 and up	65	60	55	65

Source: *Transit Noise and Vibration Impact Assessment*. FTA. Washington, DC. May 2006.
Gray shading indicates potentially applicable noise exposure limits for the Project study area based on the general assessment.

1 Distances do not include shielding from intervening rows of buildings. General rule for estimating shielding attenuation in populated areas: Assume 1 row of buildings every 100 ft; -4.5 dB for the first row, -1.5 dB for every subsequent row up to a maximum of -10 dB attenuation.
2 Roadways with 4 or more lanes that permit trucks, with traffic at 60 mph.
3 Parkways with traffic at 55 mph, but without trucks, and city streets with the equivalent of 75 or more heavy trucks per hour and 300 or more medium trucks per hour at 30 mph.
4 Main line railroad corridors typically carrying 5-10 trains per day at speeds of 30-40 mph.

6.0 Environmental Consequences

This section describes the potential operational noise and vibration impacts of the Action and No Action Alternatives, as well as assesses the potential for temporary construction noise and vibration impacts and indirect and cumulative effects.

6.1 No Action Alternative

The King of Prussia Project study area is characterized by a mix of both rural suburban to dense urban communities that include major highways such as I-76 and I-276 as well as arterials such as US Route 202. Noise levels in the No Action Alternative are anticipated to be essentially the same as in the existing condition. It takes a doubling of traffic volumes and maintenance of existing operating speeds for the noise levels to increase by 3 dBA, the threshold where most listeners detect the change. However, as reported in Chapter 3 of the Draft EIS, forecast increases in traffic volumes on King of Prussia study area roadways are predicted in 2040, resulting in higher congestion levels, lower average travel speeds. These conditions predict a noise level increase of less than 3 dBA.

Projected vibration levels in the No Action Alternative are expected to be similar to those currently experienced under existing conditions. Traffic, including heavy trucks and buses, rarely creates perceptible ground-borne vibration unless vehicles are operating very close to buildings or there are irregularities in the road, such as potholes or expansion joints. The pneumatic tires and suspension systems of automobiles, trucks, and buses eliminate most ground-borne vibration. As a result, there would be no vibration impacts associated with the No Action Alternative.

6.2 Action Alternatives

6.2.1 Noise

The noise screening assessment for the Project identifies the potential for noise impacts by each Action Alternative. The assessment findings indicate that 150 feet is the maximum distance from the proposed guideway that a noise level from Project operations could extend and have a potential impact on FTA category 2 land uses (result in a noise level greater than 60 dBA). For FTA category 3 land uses, which have a different metric than category 2 land uses (L_{eq}(h) instead of L_{dn}, Table 3-2.1), the maximum distance within which a potential noise impact could occur is less than 10 feet.

In this noise screening and without consideration of noise control measures, the number and magnitude of potential noise impacts of each Action Alternative is shown in Table 6-2.1. The potentially affected receptors include both category 2 and 3 land uses that would be close to the proposed guideway (within 150 feet). In general, the PECO-1st Ave. Action Alternative would potentially have the most noise impacts because a higher number of residences, parks and recreational facilities are near the proposed alignment compared to the other Action Alternatives. The Action Alternatives with a PECO/TP Trunk potentially would have approximately 51% fewer noise impacts than PECO-1st Ave., but more than the Action

Alternatives with a US 202 Trunk. The number of potential noise impacts by Action Alternatives with a US 202 Trunk would be approximately 55% less than PECO-1st Ave., the fewest number of noise impacts among the Action Alternatives. More detail on the potential noise impacts of each Action Alternative is presented in the Sections 6.2.1 through 6.2.5 below.

Table 6-2.1: Potential Noise Impacts by the Action Alternatives

Action Alternative	Potential Noise Impacts by Land Use Category								
	Moderate[1]			*Severe*[1]			Totals		
	1	2	3	1	2	3	1	2	3
PECO–1st Ave.	0	66	3	0	0	0	0	66	3
PECO/TP–1st Ave.	0	33	2	0	0	0	0	33	2
PECO/TP–N. Gulph	0	32	2	0	0	0	0	32	2
US 202–1st Ave.	0	29	3	0	0	0	0	29	3
US 202–N. Gulph	0	28	3	0	0	0	0	28	3

Note 1: The number of exceedances of the *moderate* and *severe* impact criteria categories are reported for each of the three FTA land-use categories: Category 1 is highly sensitive receptors; category 2 is residences; and category 3 is institutional properties.

6.2.2 Vibration

The vibration screening assessment for the Project identifies the potential for vibration impacts by each Action Alternative. The assessment findings indicate that 65 feet is the maximum distance from the proposed guideway that a vibration level from operations could extend and have a potential impact on FTA category 2 land uses (result in “frequent” vibration event activity). For FTA category 3 land uses, which have a different threshold than category 2 land uses (Table 3-2.2), the maximum distance within which a potential vibration impact could occur is 45 feet.

In this vibration screening, and without consideration of vibration control measures, the number of potential vibration impacts of each Action Alternative is shown in Table 6-2.2. The screening assessment identifies the potential for one vibration impact (Kingwood Road Park) by the PECO-1st Ave. Action Alternative in the Project study area, and potentially three vibration impacts (residential properties) by PECO/TP-1st Ave. and PECO-TP-N. Gulph. No vibration impacts are expected to occur as a result of the other Action Alternatives. More detail on the potential vibration impacts of each Action Alternative is presented in the subsections below.

Table 6-2.2: Predicted Vibration Impacts by the Action Alternatives

Action Alternative	FTA Land-use Category[1]		
	1	2	3
PECO–1st Ave.	0	0	1
PECO/TP–1st Ave.	0	3	0
PECO/TP–N. Gulph	0	3	0
US 202-1st Ave.	0	0	0
US 202–N. Gulph	0	0	0

Note 1: The FTA vibration impact criteria used to assess impact reflect the "frequent" event activity level (i.e., more than 70 events per day). The number of exceedances of the vibration impact criteria is reported for each of the three FTA land-use categories: Category 1 is highly sensitive receptors; Category 2 is residences; and Category 3 is institutional properties.

6.2.3 PECO-1st Ave.

6.2.3.1 Noise

As shown in Table 6-2.1, exceedances of the FTA *moderate* noise impact criteria are predicted at 66 residences (category 2 land uses) and three recreational properties (Kingwood Road Park, Chester Valley Trail Extension and PECO Easement) near the PECO-1st Ave. Action Alternative. No exceedances of the FTA *severe* impact criteria are predicted to occur. The locations of the potential impacts are shown graphically in Figure B-1. The majority of the potential *moderate* noise impacts are at residences less than 150 feet from the proposed guideway.

6.2.3.2 Vibration

As shown in Table 6-2.2, exceedances of the FTA vibration impact criteria are predicted at one institutional receptor (category 3 land use) in the King of Prussia study area: Kingwood Road Park. The location of the potential impact is shown graphically in Figure B-1.

6.2.4 PECO/TP–1st Ave.

6.2.4.1 Noise

Exceedances of the FTA *moderate* noise impact criteria are predicted at 33 residences (category 2 land uses), the King of Prussia Volunteer Fire Company/9/11 Memorial and the proposed Chester Valley Trail Extension near the PECO/TP–1st Ave. Action Alternative. No exceedances of the FTA *severe* impact criteria are predicted to occur. The locations of the potential impacts are shown graphically in Figure B-2. The majority of the potential noise impacts are at residences less than 150 feet from the proposed guideway.

6.2.4.2 Vibration

Three category 2 vibration impacts at residential receptors are predicted to occur as a result of the PECO/TP-1st Ave. Alternative.

6.2.5 PECO/TP–N. Gulph

6.2.5.1 Noise

Exceedances of the FTA *moderate* noise impact criteria are predicted at 32 residences (category 2 land uses), the King of Prussia Volunteer Fire Company/9/11 Memorial and the proposed Chester Valley Trail Extension near the PECO/TP–N. Gulph Action Alternative. No exceedances of the FTA *severe* impact criteria are predicted to occur. The locations of the potential impacts are shown graphically in Figure B-3. The majority of the potential noise impacts are at residences less than 150 feet from the proposed guideway.

6.2.5.2 Vibration

Three vibration impacts are predicted to occur at residential receptors as a result of the PECO/TP-N. Gulph. Alternative.

6.2.6 US 202 – 1st Ave.

6.2.6.1 Noise

Exceedances of the FTA *moderate* noise impact criteria are predicted at 29 residences (category 2 land uses) and three category 3 uses (King of Prussia Volunteer Fire Company/9/11 Memorial, the proposed Chester Valley Trail Extension and St. Augustine Cemetery) near the US 202 – 1st Ave. Action Alternative. No exceedances of the FTA *severe* impact criteria are predicted to occur. The locations of the potential impacts are shown graphically in Figure B-4. The majority of the potential noise impacts are at residences less than 150 feet from the proposed guideway.

6.2.6.2 Vibration

No vibration impacts are predicted to occur as a result of the US 202-1st Ave. Alternative.

6.2.7 US 202 – N. Gulph

6.2.7.1 Noise

Exceedances of the FTA *moderate* noise impact criteria are predicted at 28 residences (category 2 land uses) and three category 3 uses (King of Prussia Volunteer Fire Company/9/11 Memorial, the proposed Chester Valley Trail Extension and St. Augustine Cemetery) near the US 202 – N. Gulph Action Alternative. No exceedances of the FTA *severe* impact criteria are predicted to occur. The locations of the potential impacts are shown graphically in Figure B-5. The majority of the potential noise impacts are at residences less than 150 feet from the proposed guideway.

6.2.7.2 Vibration

No vibration impacts are predicted to occur as a result of the US 202-N. Gulph Alternative.

6.2.8 69th Street Transportation Center

No noise or vibration impacts are predicted to occur as a result of the proposed Project at the 69th Street Transportation Center.

6.3 Construction-Related Impacts

Project construction activities in King of Prussia would include such activities as guideway structure installation, relocating utilities, constructing passenger stations, and other ancillary facilities (e.g., traction power substations). Most construction activities are generally expected to last less than 6 months at any one location, depending on the type of activity, and the overall Project construction period is expected to be approximately three years.

Temporary noise and vibration impacts are anticipated to occur during construction in some locations. Noise levels from Project-related construction activities, although temporary, could be a nuisance at nearby sensitive receptors such as residences, hotels, and schools. Noise levels during construction would vary depending on the types of activity and equipment used for each stage of work. Activities associated with construction staging and/or material lay down areas could result in noise and vibration impacts. Similarly, potential impacts of traffic along detour routes and truck haul routes could occur.

7.0 Minimization and Mitigation

The screening assessment of potential noise and vibration impacts in this technical memorandum indicates that such impacts could occur and that more detailed noise analysis and consideration of minimization and mitigation strategies is warranted. SEPTA will undertake this further analysis after selection of a Locally Preferred Alternative and additional design. Detailed analysis typically includes measurements and modeling to characterize existing and future noise and vibration conditions. Where impacts are indicated by detailed analysis, SEPTA will consider the feasibility and reasonableness of the potential noise and vibration control measures described in the following subsections.

7.1 Long-Term Operational

7.1.1 Noise

SEPTA will examine noise control strategies that are both feasible and reasonable to address Project-related noise impacts in the King of Prussia study area. Strategies would include, but may not be limited to:

- Noise impacts at track switches may be eliminated or reduced in severity by installing "spring frogs" or other "pointless" switches that would eliminate the gap in the rail and, thereby, the impulsive or impact noise from the steel wheel striking the rail gap.
- Noise impacts due to potential wheel squeal may be eliminated or reduced in severity by increasing the radius of the track curves, applying slip-stick modifiers to "grease" the contact points between the steel wheels and the steel rail heads, or procuring new N-5 or equivalent rail vehicles that can operate effectively along tracks with radii less than 500 feet without causing wheel squeal to occur.
- Noise impacts due to rail operations may be mitigated with noise barriers, particularly on elevated structures that support track. Due to a lower average acoustical source height of 2 feet above top-of-rail, short-height parapets or walls within the track right-of-way may mitigate potential noise impacts along both elevated and at-grade track sections.

7.1.2 Vibration

The following vibration control strategies will be considered at minimum and as appropriate for the King of Prussia study area:

- Vibration impacts at switches and crossovers may be eliminated by installing special switches (such as spring frogs) that eliminate the gaps in the rails and the resulting impacts.
- Vibration impacts due to rail vehicle pass-bys may be eliminated by limiting train speeds (e.g., less than 25 mph) particularly in the vicinity of residences less than 50 feet from the proposed track alignment.
- Other vibration control measures include ballast mats or other resilient material that would separate the embedded track from the underlying track bed.

- SEPTA will maintain its wheel-trueing program, which will minimize vibration impacts due to wheel flats.

7.2 Short-Term Construction

7.2.1 Noise

SEPTA's construction plan, described in Section DEIS 2.8, would include a noise and vibration management component. Measures SEPTA would consider employing to minimize construction noise fall into two general categories: 1) design considerations; and 2) construction staging or sequencing of operations. Design considerations would include erecting temporary walls or earth berms between the noise source and the sensitive receptor, identifying haul routes that avoid sensitive receptors to the extent reasonably feasible, and locating stationary noise generating equipment at a distance from sensitive receptors.

To the extent reasonably feasible, Project construction activities would be planned to avoid prolonged noise generating activities and to minimize construction activities during the most sensitive times of day or night. SEPTA would also consider including contractor provisions such as requiring mufflers to be installed and maintained on diesel equipment and air compressors. Typical types of noise control measures and BMPs include, but would not be limited to, the following:

- Restrict some or all construction activity to daylight hours when typically there is less sensitivity to noise;
- Develop noise and vibration control plans to demonstrate that each phase of construction work would comply with the local or state noise criteria;
- Place temporary noise barriers around the construction site;
- Place localized barriers around specific items of equipment or smaller areas;
- Use alternative back-up alarms/warning procedures;
- Use higher performance mufflers on equipment during nighttime hours;
- Use portable noise sheds for smaller, noisy, equipment, such as air compressors, dewatering pumps and generators;
- Site staging and laydown areas as well as haul routes away from noise sensitive uses; and
- Alert the affected community to the construction schedule of activities.

Noise control measures and BMPs will be confirmed by SEPTA during later stages of design when the details of Project construction activities are developed and finalized.

Although not binding for federally-funded and federally-significant projects, the Township of Upper Merion's Legislative Code (Article II, Section 107-4.1: Noise) restricts construction noise between 9:00 pm and 7:00 am. SEPTA would work with the Township should any waivers to this local ordinance be required as part of the temporary construction activities. This local code

does not apply to rail operations, however, as any train operating pursuant to commonwealth or federal regulations is exempt.

7.2.2 Vibration

Measures SEPTA would consider employing to minimize construction vibration include, but may not be limited to, the following control measures:

- Use less vibration-intensive construction equipment or techniques near vibration-sensitive locations;
- Route heavily laden vehicles away from vibration-sensitive locations;
- Operate earthmoving equipment as far as possible from vibration-sensitive locations;
- Sequence construction activities that produce vibration, such as demolition, excavation, earthmoving, and ground impacting so that the vibration sources do not operate simultaneously; and
- Coordinate with hospitals and other vibration-sensitive uses during construction planning;
- Alert the affected community to the construction schedule of activities; and
- Use devices with the least impact to accomplish necessary tasks.

APPENDIX A

Acronyms

Acronyms

AA	Alternatives Analysis
ASTM	American Society of Testing and Materials
BEA	Bureau of Economic Analysis
BID	Business Improvement District
BLS	Bureau of Labor Statistics
BLVD	Boulevard
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHOP	Children's Specialized Hospital
CN	Canadian National Railway
CSX	CSX Railroad
DEIS	Draft Environmental Impact Statement
dB	decibels, linear or unweighted
dBA	A-weighted decibels
DVRPC	Delaware Valley Regional Planning Commission
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESRI	Ecological Systems Research Institute
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FPPA	Farmland Protection Policy Act
FTA	Federal Transit Administration
GIS	Geographic Information Systems
Ips	inches per second
KOP	King of Prussia
Ldn	Average Day-Night Noise Level
Leq	Average Hourly Equivalent Noise Level
Lmax	Maximum Noise Levels
LEP	Limited English Proficient
LPST	Leaking Petroleum Storage Tanks
LWCF	Land and Water Conservation Fund
MBTA	Migratory Bird Treaty Act
MCMC	Michigan City Municipal Coach
MED	Metra Electric District
μips	micro inch per second
MOA	Memorandum of Agreement
MPO	Metropolitan Planning Organization
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act

NHPA	National Historic Preservation Act
NHSL	Norristown High Speed Line
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NS	Norfolk Southern Railroad
NTD	National Transit Database
NTHP	National Trust for Historic Preservation
NWI	National Wetlands Inventory
NWP	Nationwide Permit
O&M	Operating and Maintenance
OCS	Overhead Contact System
PADEP	Pennsylvania Department of Environmental Protection
PHMC	Pennsylvania Historical and Museum Commission
PST	Petroleum Storage Tanks
PPV	Peak Particle Velocity
RMS	Root Mean Squared
ROW	Right-of-way
SCC	Standard Cost Categories
SEL	Sound Exposure Level
SEPTA	Southeastern Pennsylvania Transportation Authority
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
TOD	Transit Oriented Development
TP	Pennsylvania Turnpike
USACE	United States Army Corps of Engineers
U.S.C	United States Code
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
VFNHP	Valley Forge National Historical Park
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled

APPENDIX B

Predicted Noise and Vibration Impacts with the Action Alternatives

Figure B-1: Predicted Noise and Vibration Impacts under the PECO–1st Ave. Action Alternative

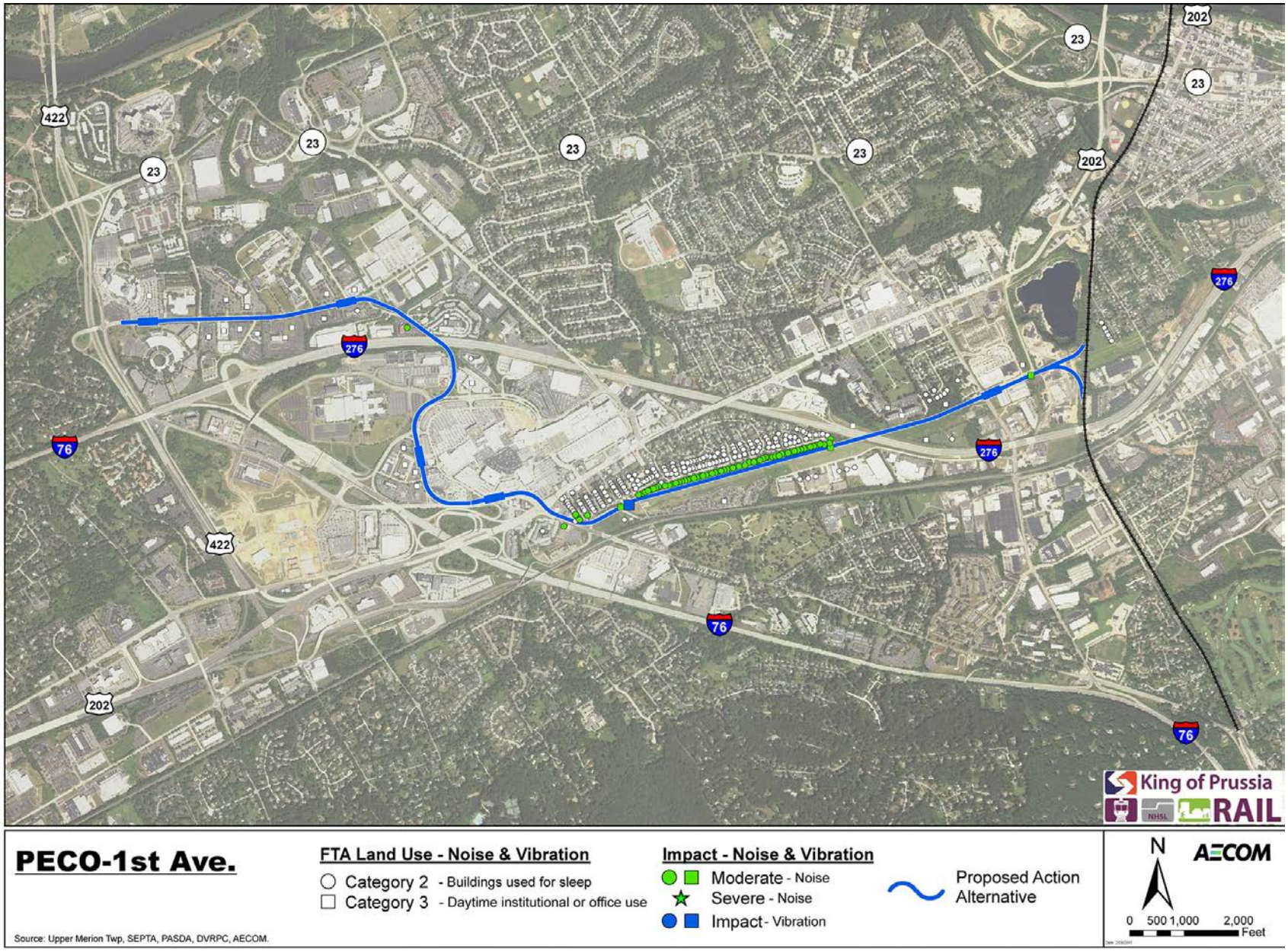


Figure B-2: Predicted Noise and Vibration Impacts under the PECO/TP–1st Ave. Action Alternative

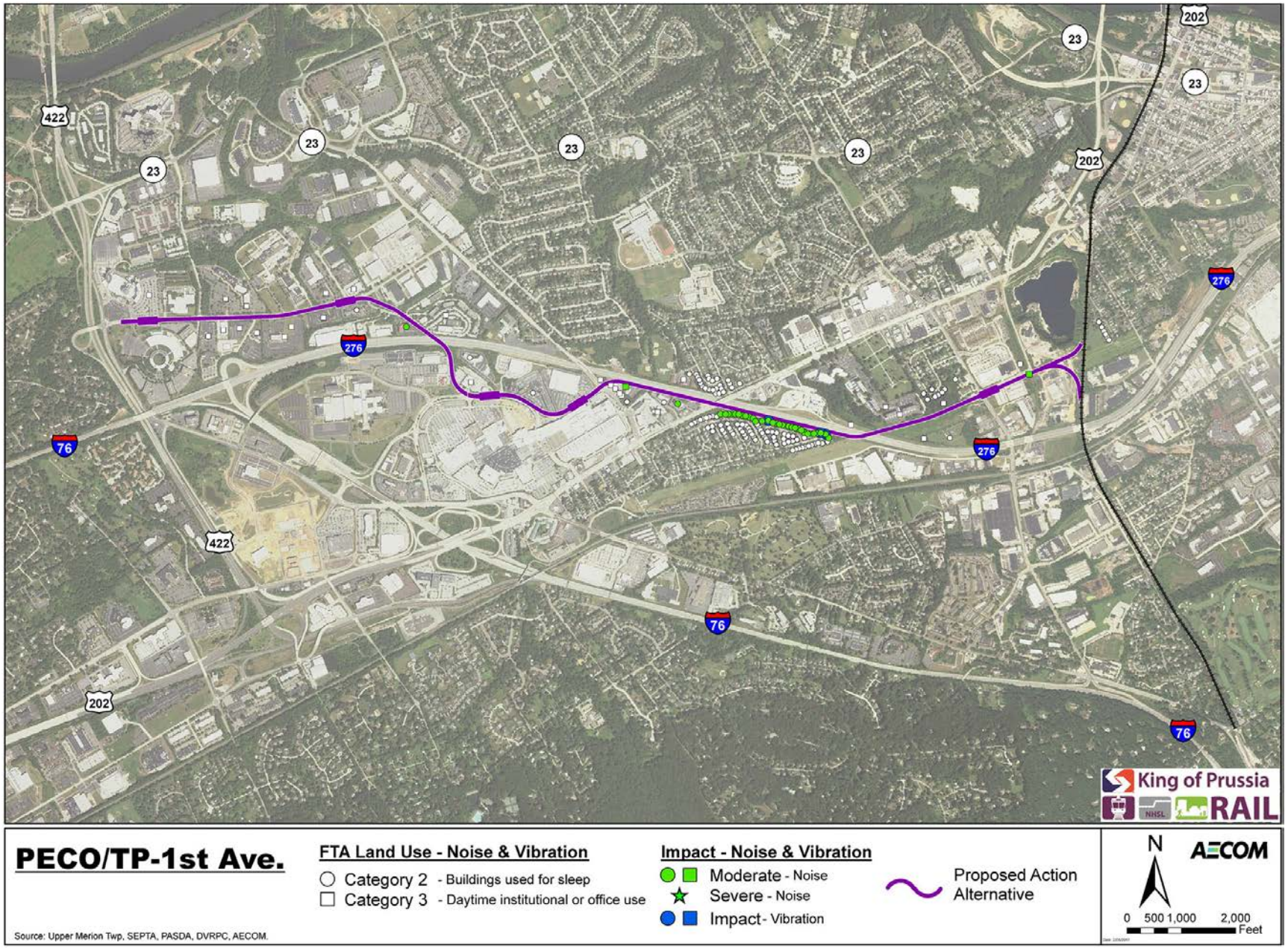


Figure B-3: Predicted Noise and Vibration Impacts under PECO/TP–N. Gulph Action Alternative

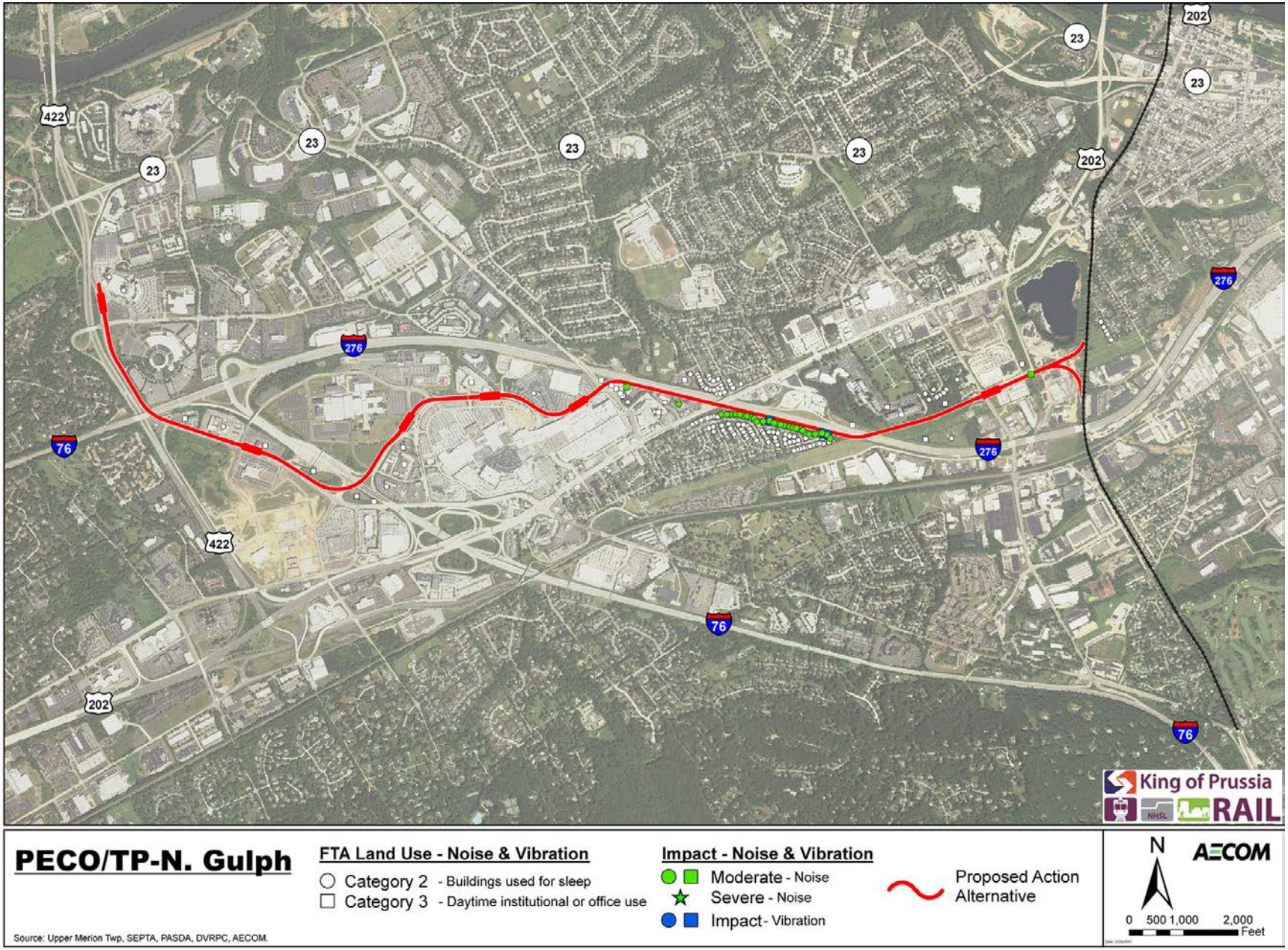


Figure B-4: Predicted Noise and Vibration Impacts under the US 202–1st Ave. Action Alternative

Figure B-5: Predicted Noise and Vibration Impacts under the US 202–N. Gulph Action Alternative